Intention to use IoT by aged Indian consumers

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Abstract

This study identifies the determinants which impact the intention to use Internet of Things (IoT) enabled devices by the aged consumers of India for household purposes. With the help of Model of Adoption of Technology in Households (MATH), a conceptual model has been developed. The model has been extended by considering two moderators (age and gender). It has been ascertained that the explanative power of the model after consideration of two moderators has been enhanced. Ten constructs of MATH have been considered which were found relevant to this study. The validation of the greater explainability by including two moderators in this modified MATH is considered as a theoretical contribution of this study. This study provides insight to the policy makers to understand how the aged consumers of India can be motivated to use IoT enabled devises for their household purposes that would eventually improve their quality of life.

Keywords – Aged Consumers, Internet of Things, MATH Model, Technology adoption, Emerging technologies.

Introduction

With the help of Information Technology (IT), our daily life activities in the household have been considerably changed. Traditional off-line activities have been almost superseded by on-line channels enabled through mobile devices.[1] This is mainly due to their ease of use, usefulness, accessibility, and relative cost advantages. Emerging technologies like Internet of Things (IoT) are gradually becoming an important building block in many such consumer technologies.[2] Now different devices connected with internet can communicate with each other. These services and their utilities have given rise to the adoption of IoT. We are increasingly being able to control our smart devices from a distance with the help of internet without physical proximity to the device. Many devices fitted with internet are being controlled remotely. In this way, IoT enabled devices are gradually being adopted in increasing number of applications in our daily lives.[2] Such use has brought considerable benefits in the household activities. However, despite its potential benefits, fully inclusive digital society is still far off in an emerging economy like India where not all consumer groups use these emerging technologies like IoT.

This emerging technology helps the households, especially the aged persons (above 60 years).[3] Using IoT technology, consumers get health support also. However, very few aged consumers are found to like to use these devices.[2] This tendency is ubiquitous throughout the world.[4] Aged persons do not like to use these devices for their different physical inabilities.[5] The aged consumers feel some unavoidable constraints for using any technology due to their old age.[6] In this perspective, we have tried to investigate how the Indian aged consumers could use IoT enabled devices in their homes. We also tried to understand what are the factors that impact the Indian aged consumers to adopt IoT enabled devices in their homes.

To fulfill our objectives, we have attempted to extend the Model of Adoption of Technology in Households (MATH).[6] Thereafter we studied how the explanative power of this model is influenced if we use some socio-demographic variables as moderators to enhance the understanding how aged consumers could adopt IoT devices better. The target consumer group in our study therefore deals with aged consumers and how they adopt modern technologies in their household activities.[7] Since the MATH model mainly deals with issues surrounding adoption of technology in household contexts, it is found to be a most suitable framework for household activities.

The aged consumers dislike adopting this technology though it helps them a lot.[8] However, not much research has been undertaken on the adoption of modern technology by the aged

consumer groups for their household purposes.[9] To fill up this gap, MATH model is expected to thoroughly explain these challenges. [10,11] The aim of this study is to identify the factors which would impact the aged consumers of India for intending to use and adopting IoT enabled devices for their household activities. This study attempts to investigate if MATH model with some necessary extensions using two moderators could interpret the intention of the aged consumers to use IoT enabled devices in their households.[7] In this background, we attempt to address the following research questions (RQs).

RQ1: What are the antecedents which could impact the Indian aged consumers intention to adopt IoT enabled devices for their household purposes?
RQ2: How can demographic factors moderate the relationship of these antecedents on the behavioral intention of Indian aged consumers to use IoT enabled?

Literature Review

It is a general observation that elderly consumers are often found more reluctant to adopt a modern technology.[8] Any modern technology like wearables that include IoT devices generally has many benefits to offer to elderly consumers to enhance their quality of life.[12] By use of such modern technologies, they can easily reduce social isolation or locational disadvantages which is always felt by them.[13] The application of IoT technology can help the elderly consumers the support of computerized health-care system.[14] But, ironically, their potential benefits are not fully realised by the aged consumers.[9] It is noted in many studies that older consumers face problems in handling these devices wherein age affects adversely on both long term and short-term acceptance.[12] Elderly consumers are found uncomfortable to use internet in technologies like IoT. [15,16,17] Studies have indicated that if aged consumers feel that use of a modern technology would increase their efficiency, or if they feel that such use has perceived usefulness and perceived ease of use, they will exhibit their intention to use it.[9,18.]

In this context, emerging technologies like IoT devices are based on use of internet whereby devices are interconnected and deliver a seamless service to the consumer even at a distance from the devices.[19] Hence, adoption of internet could mean adoption of IoT enabled technologies in both the short run and the long run. There are many advantages of use of IoT.[20] This helps to make the older consumers independent, without being constrained locationally.[19] They can easily pull on with the collaborative management of health records.[21,22,8] With the help of use of IoT devices, the old consumers easily can enrich their sense of business without

hazard.[10,13] With the help of emerging technologies, the aged consumers can better understand the different contexts and can spend more as compared to young consumers.[23]

Theoretical background

The domain of technology adoption has been studied using different models and theories. Since in this present study we are interested to understand insights of usage behaviour of modern technology like IoT by aged consumers in private and household environments, we have focussed our attention on MATH model. MATH is used to examine determinants of technology adoption in private and non-mandatory settings. It explains how consumers exhibit their behavioral intention in dealing with their private needs in homes (with the help of technology) which are mostly not compulsory in nature. Hence, this MATH model has been considered effective to explain adoption of modern technology like IoT in voluntary and private settings by the Indian aged consumers.[24,25] This MATH model mainly relies on the psychological construct of Behavioural Intention (BI). Intention may be considered as a proximal antecedent towards action when IoT in this study has been considered as the focal antecedent.[26,27] Attempts have been taken to improve the effect of MATH model in this context with the consideration of some socio-demographic moderators.

The MATH Model

In MATH, the technology of interest was Personal Computer (PC), in an era when personal computers were considered as an emerging technology which very few households had access. But in this study, IoT technology has been considered as technology of interest. MATH has been developed with the help of Theory of Planned Behaviour (TPB)[28] which acted as a guiding framework. The MATH posits that attitudinal, normative, and control beliefs impact on the behavioural intention for adoption of modern technology in households.[24] In these three belief groups, 13 constructs of MATH are divided.

An exploratory study in our context highlighted that the three constructs Utility for Children, Utility for Work Related Use, and Workplace Referents' Influences are not related with our study and have been dropped. We have adopted the remaining 10 constructs of MATH. The MATH model is shown in Figure 1. (after exclusion of three constructs).
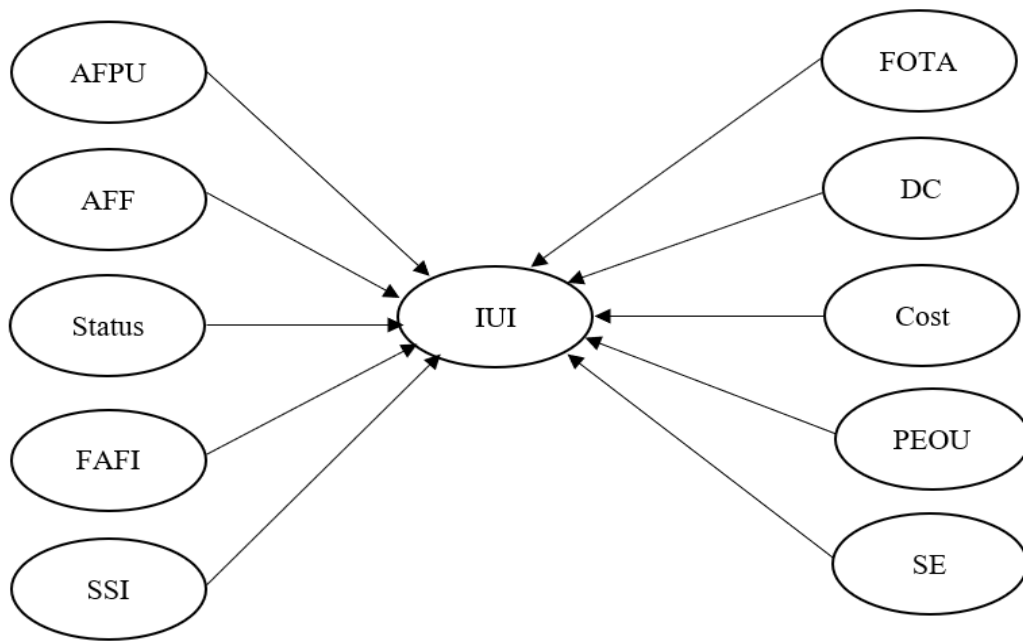
Figure 1: Contextual MATH used

Again, we have analysed the moderating effects of some socio demographic variables derived from the literature of technology adoption by aged consumers of India.

Identification of Socio-Demographic Variables

To identify the socio-demographic variables in our model, comparative literature study has been conducted.[4] We reviewed initially 373 articles wherefrom it has been noted that 113 articles were specific in the context of our study. Out of these 113 articles, 107 articles covered 'Gender' variable, 98 articles covered 'age' variable.[29] Few articles covered 'Income' (9%)[30] and 'Education' (8%). As such, we considered Gender and Age as effective moderators. It is also emphasized that several studies mentioned above used gender, age, income, and education as socio-demographic variables that influence adoption of IoT enabled devices by aged consumers for their household activities.[4] However, effects of income and education were found to be insignificant in some of these studies. That is why we argue that the consideration of age and gender as moderators is perceived to considerably impact intention to use IoT enabled devices by the Indian aged consumers in their household activities. Further, to the best of our knowledge, none of these studies examined these moderators for extending the MATH model theoretically for aged consumers.

Proposed Conceptual Model and Hypotheses Development

This current study extends the MATH model with 10 antecedents for intention to use, and also includes two demographic moderating variables Gender (GEN) and Age (AGE). While the exploration is specifically targeting aged consumers, there may be challenges in understanding why should age then be a moderator. In this context, it is pertinent to mention here that among aged persons, we have divided the sample into three groups based on their professional needs and retirement ages. These age groups are 60-65 years, 66-70 years and above 70 years. These age categories have been defined based on different retirement ages in different services sector in India. Since among the aged person (above 60 years), we have categorized three groups as stated above, it has become essential to study of their behavior towards household affairs using IoT in these three groups, all being more than 60 years. The overall model is illustrated in Figure 2.
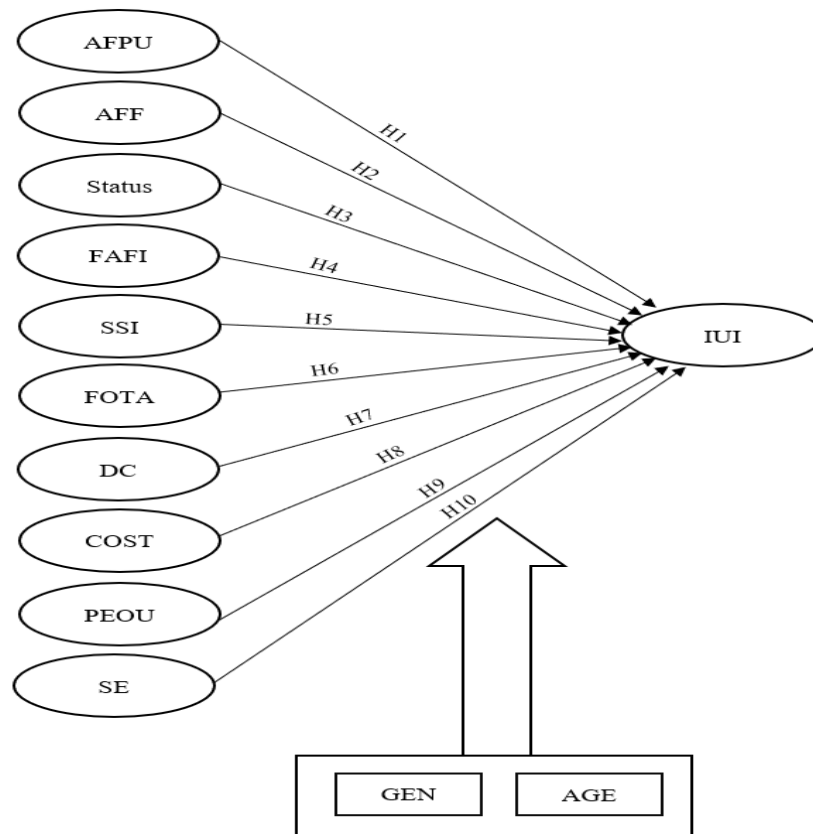

Figure 2: MATH model considering two moderators (extending Venkatesh and Brown, 2001)

Hypotheses Development

As already stated, we have used 10 hypotheses of MATH after eliminating three constructs and considered two moderators, Gender (GEN) and Age (AGE). The reasons of doing so have been explained earlier.

Application for Personal Use (AFPU)

In the household activities, new technology has become helpful, especially, to the aged consumers improving their effectiveness of works.[7] Besides, if use of that technology is found to be less complex and can be implemented with least effort and can fetch quick benefits to the household activities, then even the aged persons should not hesitate to use that technology for their use in household activities.[29,30] For example, if it is found that a device fitted with IoT can be switched on and off and can be operated while relaxing on the bed, it may attract many consumers and it would motivate especially the aged consumers much because of their inevitable physical incapability. This leads to hypothesize as follows:

H1: Application for Personal Use (AFPU) has positive and significant effects on aged consumers to Intend to Use IoT (IUI).

Application for Fun (AFF)

Whenever in the context of household activities, a modern technology like IoT is used with ease and with less exertion, this would motivate even the aged consumers to utilize that technology. By such use of modern technology like IoT, the aged user may get fun and pleasure if using the technology does not involve high learning activities or cognitive load. The pleasure and fun derived by utilizing such modern technology is considered as a hedonic outcome. This will motivate the aged consumers to intend to use that modern technology which can be implementable easily like IoT.[31] This discussion leads to formulate the following hypothesis.

H2: Application for Fun (AFF) significantly and positively induces aged consumers in the context of their household activities towards Intention to Use IoT (IUI).

Status

In the household activities, the users are required to use many technologies to facilitate their household activities with reduced efforts. The use of Information Technology (IT) in different forms in the household activities have steadily diffused different areas covering our daily

household activities.[2] The use of these modern technologies by the aged consumers would bring in even public recognition enhancing their prestige. Use of IoT enabled devices in households enhances the status of the aged consumers. Such use will help the aged consumers to gain referent power being a role model for the subsequent users. This would motivate them to use the technology helping them to upgrade their status.[7] With this background, the following hypothesis is developed.

H3: Use of IoT enabled devices in the household activities by the aged consumers would enhance their status and they would intend to use IoT (IUI).

Friends and Family Influence (FAFI)

This is defined as "the extent to which the members of a social network influence one another's behavior" (p.82).[7] This antecedent can be construed to come under category of social influence. Social influence is explained as influence of some individuals of the society on the behavior of others. The influence of the society molds the use-behavior of the people. The friends and family members of an aged citizen might have effective influence over that aged citizen in matters especially related to use-behavior so far as the household activities of that aged citizen are concerned. Adoption of any modern device by the family members or by the friends of an aged citizen would motivate the aged consumer to adopt that device, especially, if that use of the modern device facilitates the household activities.[9] These discussions have led to formulate the following hypothesis.

H4: Friends and Family Influences (FAFI) on an aged citizen has positive and significant impact on the Intention to Use (IUI) IoT devices.

Secondary Source's Influence (SSI)

SSI is founded on a normative belief structure that might influence aged consumers towards their household activities.[7] Aged consumers often spend a lot of time watching television channels and reading newspapers. Television, newspaper and so on are considered as secondary sources on information. Information derived from these secondary sources influence their decision making significantly both directly and indirectly. Information from the secondary sources have a lot of impact on their adoption behavior.[4] Thus, the aged consumers may develop intentions to use modern technology like IoT devices after being influenced by

information derived from these secondary sources. Arguing from this viewpoint, the following hypothesis is formulated.

H5: Secondary Sources' Influence (SSI) has a significant and positive impact on aged consumers to Intend to Use (IUI) IoT devices in their household activities.

Fear of Technology Advances (FOTA)

FOTA poses a knowledge barrier impending adoption of a new technology.[31] Paucity of knowledge of the users creates impediment to adopt a technology in household activities. The aged users feel reluctant to use it as it needs to learn continuously. This behavioral characteristic is more dominant in the case of aged consumers. Slightest changes required in handling a modern household device as it evolves, will significantly inhibit adoption behavior by an aged citizen. An aged citizen is likely to be more serious, cautious and at the same time always doubtful regarding his or her technical capabilities. Advancement of technology brings in panic to an aged citizen as he or she always possesses suspicion regarding the technical knowledge and the general ability to adapt to the way the technological change has happened. This fear of obsolescence stands on the way to use modern technology needed to be used by an aged citizen in discharging his or her household activities.[31] This idea leads to formulate the following hypothesis.

H6: Fear of Technology Advances (FOTA) has a significant and positive impact on an aged citizen to Intend to Use (IUI) IoT devices in household activities.

Declining Cost (DC)

Brown & Venkatesh (2005) noted some indications in literature which emphasized that income of a household is instrumental in the adoption decision making. Reduction of cost would motivate a family to purchase a device for household usage. Most of the aged consumers would usually depend on their comparatively shrinking income from any source (like pension or savings) and may be inclined to purchase a IoT device if it is found that there is reduction in cost of the device gradually over time. Reduction of cost would motivate the aged citizen to purchase and adopt that IoT enabled device since that would suit with his or her limited budget.[7] With all this background, the following hypothesis is derived.

H7: Declining Cost (DC) has an effective and significant positive impact on the adoption behavior of aged consumers who would intend to use IoT (IUI) devices for household activities.

Cost

Cost refers to expenses in money required to be incurred to purchase an IoT enabled device for performing household activities. If an aged person, despite of enjoying other facilities, realizes that the cost of purchasing a modern technology-based household device is too high to fit with his/her limited budged, it is natural that it would affect the purchase decision influencing the purchase behavior of that aged citizen. Cost significantly, as such, affects usage behavior of an aged citizen towards purchase of an IoT enabled device useable for household activities.[7] This leads to propose the following hypothesis.

H8: Cost (COST) has a significant and negative impact on an aged citizen to Intend to Use IoT (IUI) device for performing household activities.

Perceived Ease of Use (PEOU)

This belief has been borrowed from Technology Acceptance Model (TAM) developed by Davis.[32] It is a belief that helps a user to believe that some efforts are needed to use a technology like IoT.[33,34] A user would not hesitate to use a technology if it is not difficult to use. This concept is ubiquitous.[35,36,37] The aged consumers are more cautious as they are doubtful about their technical abilities. Thus, the following hypothesis is proposed.

H9: Perceived Ease of Use (PEOU) has a significant and positive impact on the aged consumers to intend to use IoT (IUI) devices necessary to perform their household activities.

Self-Efficacy (SE) and Intention to Use IoT (IUI)

Self-efficacy is conceptualized as how one can perform a behavior. Accurate skills of users would motivate them to use a technology. The self-efficacy would help an aged consumer to use a technology. The aged consumers will use IoT enabled devices if they possess self-efficacy to use the system.[38]

Intention may be considered as a proximal antecedent towards action. Here IoT has been considered as the focal antecedent. Intention may be interpreted as an extent of effort that is exerted by one for attaining the goal. Intention to use IoT (IUI) is a culmination of conscious

and sincere process. It takes some time, requires substantial deliberation, and eventually targets the consequences.[6] Thus, the following hypothesis is proposed.

H10: Self Efficacy (SE) has a significant and positive impact on an aged citizen to exhibit Intention to Use IoT (IUI) enabled device necessary to perform household activities.

Research Methodology

There are 10 constructs and two moderators in the survey instrument. To validate both the models (without moderators & with moderators), we have prepared the questionnaire. The items have been prepared with the help of 10 constructs. Initially we developed 47 items which were scrutinized by 7 experts for face validity. These experts have knowledge in the domain of this study. They opined that out of these 47 items, 11 items suffer from the defects of readabilities. We eliminated these items from our model. We started our works with 36 items against 10 constructs. Details of the research instruments with their sources have been illustrated in Appendix 1.

For selecting the appropriate sample, we attended some conferences and seminars in India at Bengaluru, Mumbai, Delhi, Chennai, and Kolkata. The issues of those conferences and seminars covered adoption models of IoT by consumers of different ages including aged consumers. We attended these conferences and seminars during Dec 2017, Jan, and Feb of 2018. From those conferences and seminars, we could identify a few experts who work closely with aged people in the social sector. We requested them to favor us with list of aged persons (more than 60 years) who are the potential users of IoT solution. These resource persons subsequently provided us list of 422 prospective respondents with their details. A convenience sampling was used to identify the initial experts following which a snowball sampling methodology was followed to identify the aged consumers. It was observed that 30 respondents are aged below 60 years and 29 have incomplete addresses. Eliminating them, we sent 36 questions to 363 respondents with a request to respond within 45 days. Within time, we received 349 replies. We got those responses verified by those seven experts who opined that 29 replies were vague. Excluding these 29 vague responses, we started our analysis with 320 usable respondents against 36 questions. The demographic information is shown in table 1.

Table 1: Demographic Information

Particulars	Category	Number	Percentage (%)
Gender	Male	197	61.6
	Female	123	38.4
Age	60-65 years	180	56.3
	66-70 years	96	30.0
	> 71 years	44	13.7

Data Analysis

For ascertaining internal consistency of the constructs, we have computed Cronbach's alpha of each construct. We have also measured Mean, Standard Divisions (SD) and Average Variance Extracted (AVE) for each construct. It appears that square roots of all AVEs are greater than the corresponding bifactor correlation coefficients satisfying Fornell and Larcker criteria[39] confirming discriminant validity. The results are shown in table 2.

Table 2: Measurement Model Estimation

Construct	ICR (α)	Mean	SD	AVE	AFPU	AFF	Status	FAFI	SSI	FOTA	DC	Cost	PEOU	SE	IUI	GEN	AGE
AFPU	.87	4.42	1.35	.82	.91												
AFF	.85	5.61	1.06	.84	.41	.92											
Status	.82	4.89	1.49	.88	.31	.42	.94										
FAFI	.81	4.75	1.51	.82	.21	.40	.26	.91									
SSI	.89	4.72	1.12	.82	.49	.37	.28	.27	.91								
FOTA	.91	4.08	1.30	.84	.41	.30	.31	.37	.28	.92							
DC	.86	4.79	1.16	.85	.36	.21	.44	.45	.29	.32	.92						
Cost	.88	3.21	1.42	.81	.44	.22	.46	.41	.32	.27	.34	.90					
PEOU	.81	4.16	1.59	.76	.21	.28	.41	.45	.34	.29	.36	.27	.87				
SE	.82	5.14	1.39	.84	.40	.26	.44	.44	.45	.30	.37	.29	.45	.92			
IUI	.86	0.68	1.67	.81	.31	.24	.39	.43	.44	.31	.38	.41	.51	.32	.90		
GEN	1	0.67	0.46	1	.41	.41	.38	.41	.51	.33	.41	.43	.54	.31	.29	1	
AGE	1	67.42	4.19	1	.32	.43	.36	.37	.44	.43	.46	.44	.37	.27	.31	.38	1

Note: The above Table is concerned with discriminant validity test. The Average Variances (AVs) being square roots of corresponding AVEs (Column 5) are shown in diagonal positions from column 6 to column 18.

To identify convergent validity, we have computed loading factor of each item. The Composite Reliability (CR) Average Variance Extracted (AVE) of each construct has been computed and they are within allowable range. The parameters are shown in Table 3.

Table 3: Computation of LF, AVE and CR

Latent Variables	Item	LF	AVE	CR
AFPU	AFPU1	0.92	0.82	0.86
	AFPU2	0.90		
	AFPU3	0.89		
AFF	AFF1	0.91	0.84	0.87
	AFF2	0.92		
	AFF3	0.92		

Status	Status1	0.92	0.88	0.91
	Status2	0.94		
	Status3	0.96		
FAFI	FAFI1	0.91	0.82	0.84
	FAFI2	0.90		
	FAFI3	0.89		
	FAFI4	0.91		
SSI	SSI1	0.89	0.82	0.85
	SSI2	0.90		
	SSI3	0.93		
FOTA	FOTA1	0.91	0.84	0.88
	FOTA2	0.94		
	FOTA3	0.90		
DC	DC1	0.93	0.85	0.89
	DC2	0.89		
	DC3	0.91		
	DC4	0.96		
Cost	Cost1	0.90	0.81	0.86
	Cost2	0.88		
	Cost3	0.92		
PEOU	PEOU1	0.91	0.76	0.81
	PEOU2	0.90		
	PEOU3	0.91		
	PEOU4	0.90		
SE	SE1	0.94	0.84	0.88
	SE2	0.92		
	SE3	0.89		
IUI	IUI1	0.93	0.81	0.83
	IUI2	0.88		
	IUI3	0.89		

Note: The loadings of items lie between 0.88 and 0.96, the values of AVEs lie between 0.76 and 0.88 and the values of CRs lie between 0.81 and 0.91. All the parameters have the values as shown in the Table 5 are found to be within their respective acceptable range.

The values of path coefficients and p-values have been computed in the two models, that is, before consideration of effects of 2 moderators on MATH model (Model-1) and after consideration of effects of 2 moderators on MATH model (Model-2) along with computations of R^2 and adjusted R^2 before and after consideration of effects of moderators. All these are shown in Table 4 and Table 5 respectively.

Table 4: Path coefficients and p-values

	Model 1	
	Path	p - value
R^2	0.76	
Adjusted R^2	0.74	
AFPU	0.03	0.52
AFF	0.27	0.006
Status	-0.06	0.16
FAFI	0.15	0.02
SSI	0.02	0.53
FOTA	-0.07	0.12
DC	0.05	0.19
Cost	-0.06	0.07

|	Path	p – value
PEOU	0.12	0.05
SE	0.59	< 0.001

Note: The above Table shows the values of path coefficients along with the p-values with estimated values of R^2 and adjusted R^2. These have been estimated prior to use of two moderators (Age and Gender).

**Table 5:** Path coefficients and p-values with moderators

	Model 2	
	Path	**p – value**
R^2	0.86	
Adjusted R^2	0.84	
AFPU	-0.08	0.72
AFF	0.38	0.35
Status	-0.27	0.27
FAFI	0.13	0.40
SSI	0.08	0.64
FOTA	0.01	0.94
DC	0.08	0.64
Cost	-0.03	0.87
PEOU	-0.29	0.41
SE	0.58	0.07
AFPU $\times$ GEN	0.22	0.54
AFPU $\times$ AGE	0.29	0.31
AFF $\times$ GEN	-0.38	0.28
AFF $\times$ AGE	0.04	0.83
Status $\times$ GEN	0.13	0.48
Status $\times$ AGE	0.27	0.34
FAFI $\times$ GEN	0.12	0.71
FAFI $\times$ AGE	-0.26	0.34
SSI $\times$ GEN	-0.21	0.50
SSI $\times$ AGE	0.06	0.78
FOTA $\times$ GEN	0.13	0.53
FOTA $\times$ AGE	-0.08	0.69
DC $\times$ GEN	0.17	0.58
DC $\times$ AGE	0.11	0.71
Cost $\times$ GEN	0.04	0.83
Cost $\times$ AGE	0.01	0.94
PEOU $\times$ GEN	0.28	0.37
PEOU $\times$ AGE	-0.03	0.92
SE $\times$ GEN	-0.52	0.27
SE $\times$ AGE	0.08	0.84

Note: The above Table highlights that all the estimated values have been obtained concerning to path coefficients and p-values after consideration of the two moderators (Age and Gender).

After validation with the help of PLS regression analysis through sample survey as discussed earlier, the detailed analysis has been shown in Figure 3 with respect to MATH model and Figure 4 with consideration of relevant socio demographic two moderators. The p-values have not been shown in these two figures to avoid complexity.
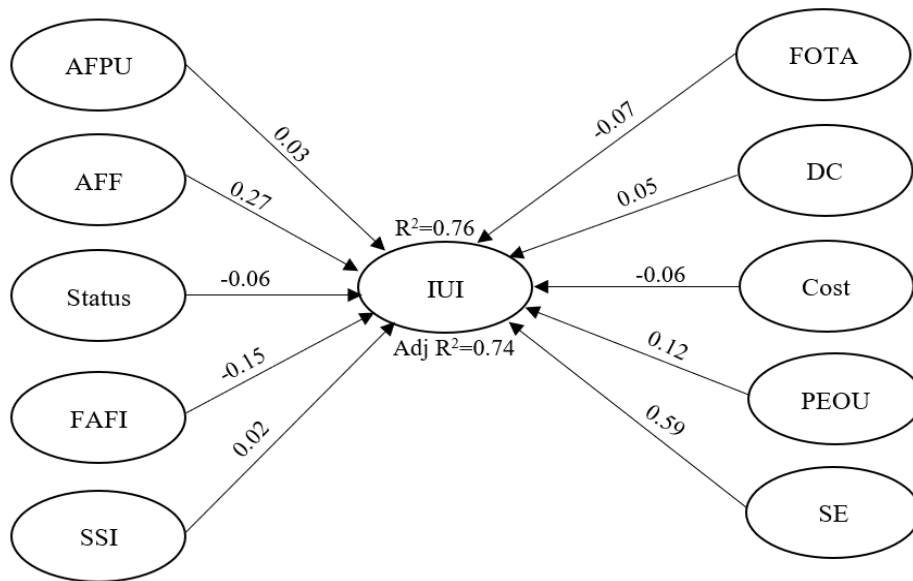
Figure 3: Model 1- Contextual MATH Model without moderators

(**Note:** The levels of significance are shown in Table 7)
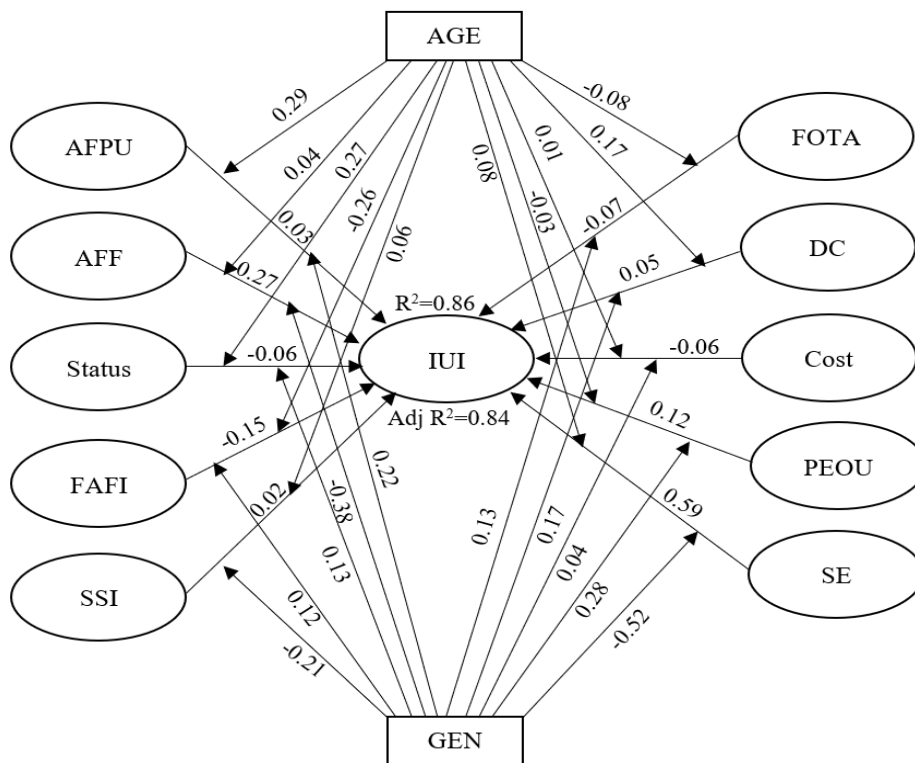
Figure 4: Model 2 - Contextual MATH Model with moderators

(**Note:** The levels of significance are shown in Table 8)

Discussion on findings

The results indicate that we have been able to address our research questions. The MATH model has been meaningfully able to explain the intention of aged consumers to adopt IoT

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(RQ2). The MATH model has been able to account for more than 70% variance of intention to use IoT (IUI) without consideration of the effect of moderators. (MATH model adjusted $R^2 = 0.74$ without consideration of moderators). Given this context, we can conclude that MATH model has been successfully able to elucidate the intention of use of IoT enabled devices by the elderly consumers of India in their household activities. This addresses the RQ1.

Further it appears from our findings that considerations of effect of two moderators (Gender & Age) have meaningfully enhanced the explanative power (adjusted $R^2 = 0.74$ to adjusted $R^2 = 0.84$). We argue that socio-demographic perspectives are feasible and valuable as an extension of MATH model to elucidate the behavioural intention of the elderly consumers to intend to use IoT in their household activities. It appears AGE has a negative effect on the adoption affairs of IoT by the Indian aged consumers. Thus, inclusion of moderators has enhanced the effectiveness of the model. By this way, we claim that we have been able to explain and address the RQ2. In terms of RQ1, MATH model itself could explain the issue of acceptance very well as it has resulted in high explanative power. Inclusion of two socio-demographic variables has enhanced the explanative power of the extended model.

The study has principally focused on extending the MATH model by including demographic variables as moderators. We have excluded three constructs of that MATH model. These are UFC, UFW, and WRI. These constructs are not specific for the present context. This has been already clearly and exhaustively explained in this study. However, the remaining ten constructs of MATH model have been considered relevant in the present study. With the help of these ten constructs and with the consideration of two moderators (AGE and GEN) which is claimed to be unique contribution of this study, we have seen from the empirical study that such consideration of two moderators has enriched the model.

So far as H1 is concerned, it appears that our study shows that it is strongly supported. This hypothesis is supported also by earlier study of Venkatesh and Brown.[7] Relating to H2, we find that the empirical study supports this hypothesis which is also in agreement with earlier studies.[31] Moreover, so far as H3 is concerned, the hypotheses-testing shows that it is supported. Not only that. This hypothesis is confirmed by earlier research studies.[2] Regarding H4, the empirical study shows that this hypothesis has been supported.[9] Not only the hypothesis H5 has been supported in this empirical study, but this has also been confirmed by earlier studies.[4] So far as H6 is concerned, it is seen that it has been validated through statistical analysis. It has also been supported by earlier studies.[31] Impact of DC on IUI (H7) has been confirmed after hypotheses testing and this also has a support from earlier studies.[30] With

increase of Cost, the hypothesis (H8) asserts that aged Indian consumers would exhibit negative behavior to intend to use IoT enabled devices in their household activities. This has received support from the statistical analysis conducted. This also has been supported by earlier studies.[7] It is natural that if use of technology is perceived to be easy to handle, what to speak of aged consumers, all persons irrespective of their ages would exhibit intention to use that technology. This idea has been lent from TAM[32] and from MATH. This has been hypothesized in this study by formulating the hypothesis H9. This has been supported by the empirical analysis. It also is found to have received support from earlier studies.[34] It also appears that H10 has received support from earlier studies.[38] Consideration of MATH after adjustment along with two moderators AGE and GEN enhance the explanative power of the theoretical model. This proposed model has been able to appropriately investigate the behavior of the aged consumers of India towards Intending to Use IoT enabled devices in the household activities which is the core aim of this study.

Contribution to Theory

The core contribution of our research is towards introducing demographic variables as moderators in the MATH model for aged consumers. We have arrived at such findings which would be helpful to extend the body of literature surrounding technology adoption by aged consumers. We have identified the research gap[10] and from that, we could frame research questions. These have been duly addressed through contribution of appropriate constructs which effectively could represent traits and beliefs. Our research has been able to exert significant influence on the affairs of adoption of modern technology like IoT by Indian aged consumers in their household activities. We have been able to extend the existing body of knowledge for technology adoption studies for aged consumers to bridge the digital divide.[2] This study principally extends existing literature to include the two socio-demographic variables to the existing MATH model. We have included two moderators (socio-demographic variables) like Gender and Age to effectively enrich the model to interpret insights concerning to adoption of IoT by the aged consumers of India in their households.[40] Additionally, through examination of MATH model, we have revisited some established relationships in technology adoption literature to specifically interpret the adoption issues by aged consumers. We have done this with the help of their (constructs) corresponding quantitative instruments and subsequent validation using surveys. By extending a theoretical model like MATH, our study has enriched the other existing allied studies[41] which explored the issues without empirical

validation through robust measurement instruments. We have analysed the intention of the aged consumers to use IoT enabled devices in their household activities with consideration of two moderators, Gender and Age. This model may be applied to the IT based other services in general like e-commerce or e-government adoption and so on.[42] It may be considered as a baseline for other technology adoption. Consideration of the two socio-demographic variables as moderators has strengthened our theoretical contribution.

Our study has built upon the literature surrounding adoption behaviour of modern technology like IoT by aged consumers of India. It provides insights to realise the issues with marked division between young consumers & aged consumers in the context of household activities. Further this study has analysed theoretically the inclination of behavioural intentions to use IoT by the aged consumers whose age groups have been divided in three groups as already stated. The segregated groups indicated that higher is the age, greater is the moderation impact on the relationships of the antecedents with the intention to use IoT Devices. The model can also be applied to analyse adoption behaviour such as studies of unemployed groups with employed groups, lower income groups with higher income groups and so on. By considering two moderators, the explanative power of the model has been enhanced. It transpires after achieving high degree of determination that the factors of our model could capture the perceptions and beliefs of aged consumers compared to younger consumers.

Implication for practice

This research study has considerable practical implications. To upgrade standard of living, the Government of India (GOI) is giving much priority for e-inclusion. This e-inclusion will improve quality of life, improve economic performance, develop social participation. The wave of this improvement will enhance the quality of life of aged consumers. In this context, GOI is exerting massive efforts to accelerate issues of adoption of IoT to all the consumers including the aged consumers.[43] This initiative is found in existence in all other countries.[4,44] To achieve this, our study has contributed effectively to the authorities for strategy making. The use of MATH model has derived many advantages to the authorities to analyse how the elderly consumers' involvement may be ensured to motivate them to use the IoT technology in their household atmosphere.[45]

This study highlighted that applications of IoT enabled devices in households will bring fun for the elderly consumers. It appears from the study that friends & family will support the elderly consumers in their adoption decision. It appears that faith of aged consumers on their

capabilities and skills has strong impact on the adoption behaviour of elderly consumers. The results also highlighted that the rate of adoption of IoT by the aged citizens are impacted negatively by the cost. However, the study of the estimates of significant relationships (p values) highlights that the effects are unevenly scattered across different aspects. This makes it difficult to develop a meaningful and feasible strategy. This study indicates that the authorities should take holistic attempt to make the elderly consumers aware regarding potential benefits of IoT towards its usage in household purposes. This will increase the adoption rate for the elderly consumers. Besides, the authorities of India can take up a project like that which has been taken up by Ireland where a project named 'Say IT on the radio' by Dundalk.fm. Through this, there is scope for the elderly consumers to share their positive experiences on modern technology (internet) with other aged consumers (listeners). Projects like this would help Indian elderly consumers to be motivated to intend to use IoT. It is considered as an ideal example. It is expected that this extended model of MATH (inclusion of 2 moderators) having high explanative power will be replicable, especially, in other developing countries. This may be construed to be an additional practical implication of our findings in this study.

Conclusion

It has been noted that demographic ageing is an important trend especially in Indian context where there exist diverse cultural beliefs. It is noted that aged consumers with different age groups have different beliefs, attitudes, and intentions when we consider their usage behaviour for modern technology like IoT. In this perspective, we have taken an attempt to understand insights regarding the use of IoT enabled services by the aged consumers (beyond 60 years). Our findings show that MATH model can explain more than 70% variance relating to issues of adoption of IoT by aged consumers of India with consideration of two moderators (Gender and Age). We have identified some constructs from the MATH model. This could significantly explain the traits and beliefs in this specific context.

In brief, we can conclude.

- Aged consumers are found reluctant to adopt modern technology like IoT in general.
- MATH model could explain the usage behaviour of aged consumers to use IoT in their households.

- With consideration of age and gender as moderators over and above consideration of some factors from MATH model, we could more clearly explain the insights of aged consumers for their usage behaviour of technology like IoT in their household activities.

- Age and gender have appreciable effects to elucidate behavioural intention of aged consumers to use modern technology like IoT for their household purposes. These two variables act as vital moderators influencing the intention of the users.

- Age having negative effect on intention, the elderly consumers cannot be considered as a homogeneous group, that is, there is no scope to conclude that aged consumers having more than 60 years of age would exhibit their usage behaviour in uniform way regardless of their age and that is why in this study, we have divided the aged consumers in different age groups beyond 60 years.

Limitations and direction for future research

It is important to mention that in India, use of IoT enabled services is in infancy stage. The survey has been conducted with the help of feedbacks of 320 usable responses. These consumers are non-adopters, and their replies are predictive. Hence, while applying our proposed model to the actual adopters (only aged consumers here), due precautions are to be given to generalise the result. There might be necessity to include at least another construct like Actual Use of IoT by elderly consumers. This might modify the explanative power of the proposed model. It is left for the future researchers to nurture. India is a vast country. It has varied cultural conception from place to place. We have not considered the issue of cultural difference in our study though culture might influence the adoption behaviour even to the aged Indian consumers. This may be dealt with by future researchers. We have conducted our survey with 320 usable responses. India is a vast and highly populated country. Hence, this number of responses (320) should not be considered as a general representation of aged demography of India. The survey works have been carried out for a limited period. A longitudinal study might yield different results. This may be taken up by the future researchers. We have considered many constructs along with consideration of socio-demographic variables. However, inclusion of other moderators like social status and others could have strengthened the model. This may be considered as one of the limitations of this study. Owing to consideration of high number of factors, we have obtained many insignificant paths. There may be two strategies to address this situation. First to increase the sample size and second is to implement statistical corrections. This second option is considered not suitable in the present context. Hence in future,

researchers may conduct survey with more sample. However, despite of all these limitations mentioned, it is claimed that there is no reason to undermine this proposed model since, with consideration of moderators, this model has achieved high explanative power.

Appendix 1: Summary of Questionnaire (Research Instruments)

Items	Source	Statements	Response [SD][D][N][A][SA]
AFPU1	Venkatesh and Brown, 2001; Brown, Dennis and Venkatesh, 2010	I believe that the IoT devices can be connected with various applications for personal productivity.	[1][2][3][4][5]
AFPU2		I think that the IoT devices can support different household activities.	[1][2][3][4][5]
AFPU3		The IoT devices atr associated with applications that help facilitating different activities at home.	[1][2][3][4][5]
AFF1	Venkatesh and Brown, 2001	I enjoy using IoT enabled devices at home.	[1][2][3][4][5]
AFF2		The IoT devices have applications that can create fun.	[1][2][3][4][5]
AFF3		The IoT devices provide many applications those are quite enjoyable.	[1][2][3][4][5]
Status1	Venkatesh and Brown, 2001; Czaja, 2013	I believe that, people who use IoT devices at home have more status than people who do not use IoT devices	[1][2][3][4][5]
Status2		I think that, people who use IoT devices at home have a high profile	[1][2][3][4][5]
Status3		Using IoT enabled devices at home is a status symbol	[1][2][3][4][5]
FAFI1	Venkatesh and Brown, 2001; Chen and Chan, 2011	My friends think I should use IoT enabled devices at home for personal use.	[1][2][3][4][5]
FAFI2		Those who are in my social circle think I should use IoT devices at home.	[1][2][3][4][5]
FAFI3		My family members think I should use IoT devices for household purpose.	[1][2][3][4][5]
FAFI4		My relatives think I should use IoT devices at home.	[1][2][3][4][5]
SSI1	Venkatesh and Brown, 2001	Information from different print media suggests that I should use IoT devices at home.	[1][2][3][4][5]
SSI2		Information that I could gather by watching TV encourages me to use IoT devices at home.	[1][2][3][4][5]
SSI3		Based on what I have heard in different conferences and seminars, I am encouraged to use IoT devices at home.	[1][2][3][4][5]
FOTA1	Venkatesh and Brown, 2001; Lin and Bhattacherjee, 2010	Technological advancement and its trend make me worried.	[1][2][3][4][5]
FOTA2		I am worried because of rapid advances in IoT technology.	[1][2][3][4][5]
FOTA3		I am afraid because today's best IoT devices will be obsolete soon.	[1][2][3][4][5]
DC1	Venkatesh and Brown, 2001; Tsai et al., 2019	I believe the cost of IoT enabled devices is constantly reducing.	[1][2][3][4][5]
DC2		I think the cost of IoT enabled devices will continue to reduce in future.	[1][2][3][4][5]
DC3		I believe more sophisticated IoT enabled devices will appear in market with lower cost in near future.	[1][2][3][4][5]
DC4		I believe maintenance and support cost of IoT enabled devices will reduce further in future.	[1][2][3][4][5]

Cost1	Venkatesh and Brown, 2001	I believe the cost of IoT enabled devices is quite high to be purchased by common people.	[1][2][3][4][5]
Cost2		I think IoT enabled devices are important to purchase for household purpose.	[1][2][3][4][5]
Cost3		IoT devices those are available in market today are very expensive.	[1][2][3][4][5]
PEOU1	Davis, 1989; Venkatesh and Brown, 2001	I found IoT enabled devices is very easy to use.	[1][2][3][4][5]
PEOU2		I think I can easily get all the information from applications related to IoT enabled devices.	[1][2][3][4][5]
PEOU3		Interacting with IoT enabled devices does not require a lot of effort.	[1][2][3][4][5]
PEOU4		Interacting with IoT devices is easy and understandable.	[1][2][3][4][5]
SE1	Venkatesh and Brown, 2001	I can use IoT devices at home even if nobody helps me.	[1][2][3][4][5]
SE2		I feel comfortable using IoT devices at home.	[1][2][3][4][5]
SE3		I can easily operate IoT devices at home on my own.	[1][2][3][4][5]
IUI1	Venkatesh and Brown, 2001; Brown and	I intended to use IoT devices for household purposes,	[1][2][3][4][5]
IUI2	Venkatesh, 2005	IoT devices are quite helpful for using different household purposes.	[1][2][3][4][5]
IUI3		I find the IoT devices can be used for the security of my family.	[1][2][3][4][5]

References

1. Chhonker MS, Verma D, Kar AK, Grover P. m-commerce technology adoption: Thematic and citation analysis of scholarly research during (2008-2017). 2018; TBL. 31(3/4):208-233.
2. Agarwal N, Chauhan S, Kar AK, Goyal S. Role of human behaviour attributes in mobile crowd sensing: a systematic literature review. Digit. Policy, Regul. Gov. 2017; 19(2): 168-185. Doi: 10.1108/DPRG-05-2016-0023.
3. Wang X, McGill TJ, Klobas JE. I Want It Anyway: Consumer Perceptions of Smart Home Devices. 2020; J. Comput. Inf. Syst. 60(5): 437-447. doi: 10.1080/08874417.2018.1528486.
4. Niehaves B, Plattfaut R. Internet adoption by the elderly: employing IS technology acceptance theories for understanding the aged-related digital divide. 2014; Eur. J. Inf. Syst. 23(6): 708-726. doi: 10.1057/ejis.2013.19.
5. Becker SA. E-government usability for older adults. Commun. ACM, 2005; 48(2): 102–104. doi: 10.1145/1042091.1042127.
6. Brown SA, Venkatesh V. Model of adoption of technology in households: a baseline model test and extension incorporating household life cycle. MIS Q. 2005; 29(3): 399–426. doi: 10.2307/25148690.
7. Venkatesh V, Brown SA. A longitudinal investigation of personal computers in homes: adoption determinants and emerging challenges. 2001; MIS Q. 25(1): 71–102. doi: 10.2307/3250959.
8. Czaja SJ. Factors influencing use of an e-health website in a community sample of older adults. 2013; J Am Med Inform Assoc, 20(2): 277–284. doi: 10.1136/amiajnl-2012-000876.
9. Chen K, Chan AHS A review of technology acceptance by older adults. 2011; Geron technology, 10(1): 1–12.

10. Porter CE, Donthu N. Using the technology acceptance model to explain how attitudes determine Internet usage: the role of perceived access barriers and demographics. 2006; J. Bus. Res. 59(9): 999–1007. doi: 10.1016/j.jbusres.2006.06.003.

11. Mathai N, McGill T, Toohey D. Factors Influencing Consumer Adoption of Electronic Health Records, 2020; J. Comput. Inf. Syst. doi: 10.1080/08874417.2020.1802788

12. Shareef MA, Archer N, Dwivedi YK. Examining adoption behavior of mobile government. 2012; J. Comput. Inf. Syst. 53(2): 39-49. doi: 10.1080/08874417.2012. 11645613.

13. Chatterjee S, Kar AK, Dwivedi YK, Kizgin H. Prevention of cybercrimes in smart cities of India: from citizen's perspective. 2018a; Inf. Technol. People, Early site. doi: 10.1108/ITP-05-2018-0251

14. Dwivedi YK, Shareef MA, Simintiras AC, Lal B, Weerakkody V. A generalised adoption model for services: A cross-country comparison of mobile health (m-health). 2016; Gov. Inf. Q. 33(1): 174-187. doi: 10.1016/j.giq.2015.06.003.

15. Nord JH, Paliszkiewicz J, Koohang A. (2014). Using social technologies for competitive advantage: impact on organizations and higher education. 2014; J. Comput. Inf. Syst. 55(1): 92-104. doi: 10.1080/08874417.2014.11645744.

16. Aldossari MQ, Sidorova A. Consumer Acceptance of Internet of Things (IoT): Smart Home Context. J Comput Inform Syst. 2018; In Press. doi: 10.1080/08874417. 2018.1543000.

17. Hsu C-L, Lin C-C. (2018). Exploring Factors Affecting the Adoption of Internet of Things Services, 2018; J. Comput. Inf. Syst. 58(1): 49-57. doi: 10.1080/08874417.2016. 1186524.

18. Chatterjee S, Kar AK, Gupta MP. Alignment of IT authority and citizens of proposed smart cities in India: system security and privacy perspective. 2017; Glob. J. Flex. Syst. Manag. 19(1): 95-107. doi: 10.1007/s40171-017-0173-5.

19. Schroeder A, Naik P, Ziaee Bigdeli A, Baines T. Digitally enabled advanced services: a socio-technical perspective on the role of the internet of things (IoT). 2020; Int. J. Oper. Prod. Manag. 40(7/8): 1243-1268. doi: 10.1108/IJOPM-03-2020-0131.

20. Esmaeilpour Ghouchani B, Jodaki S, Joudaki M, Balali A, Rajabion L. A model for examining the role of the Internet of Things in the development of e-business. 2019; VINE J. Inf. Knowl. Manag. Syst. 50(1): 20-33. doi: 10.1108/VJIKMS-04-2019-0058.

21. Smith T, Koohang A, Behling R. Understanding, and prioritizing technology management challenges. 2014; J. Comput. Inf. Syst. 51(1): 91-98. doi: 10.1080/08874417.2010. 11645453.

22. Koohang A, Paliszkiewicz J. Knowledge construction in e-learning: An empirical validation of an active learning model. 2013; J. Comput. Inf. Syst. 53(3): 108-114. doi: 10.1080/ 08874417.2013.11645637.

23. Koohang A, Hatch M. Leadership effectiveness in IT-centered organizations: Gender and levels of management. J. Comput. Inf. Syst. 2017; 57(4): 385-391. doi: 10.1080/ 08874417.2017.1330128.

24. Choudrie J, Dwivedi YK. Investigating factors influencing adoption of broadband in the household. 2006; Comput. Inf. Syst. 46(4): 25-34. doi: 10.1080/08874417.2006. 11645911.

25. Dwivedi YK, Khan N, Papazafeiropoulou A. Consumer adoption and usage of broadband in Bangladesh. 2007; Electron Govern. 4(3): 299-313. doi: 10.1504/EG.2007.014164.

26. Choudrie J, Dwivedi YK. The demographics of broadband residential consumers in a British local community: The London borough of Hillingdon. 2005; J. Comput. Inf. Syst., 45(4): 93-101. doi: 10.1080/08874417.2005.11645860.

27. Dwivedi YK, Rana NP, Jeyaraj A, Clement M, Williams MD. Re-examining the unified theory of acceptance and use of technology (UTAUT): Towards a revised theoretical model. 2019; Inform Syst Front. 21(3): 719-734. doi: 10.1007/s10796-017-9774-y.

28. Ajzen I. The theory of planned behavior. Organ Behav Hum Decis Process. 1991; 50(2):179–211. doi: 10.1016/0749-5978(91)90020-T

29. Brown SA, Dennis AR, Venkatesh V. Predicting collaboration technology use: integrating technology adoption and collaboration research. 2010; Manag. Inf. Syst. 27(2): 9–53. doi: 10.2753/MIS0742-1222270201.

30. Tsai JM, Cheng MJ, Tsai HH, Hung SW, Chen YL. Acceptance and resistance of telehealth: The perspective of dual-factor concepts in technology adoption. 2019; Int J Inf Manage. 49: 34-44. doi: 10.1016/j.ijinfomgt.2019.03.003.

31. Taylor S, Todd PA. Understanding information technology usage: a test of competing models. 1995; Inf. Syst. Res. 6(4): 591–570. doi: 10.1287/isre.6.2.144.

32. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. 1989; MIS Q. 13(3): 319–339. doi: 10.2307/249008.

33. Allam H, Bliemel M, Ali-Hassan H, Blustein J, Spiteri L. If you Build it, They Won't Come: What Motivates Employees to Create and Share Tagged Content: A Theoretical Model and Empirical Validation. Int J Inf Manage. 2020; 54:102148. doi: 10.1016/j.ijinfomgt. 2020.102148

34. Chatterjee S, Kar AK. Why do small and medium enterprises use social media marketing and what is the impact: Empirical insights from India. 2020; Int J Inf Manage. 53: 102103. doi: 10.1016/j.ijinfomgt.2020.102103.

35. Alkhowaiter WA. Digital payment and banking adoption research in Gulf countries: A systematic literature review. Int J Inf Manage. 2020; 53:102102. doi: 10.1016/ j.ijinfomgt. 2020.102102

36. Sarkar S, Chauhan S, Khare A. A meta-analysis of antecedents and consequences of trust in mobile commerce. 2020; Int J Inf Manage. 50: 286-301. doi: 10.1016/j.ijinfomgt.2019 .08.008.

37. Zhao Y, Ni Q, Zhou R. What factors influence the mobile health service adoption? A meta-analysis and the moderating role of age. 2018; Int J Inf Manage. 43: 342-350. doi: 10.1016/j.ijinfomgt.2017.08.006.

38. Chatterjee S, Kar AK, Gupta MP. Success of IoT in Smart Cities of India: an empirical analysis. 2018c; Gov. Inf. Q. 35(3): 349-361. doi: 10.1016/j.giq.2018.05.002.

39. Fornell C, Larker DF. Evaluating structural equation models with unobservable variables and measurement error: algebra and statistics. 1981; J Mark Res. 18(3): 382–388. doi: 10.2307/3150980.

40. Janssen M, Luthra S, Mangla S, Rana NP, Dwivedi YK. Challenges for adopting and implementing IoT in smart cities. 2019; Internet Res. Early site. doi: 10.1108/INTR-06-2018-0252.

41. Van Dijk J. Digital divide research, achievements and shortcomings. 2006; Poetics. 34(4/5): 221–235. doi: 10.1016/j.poetic.2006.05.004.

42. Dwivedi YK, Rana NP, Janssen M, Lal B, Williams MD, Clement M. An empirical validation of a unified model of electronic government adoption (UMEGA). 2017; Gov. Inf. Q. 34(2): 211-230. doi: 10.1016/j.giq.2017.03.001.

43. Chatterjee S, Kar AK. Regulation and governance of the Internet of Things in India. 2018b; Digit. Policy, Regul. Gov. 20(5): 399-412. doi: 10.1108/DPRG-04-2018-0017.

44. Dwivedi YK, Wastell D, Laumer S, Henriksen HZ, Myers MD, Bunker D. Research on information systems failures and successes: Status update and future directions. Inform Syst Front. 2015; 17(1): 143–157. doi: 10.1007/s10796-014-9500-y.

45. Lin CP, Bhattacherjee A. Extending technology usage models to interactive hedonic technologies: a theoretical model and empirical test. 2010; Inf. Syst. J. 20(2): 163–181. doi: 10.1111/j.1365-2575.2007.00265.