Pertanika J. Sci. & Technol. 25 (3): 835 - 846 (2017)

SCIENCE & TECHNOLOGY

Journal homepage: http://www.pertanika.upm.edu.my/

Internet of Things – Technology Adoption Model in India

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ABSTRACT

Internet of Things (IoT) is the biggest ICT revolution that the world is witnessing with potential to be the next biggest technology disruptor that will improve productivity and efficiency across different industries and services sector. The purpose of this paper is to study adoption of Internet of Things (IoT) enabled technologies in the corporate sector in India and also to identify factors influencing its adoption rate. It prescribes a suitable model serving as a blue print for enterprises. The methodology used is exploratory research as significance of Technology Adoption Model (TAM) in IoT projects is still not studied to lay the groundwork for future studies. Literature review proposed different models based on TAM or their abridged versions. In this study, a team of five experts in IoT project adoption proposed factors crucial to successful IoT project implementation. Based on these, questionnaires were developed and sent to respondents who are senior officers at their respective selected companies. Data obtained was used to validate existing and proven TAM research model. Based on this, the study proposed a new model (IOT-TAM). Variables namely Perceived utility, Perceived ease of use, intrinsic variables and external organization were developed. First generation multivariate method of multiple regressions was used to assess reliability and validity of the model measures.

Keywords: Indian enterprises, internet of things, technology adoption, technology adoption model

INTRODUCTION

Internet of Things (IoT) is a new age communication paradigm that refers to objects, sensors, actuators and assemblies communicating in bi-directional mode with each other, generating and transmitting data and interacting across a digital network. Each of the objects is uniquely identifiable and has the capacity and willingness to broadcast information about itself or its surroundings for further decision making.

Andrea et al. (2014), noted that IoT has many applications including Smart Cities (A **smart city** is an urban development vision to integrate information and communication

Article history:
Received: 29 December 2016
Accepted: 21 April 2017

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ISSN: 0128-7680

technology (ICT) and Internet of things (IoT) technology in a secure fashion to manage a **city's** assets), planning for safety of buildings, waste management, traffic congestion, noise monitoring, energy conservation and smart parking.

The major focus of IoT studies has been on technology, infrastructure and supplier innovation but little has been studied on the awareness of this technology among manufacturers in India. Adoption of IoT i is beneficial to these companies as it offers many advantages such as cost competitiveness and a shift from traditional labour intensive business process to technology aided and automated business processes. This is be in line with the Government of India's resolve to shift to Smart Manufacturing. However, there is a lack of a framework for Indian policy makers to determine the facilitators for adoption of IoT. The purpose of this paper is therefore to build on the Technology Adoption Model (TAM) and suggest a framework for adoption of IoT among businesses in India. The paper begins with a discussion of established TAM model that shows how users accept and use a technology. Next, it proposes a model IoT-TAM based on a IoT implementation case and then uses a survey method to gather data about the current state of IoT adoption in India and finally uses this data to validate the IoT-TAM model and its variables. The results of the survey were analysed using SPSS.

Internet of Things aims to transform the real-world objects into intelligent virtual objects. The IoT aims to unify everything in our world under a common infrastructure (Somayya, 2015).

Nunberg (2012) defines IoT as a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic, wireless and optical networking technologies.

Kosmatos, Tselikas and Boucouvalas (2011) have described broad applications of IoT using RFID integrated with smart objects while Aggarwal and LalDas (2012) show that though IoT applications have many benefits, there are also security issues which are a significant determinant of user ease of acceptance of the technology.

The Technology Acceptance Model

Technology Acceptance Model (TAM) is one of the successful measurements for effective computer usage among end users. It is modelled after Everett Rogers's (1983) theory on diffusion of innovation where technology adoption is a function of a variety of factors including Relative advantage and ease of use.

It is necessary for organisations to evaluate technology adoptions as they spend a huge amount of resources implementing new technologies. This also helps predict the extent to which users will use the system provided to them. Understanding people's behaviour in accepting or rejecting computer related technologies is one of the most challenging issues in information systems (Swanson, 1988). This includes user beliefs and attitude, satisfaction measures, adaptation to change, role of culture, education and awareness.

The TAM is a modification of the Theory of Reasoned Action (TRA) which is a widely studied social psychology model concerned with the determinants of consciously intended behaviour.

According to TRA, a person's performance of a specific behaviour is determined by his/her behavioural intention (BI) to perform the behaviour and BI which is jointly determined by the person's attitude (A) and subjective norm (SN) concerning the behaviour.

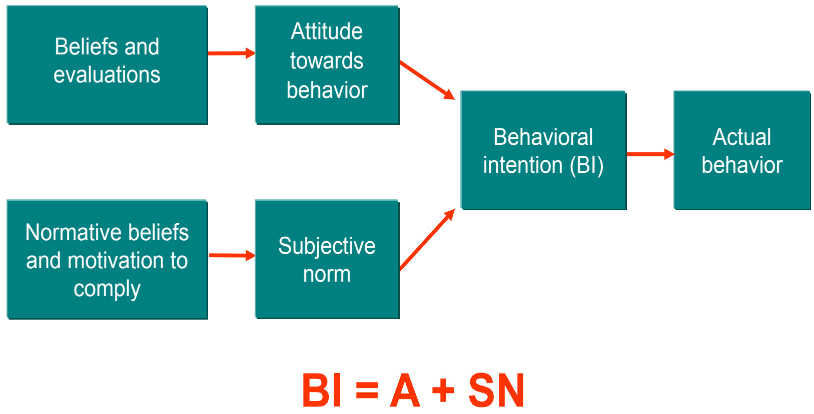

Figure 1. Theoretical Framework (TRA)

Literature Review

Davis (1989) has discussed the TAM theory in information systems and suggested that two main factors, Perceived Usefulness (PU) and Perceived Ease of use (PEOU), drive the adoption of a technology.

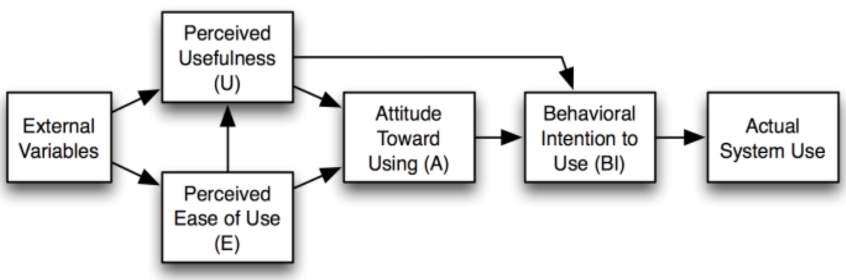

Figure 2. Original Technology Acceptance Model (TAM)

Venkatesh et al. (2000) examined the TAM model and proposed "Unified theory of acceptance and use of technology" (UTAUT) which has has four key constructs to explain user intentions to use an Information system and subsequent usage behaviour which are performance expectancy, effort expectancy, social influence and facilitating conditions. The theory was a consolidation of the constructs of eight models of earlier research to explain information systems usage behaviour (theory of reasoned action, technology acceptance model, motivational model, theory of planned behaviour, a combined theory of planned behaviour / technology acceptance model, model of personal computer use, diffusion of innovations theory, and social cognitive theory).

Gaur and Ramakrishnan (2016) have explained the practical application of IoT in areas of manufacturing quantifying benefits and its relevance and adoption in the context of Industry 4.0.

Ferguson (2002), has emphasised the importance of objects having the ability to communicate as a major factor for companies to become more efficient, speed up processes, reduce error, prevent theft, and incorporate complex and flexible organisational systems through IoT.

Rahman (2014) has developed a conceptual model based on TAM for adoption of healthcare IT systems with emphasis on proposed perceived usefulness and perceived ease of use.

Zanella et al. (2014) has showcased IoT as the building block for Smart Cities in the near future where objects will be primarily driving everyday life activities.

Willis (2008) has done a comprehensive evaluation of TAM as a means to understanding online social networking behaviour. His findings suggest that TAM is a reasonable model of acceptance of online social networking systems, but the subjective norm component was not predictive of acceptance.

Park (2009) has used the TAM model to understand the behavioural intention of students to implement and use e-Learning in institutions and formulated a generic model.

Biddlecomb (2005) has discussed the concept of networking of individual machines making them readable and traceable on the Internet. Butler (2006) foresee tiny computers that constantly monitor ecosystems, buildings and even human bodies by 2020. Want (2006) has described the use of RFID as an initial evolution of object-to-object communication and its utility while Moeinfar (2012) has discussed the use of active RFID in container tracking.

Dodson (2008) has explained how billions of objects uniquely identified by EPC codes and IPV6 numbering can make objects as simple as razors or soft drink cans detectable and viewable by computers.

Gershenfeld (2011) on the other hand has reflected on aspects of privacy, trust and interaction when using IoT devices. He also discussed data exchange possibilities due to the pervasive and ubiquitous nature of these objects.

Andrea (2014) explained that the Internet of Things (IoT) shall be able to incorporate transparently and seamlessly a large number of different and heterogeneous end systems, while providing open access to selected subsets of data for the development of a plethora of digital services; this opens a huge opportunity for data based services on IoT.

METHODS

Research Methodology

Purpose of research. The purpose of this research is to suggest a technology adoption model (based on TAM) for IoT projects which are becoming one of the biggest technology disruptors of this decade. It is descriptive in nature whereby a survey method was used to understand the current status of IoT adoption among Indian organisations and using the data to propose and validate an IoT-TAM model.

Data collection method. Cross sectional survey method was used to collect data from participants with good knowledge of IoT to assess how they have overcome technology acceptance barrier for IoT in their respective organisations. The respondents were either business leaders or technology leaders with decision making powers Responses were combination of nominal (mode central tendency), ordinal (illustrated median) and five point Likert-type scales.

Proposed model. In the study, an IoT-TAM model is proposed. A set of five organisational constructs was selected by expert opinion to develop hypothesis, research model and survey questions:-

- Perceived Usefulness of IoT (PUIOT),
- External Organisation variables (EOVIOT),
- Internal Organisation variables (IOVIOT)
- Perceived ease of use (PEUIOT) which is dependent on the current IT landscape and its strategic role and finally
- Behavioural intention to use (BIUIOT).

The model is supported by the TAM and UTAUT model.

Table 1
Constructs of the model and sample questions

Constructs	Summary	Survey Questions
PUIOT	Perceived usefulness	*How would you rate IoT adoption as being extremely useful in your organisation?*
		Do you agree that IoT can help decrease operating costs?
		Do you agree that IoT adoption can help improve efficiency of employees and machines?
		Do you think that IoT adoption can encourage new business models in traditional organisations?
EOVIOT	External Organisation Variables	*Do you agree that the industrial environment is conducive for organisations to adopt IoT?*
		Do you agree that generally organisations who have adopted IoT or implementing IoT projects are likely to be successful?
		Do you consider IoT as an important enabler for organisations with global scope of operations and hence involvement of cross cultural employees?
IOVIOT	Internal Organization Variables	*Do you consider your organisation's maturity in using IT technologies helped expedite adoption of IoT ?*
		As a CIO did your role and personal belief play an important part in IoT adoption in your enterprise?
		Do you have budgets for new initiatives such as IoT as a regular practice and did that help in adoption?
PEUIOT	Perceived ease of use	*Do you consider that enough IoT skills exist in Indian markets?*
		Do you agree that no technical challenges exist for IoT adoption in India?
		Do you agree that no security challenges exist in IoT adoption?
BIUIOT	Behavioural Intention to use	*Would you be looking at implementing or adopting an IoT project more aggressively in the coming year?*
		Would you be considering marking major budgets for IoT adoption this year?
		Have you planned for upgrade of skills for IoT adoption in your internal IT team?

The model below shows the relation between the above five constructs.

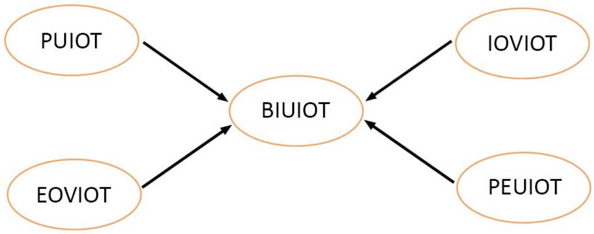

Figure 3. Constructs and relationship

Hypothesis

H1: Perceived usefulness of IOT (PUIOT) positively affects the behavioural Intention to use IoT (BIUIOT)
H2: A more robust Internal IT organisation (IOVIOT) variables positively influence BIUIOT
H3: Complexity of External Organisational variables (EOVIOT) positively influence BIUIOT
H4: Perceived ease of use of IOT (PEUIOT) positively influence BIUIOT

Sampling size and survey. In this study, the sample target was executives and business leaders who work in IT companies and have knowledge of IoT and implementing an associated project after understanding the above constructs.

The survey was conducted online using Google Forms and to ensure a higher response rate, convenience sampling was used to identify respondents.

The survey questionnaires were completed by 171 participants and showed a confidence rate of 90% which was found to be sufficient. Data was refined from manipulation and null or repetitive responses to get around 168 valid responses whereby:

- 50 respondents were CMO (Chief Marketing Officers) and equivalent
- 45 were Operations Head or Line Heads
- The rest consisted of department Managers and executives .

Sample distribution. Of the respondents, most of them were from other categories (mode).

Table 2
Sector wise respondents

Sector	Frequency	Percent
Financial Services	16	9.5
Telecommunications	32	19.0
Process Manufacturing	44	26.2
Discreet Assembly	12	7.1
Pharma Life sciences	12	7.1
Others	52	31.0
Total	**168**	**100.0**

Majority of the organisations had a turnover of over 1000 crores.

Table 3
Size of business

Size of Business	Frequency	Percent
< 250 crores INR	28	16.7
250-1000 crores INR	34	20.2
1000-6000 crores INR	70	41.7
>6000 crores INR	36	21.4
Total	**168**	**100.0**

The organisations have global operations

Table 4
Scope of operations

Scope of Operations	Frequency	Percent
Global Operations and Manufacturing	22	13.1
India-only operations	52	31.0
India manufacturing but global exports	94	56.0
Total	**168**	**100.0**

The respondents were mainly from the operational and strategic sections indicating that these organisations view IT as a business enabler.

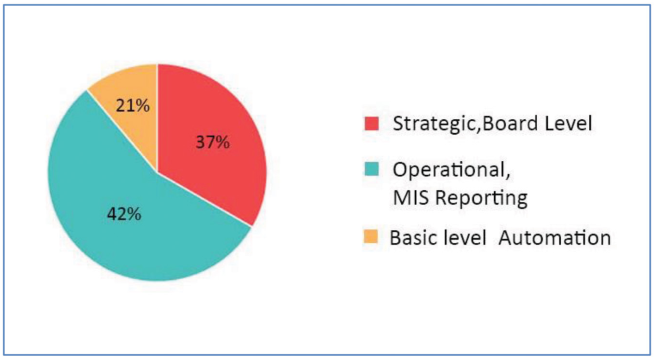

Figure 4. Role of IT

Factor and Reliability Analysis

The determinant value is 3.99E-05 which is greater than 0.00001 and hence, no singularity exists and there is no need for eliminating any questions. Value of KMO is .755 which shows the sample is adequate. We have used the Principal components analysis with Varimax rotation method.

DISCUSSION

The dependent variables have been considered as Behavioural Intention to use IoT (BIUIOT) while the independent variables are grouped as Perceived usefulness of IoT, External Organisation Variables (EOVIOT), Internal Organisation Variables (IOVIOT) and Perceived ease of use of IoT technology (PEUIOT).

In order to examine the relationship between the variables and adoption of IoT, this study adopts research statistical methods by Chin (1998), Pedhazur(1982) , Joreskog (1989), Stevens (2002) and Tabachnick (2001).

First Generation multiple regression analysis was used on the data appropriate for evaluating first the constructs, and secondly, the relationships between individual constructs.

Table 5
Calculation of R

Model Summary[e]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	0.535[a]	0.286	0.259	0.975	0.286	10.600	6	159	0.000	2.016
2	0.613[b]	0.376	0.332	0.926	0.091	4.473	5	154	0.001	
3	0.637[c]	0.405	0.346	0.916	0.029	1.839	4	150	0.124	
4	0.659[d]	0.434	0.338	0.921	0.029	0.790	9	141	0.626	

The table above shows the model summary whereby R is the correlation between the observed and predicted values of the dependent variable. R square is proportion of variance in the dependent variable (BIUIOT) which can be predicted from the independent variables; 25.9% variance in BIUIOT can be explained from the variable 1, 37.6% from the variable 2, 40.5% from variable 3 and 43.4% from variable 4. The Adjusted R square is a more accurate value, the standard error of the estimate, also called the root mean square error, is the standard deviation of the error term, and is the square root of the Mean Square Residual.

Table 6
Analysis of Variance

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	60.426	6	10.071	10.600	.000[b]
	Residual	151.068	159	0.950		
	Total	211.494	165			
2	Regression	79.584	11	7.235	8.447	.000[c]
	Residual	131.910	154	0.857		
	Total	211.494	165			
3	Regression	85.752	15	5.717	6.820	.000[d]
	Residual	125.742	150	.838		
	Total	211.494	165			
4	Regression	91.788	24	3.824	4.505	.000[e]
	Residual	119.706	141	0.849		
	Total	211.494	165			

Sum of Squares associated with the three sources of variance, Total, Model and Residual, for the regression sum of squares is 10.071 for variable 1 while the sum of squares for residual is .950. The p-value associated with this F value is very small (0.0000). These values are used to answer the question "is the independent variable reliably predicting the dependent variable?". The answer is yes since the p value is less than the alpha level.

Model 1 which relates to the H1 hypothesis of positive correlation between perceived usefulness and behavioural intent to adopt IoT shows an R value of .259 which shows that 25.9% of the variances in adoption of IoT are explained by independent variable PUIOT and the significance value of regression model is 0 which shows a significant positive correlation.

Model 2 which relates to the H2 hypothesis of positive correlation between external organisation variables and behavioural intent to adopt IoT shows an R value of .332 which indicates that 33.2% of the variances in adoption of IoT are explained by independent variable EOVIOT and the significance value of regression model is 0 which shows a significant positive correlation.

Model 3 which relates to the H3 hypothesis of positive correlation between internal organisation variables and behavioural intent to adopt IoT shows a R value of .346 which indicates that 34.6% of the variances in adoption of IoT is explained by independent variable EOVIOT and the significance value of regression model is 0 which shows a significant positive correlation.

Model 4 which relates to the H4 hypothesis of positive correlation between perceived ease of use variables and behavioural intent to adopt IoT shows a R value of .338 which shows that 33.8% of the variances in adoption of IoT is explained by independent variable EOVIOT and the significance value of regression model is 0 which shows a significant positive correlation.

All four have a positive and significant correlation with IoT adoption and all four hypotheses are fully supported. The organisations' ability to adopt IoT for different use in their organisation is positively influenced by the traditional TAM model determinants i.e. perceived usefulness and perceived ease of use as with other information technology projects. Apart from the two other factors which play a major role in IoT adoption are the maturity levels of the organisation which is indicated by the role of IT executive and their influence in the organisation and current investments in cutting edge IT applications. A higher degree of evolution of IT is a positive influencer. Also, organisations are positively influenced where the external conducive environment be it technology adopted by competitors, infrastructure for supporting IT such as data network and skilled resource pool or government thrust area and incentives is conducive for adoption of smart technologies.

CONCLUSION

The findings of this study are consistent with the TAM model (Venkatesh and Davis 2000, 2004). whereby there is greater user involvement, system acceptance, and system success (Swanson, 1974; Ives & Olson, 1984; Hartwick & Barki, 1994). As countries across the world move towards Smart Cities, Smart Transportation, Smart Water management and Energy management and Industry 4.0, each stake holder has a role to play in getting interested parties to adopt IoT in their workplaces. A key to successful adoption has been determined by the above study and hence a healthy ecosystem comprising skilled resources which can be ensured by imparting education in IoT technologies as part of courses, robust infrastructure and data networks, government incentives based on measurable benefits and finally encouraging leading organisations to set trends for others to follow must be adopted holistically.

This study has proposed a model for successful IoT adoption by first validating the existing TAM model in organisations having implemented IoT projects. Based on survey results, an amended version of IoT-TAM is proposed. This research can be a foundation for future research which can validate the model and also determine which of the above four components carries more weight. This model can also help consulting companies who are implementing IoT projects or management of companies to successfully create a blue print for IoT implementation based on other intrinsic factors in the organisation. Any organisation which scales up well on the four dependent variables can be sure of success in the independent variable which is acceptance of IoT. Future research can also validate the model from specific industry sector and country perspective.

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