International Journal of Innovation, Creativity and Change. www.ijicc.net
Volume 12, Issue 4, 2020

The Adoption of the Internet of Things in Vietnam

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On the basis of developing the theory of the Technology Acceptance Model (TAM), the research has measured the affecting factors of the innovative willingness of IoT personal technology and the impact of innovative readiness of IoT personal technology to the intention of using IoT applications in Vietnam. With the use of quantitative methods based on data collected from individuals using smart devices on the Internet of Things technology platform in Vietnam, the results show that there are 3 main variables that directly affect the adoption intention of an IoT device. The innovative willingness of IoT personal technology is to realise the usefulness, ease of use and risk of IoT. At the same time, the results also show the direct impact of the innovative willingness to IoT personal technology to the adoption intention of IoT devices. Based on those results, this study presents some specific policy implications.

Key words: *Internet of Things - IoT, Adoption of IoT, Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA), Theory of Planned Behaviour (TPB), Smart Devices IoT.*

Introduction

Studies of the Internet of Things (IoT) are carried out in many aspects such as research on vision, structure and development orientation of IoT (Gubbi, Buyya, Marusic, and Palaniswami (2013), M. Wu, Lu, Ling, Sun, and Du (2010), Miorandi, Sicari, De Pellegrini, and Chlamtac (2012)). This research focusses on analysing the orientation of technical architecture development of IoT. Another research on IoT is the IoT applications in businesses such as: monitoring and control; big data and business analytics; and information sharing and collaboration (Lee and Lee (2015)). These types of researches focus on identifying application scenarios, potentials, open issues and challenges in developing IoT applications in businesses and organisations (Borgia (2014)). A number of recent studies provide an IoT approach in the perspective of the user behaviour of smart devices based on the IoT technology platform due to the strong growth in the number of smart device users with IoT connection. These researches focus on user behaviour who are accepting the use of smart devices with IoT connection

(Atzori, Iera, and Morabito (2010), Mital, Chang, Choudhary, Papa, and Pani (2018)). Studies in this direction will support the development of smart devices to meet the needs of users with increasing numbers and demand currently (Azis et al., 2019).

The Internet of Things (IoT), Blockchain, along with Artificial Intelligence (AI), Big Data, are ground-breaking technological solutions of the way of industrial network 4.0. IoT is the basic foundation for developing e-government, smart cities, smart houses, etc. According to statistics from the Vietnam Internet Network Information Centre, in 2018 Vietnam continues to develop and has some small positive changes based on achievements in 2017 and the last several years. With a population of 96.02 million and an urbanisation rate of 35%, the number of Internet users in Vietnam in 2018 reached 64 million, accounting for 67% of the population. It is forecasted that by 2020, Vietnam will be in the top 10 of countries enjoying Internet access, with at least 80% of the population using the Internet – about 76.6 millions of user. Smart phones are still popular access devices with 72% of users, up to 43% accounted for by laptops/desktops, tablets reaching 13% and 5% are Internet-connected TV devices. The above figures present the strong development trend of the Internet in the Vietnam market. However, for a country with a transiting economy like Vietnam, technological development is at an early stage. Vietnam is facing the risk of falling behind in the industrial revolution 4.0. Although the Internet has developed strongly in Vietnam in the past, the IoT application is still limited in some areas. In developed countries, IoT is being considered a key factor in socio-economic development (Rezaei & Nemati, 2017).

Currently there are not many specific studies on IoT acceptance (the adoption of the Internet of Things) in Vietnam. Therefore, it is necessary to have empirical evidence about the factors affecting the adoption of IoT technology by individual users in Vietnam. This study is conducted in the context of Vietnamese individual users, based on the theory of the Technology Acceptance Model, in order to identify and evaluate the affecting factors of the innovative willingness of IoT personal technology and the impact of innovative readiness of IoT personal technology to the intention of using devices with the IoT technology platform. Based on those results, this study provides specific policy implications for IoT development to promote socio-economic development.

Research Rationale and Hypotheses

Internet of Things

The Internet of Things (IoT) is a novel paradigm that is rapidly gaining ground in the scenario of modern wireless telecommunications. The basic idea of this concept is the pervasive presence around us of a variety of things or objects such as Radio-Frequency Identification (RFID) tags, sensors, actuators, mobile phones etc., which through unique addressing schemes,

are able to interact with each other and cooperate with their neighbours to reach common goals.(Atzori et al. (2010).

According to Atzori et al. (2010), when technologies and standards are highlighted and classified with reference to the IoT vision, they are characterised best: *"Things"-oriented visions; "Internet"-oriented visions; "Semantic"-oriented visions.*

On the other hand, according to the Global Standards Initiative on the Internet of Things, IoT is a global infrastructure for information society, supporting intensive services (computing) through objects (both real and virtual) to be connected with each other thanks to integrated information and communication technology.

Internet of Things by 2020: there will be about 50 billion objects connected to the Internet; + 4 billion people connected; + USD 4 trillion revenue; + More than 25 million applications; + Over 25 billion embedded and intelligent systems; + 50 trillion Gigabytes of data. Therefore, the Internet of Things is the key to future success. The impact of the IoT is very diverse, in the fields of infrastructure management, health care, construction and automation, transportation, education, etc.

Access and Use Smart Devices Based on IoT Technology Platform

Studies on access and use of smart devices based on IoT technology are based on the theory of reasonable action (Theory of Reasoned Action - TRA) and planned behaviour (Theory of Planned Behavior - TPB) (Fishbein Ajzen (1975), Ajzen (1991). Later Davis (1989) developed the Technology Acceptance Model (TAM). TAM has been tested and expanded by a large number of case studies Venkatesh and Davis (2000); J.-H. Wu and Wang (2005). The unified theory of acceptance and use of technology (UTAUT) was developed by (2003), explaining the user's adoption intention to an information system and the next user behaviour. In this study, the author will use the TAM and UTAUT model as the foundation, including the study of the 'perceived risk' variable and the intermediary 'personal technological innovation variable' of the smart device based on the IoT technology platform.

Adoption Intention of Smart Devices with IoT

The Theory of Planned Behaviour (TPB) (Ajzen, 1991)) argues that the adoption intention to display a person's behaviour is expected to lead to the use of one's own goods and services. In other words, the higher the intention to display the behaviour, the greater the ability to perform that behaviour. This study received the consensus of (Davis (1989); J.-H. Wu & Wang, 2005), Marinkovic and Kalinic (2017). Therefore, the study of adoption intention of smart devices with IoT plays an important role in studying the behaviour of using those devices.

In consumer behavioural research, a behaviour intention refers to a user's intention to buy (or consuming intention). The user's intention to buy is understood as the willingness of the customer to purchase the product (Tirtiroglu and Elbeck (2008). In the study of the use of electronic goods, the adoption intention to use technology services is used as a predictor for the future use of smart devices with IoT technology platforms. Davis (1989); Venkatesh et al., (2003). In the context of this study, the authors use the concept of buying intention to refer to the use of smart devices with the IoT technology platform.

Personal Innovativeness in Information Technology (PIIT)

Based on the popular theory of innovation of Rogers (2010), Agarwal and Prasad (1998) have shown that higher creative personal innovativeness will apply innovation sooner. Lu, Yao, and Yu (2005) in the study of affecting factors of the adoption of wireless Internet services based on mobile technology, have also pointed out the relationship between personal innovativeness in information technology can affect the technology adoption through perceived usefulness and perceived ease of use. In the field of technology, individuals with a higher PIIT level will develop a positive perception of innovation and have a more positive adoption intention to new information systems. Studies on information systems have shown that users with high PIIT will easily adapt to rapid changes of information systems. Sun (2012) in research has shown that innovative people are more likely to tolerate the risk associated with system changes and more likely to perform innovative system use. Lin and Nguyen (2011) in the study of factors affecting e-payment acceptance in Vietnam and Taiwan, also pointed out the willingness of personal innovativeness of information technology to influence the relationship between engine use (perceived usefulness, ease of use) to use electronic payments.

In the context of Vietnam, although the Internet is relatively developed but the IoT is in its early stages of development, the impact of personal innovativeness in information technology will affect the adoption intention to smart devices with the IoT technology platform. Therefore, it can be hypothesised:

H_{1a}: The willingness to innovate personal technology has a positive relationship to realising the usefulness of smart devices with IoT.
H_{1b}: The willingness to innovate personal technology has a positive relationship to realising the Perceived Ease Of Use with IoT.
H_{1c}: The willingness of individual technology innovation has a positive relationship to the adoption intention to smart devices with IoT.

Perceived Usefulness (PU) Of Devices with IoT

Perceived usefulness is a factor in the traditional TAM model and is widely studied in the application of new technologies. Perceived usefulness is defined as the level at which a person believes that using a particular system will improve the performance of their work Davis (1989). Research of Mital et al. (2018) has also shown that perceived usefulness will positively affect the adoption of smart devices with IoT. Therefore, in this study, the following hypothesis will be checked:

H_2: The higher the perceived usefulness is, the greater the intention to use smart devices with IoT.

Perceived Ease of Use of Devices with IoT

The ease of use of technology products and services is developed based on the TAM by studies Keat and Mohan (2004). The ease of use of smart devices based on the IoT technology platform, is understood in this study as the device users select as the technology device with IoT that does not need much effort to undergo many operations. The simpler the operation is, the more ready the user is to use. In the context of Vietnam, when users start using smart devices with IoT, the simpler the operation is, the more attractive it be to the users, especially for older or middle or low-income classes. Therefore, it can be hypothesised:

H_3: The Perceived ease of use (PEOU) (of IoT smart devices) has a positive relationship to the adoption intention to smart devices with IoT.

Social Influence (SI)

Social influence is the perception of social impacts or persons that influence customers who think they should or should not use the service (Ajzen (1991)). If a person thinks that important people encourage and support the conduct of behaviour, his intention to display the same behaviour will form. Previous studies have provided evidence of positive effects of social influences on the intention to display its behaviours (Chang (1998), Choo, Chung, and Thorndike Pysarchik (2004). In the context of Vietnam, when individuals use smart mobile devices with IoT, the use of the same smart devices by their relatives has a big impact on their use. Therefore, the hypothesis is:

H_4: Social influence has a positive relationship to the adoption intention to smart devices with IoT

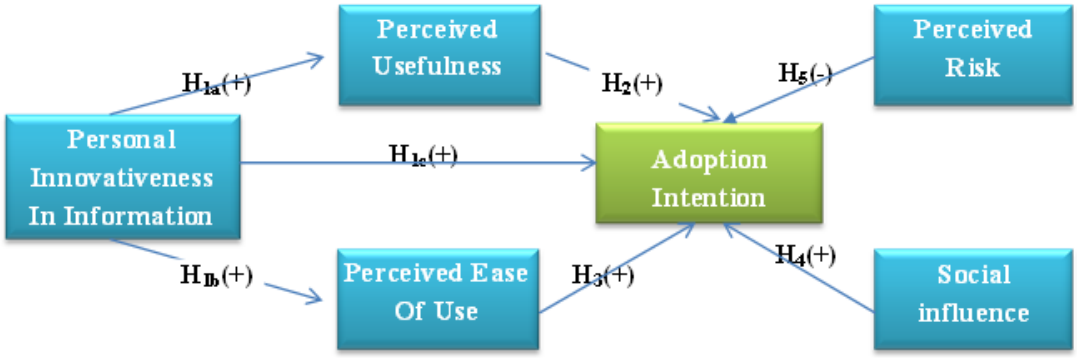
Perceived Risk (PR)

User's perceived risk is an important barrier for users considering whether to use smart devices with IoT technology platforms. The study of Featherman and Pavlou (2003) used and expanded the TAM with the inclusion of a 'perceived risk' variable into the model to explain users' acceptance of online transactions. This study analysed the impact of perceived risks, personal risks and risks in general. In the case of using smart devices based on IoT technology, it often involves security risks, financial risks, etc. and directly affects the decision to use such smart devices. Therefore, the hypothesis is:

H_5: The level of perceived risk to have an inverse relationship with the adoption intention to smart devices with IoT

The research model is proposed in Figure 1:

Figure 1. Proposed research model



Research methods

Measurement

In this study, the authors use the below concepts: personal innovativeness in information technology, perceived usefulness, perceived ease of use, perceived risk, social influence and user intention of smart mobile devices with the IoT technology platform. All of these scales are inherited from previous studies and adapted to the context of Vietnam. The scales use Likert 5 levels, where level 1 is ‘completely disagree’, 5 is ‘completely agree’.

The scale of personal innovativeness of technology is inherited from the scales of Lu et al. (2005), Lin and Nguyen (2011)) including 4 observed variables. The perceived usefulness scale consists of four observed variables inherited from Mital et al. (2018). The perceived ease of use scale is inherited from the study Mital et al. (2018) including 4 observed variables. The perceived risk scale inherited from Keat and Mohan (2004) includes 4 observed variables. The

social influence scale consists of three observed variables inherited from Lu (2014). The use intention scale of smart devices with IoT has four observed variables inherited from Mital et al. (2018).

The survey questionnaire was designed based on the conceptual observational variables in the model. In addition, the survey also has demographic questions such as gender, age, income, smart device ownership (smart mobile, smart TV).

Data Collection

The survey objects are Vietnamese who use smart devices based on the Internet of Things technology from January 2019 to March 2019 by direct survey. The questionnaire is designed with 23 questions corresponding to 23 observed variables of 5 variables of the research model. The questionnaire is using a Likert scale of 5 levels.

Sample results obtained 290 valid answer sheets included in the analysis. Some demographic information of the survey sample is as follows: The proportion of men is 63%, 37% of women; Age of under 20 year old is 29%; 46% from 21-30 years old; 25% from and above 31 years old; income below 500 USD accounts for 38%, 500-1000 USD is 43%, over 1000 USD is 19%; 100% of respondents own smart phones; 35% of respondents use smart TV.

Methodology

After having the data, SPSS 20 & AMOS 20 were used to test the hypothesised relationships in the research model as well as to evaluate the reliability of the measurement scale based on Cronbach Alpha reliability coefficients, EFA and CFA, SEM.

Results

Assessment of scale reliability: Performing the reliability test of scales with the reliability coefficient Cronbach Alpha obtained that all observed variables are correlated, with the total variable greater than 0.3 and Cronbach Alpha coefficient of all factors is greater than 0.6, so the scales of the components PU, PEOU, PR, PIIT, AIT, SI are accepted and included in the next factor analysis.

Exploratory Factor Analysis (EFA): The exploratory factor analysis (EFA) is used to reassess the degree of convergence of observed variables by components. Research on implementing KMO and Bartlett's tests in factor analysis shows that KMO coefficient = 0.835> 0.5 inspection value Bartlett's has significance level (Sig. = 0.000 <0.05) indicates that the EFA is appropriate. Indicators have 'Factor loading'> 0.5. At Eigenvalues values greater than 1 and with the factor extraction method used as Principal Axis Factoring (PAF) with Varimax

perpendicular rotation, factor analysis extracted 6 factors from 23 observed variables and with the extracted variance is 71% (greater than 50%) satisfactory.

Structural Equation Modelling (SEM): performing SEM analysis on AMOS 20 software we obtain the results as shown in Figure 2.

Figure 2. Results of analysis of Structural Equation Modelling

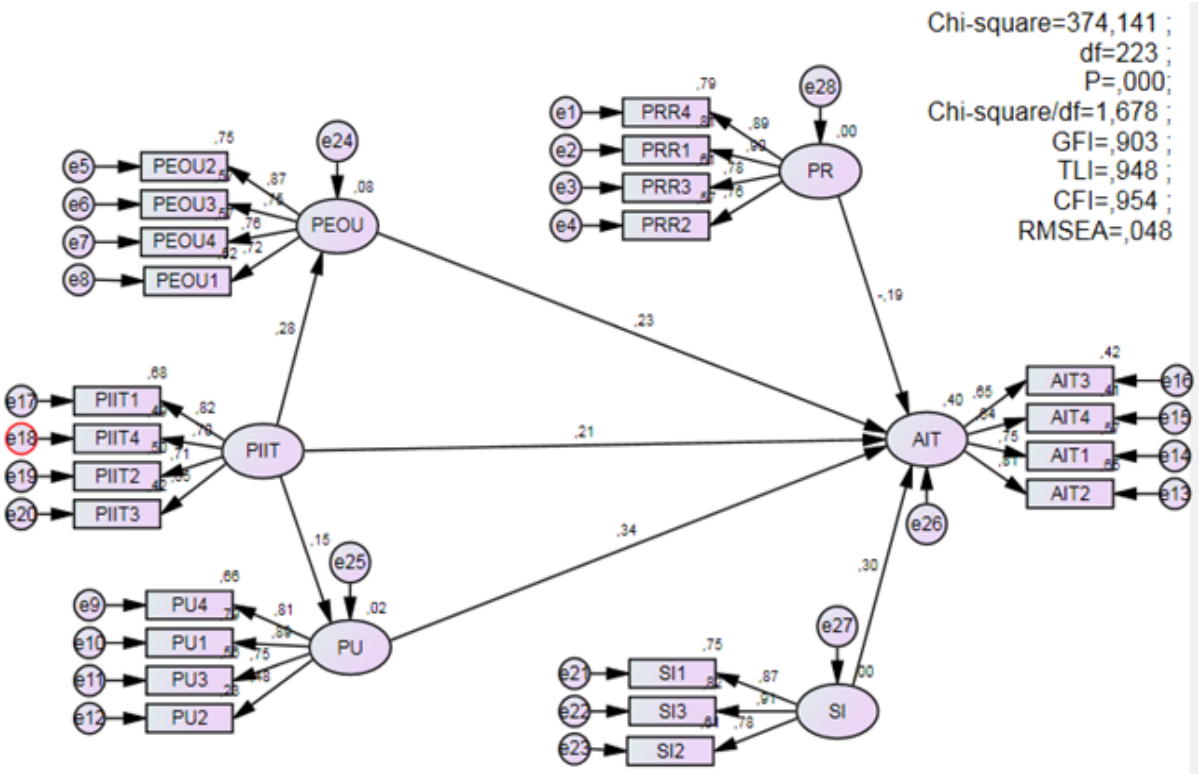


Table 1: The weights are not standardised SEM

			Estimate	S.E.	C.R.	P
PEOU	<---	PIIT	.284	.072	3.938	***
PU	<---	PIIT	.165	.076	2.171	.030
AIT	<---	PIIT	.181	.056	3.238	.001
AIT	<---	SI	.201	.041	4.870	***
AIT	<---	PR	-.127	.041	-3.103	.002
AIT	<---	PEOU	.193	.054	3.592	***
AIT	<---	PU	.268	.051	5.250	***

Source: SEM analysis results

The SEM results show that the weight observed variable is up to the permitted level (> = 0.5) and statistically significant, the p values are equal to 0.000. Thus, it is possible to conclude the

observed variables used to measure the component variables of the scale can achieve convergent values. SEM showed a model of 223 degrees of freedom, the value of Chi-square inspection = 374.141 with p-value = 0.000 <0.05; Chi-square / df = 1.678 satisfactory <3 and the indicators show the model is suitable for market data (CFI = 0.954; TLI = 0.948; GFI = 0.903> 0.9 and RMSEA = 0.0048 < 0.08). The components of the variables PU, PEOU, PR, PIIT, AIT, SI have no correlation between the errors of the observed variables, so they can achieve unidirectional properties. In addition, the study examined the discriminant value of concepts in the model. The results show that the concepts in the model achieve distinctive value and are consistent with published studies. The personal innovativeness in information technology has a positive impact on perceiving usefulness and perceiving ease of use. Personal innovativeness in information technology, perceived usefulness, perceived ease of use, perceived risk, social influence have a positive effect to user intention of smart mobile devices with the IoT technology platform.

Hypotheses testing: From the testing results from the non-standardised regression table (Table 1) shows the significance level of 5% (95% confidence level), the testing value of the relationship is statistically significant (P value < 0.05 = ***), it can be concluded that the hypotheses H_{1a}, H_{1b}, H_{1c}, H_2, H_3, H_4, H_5 are approved.

Discussion

This study uses the TAM model and model developments to measure the use of smart devices with IoT technology platforms. The use of IoT smart devices is a testament to the access to high-tech products and services for customers in the market. Therefore, promoting the use of these high-tech products will accelerate the process of approaching technology development trends in the era of industrial revolution 4.0. With the initial assumption, 4 variables '*personal innovativeness in information technology*', '*perceived usefulness*', '*perceived ease of use*', '*social influence*' have positive and variable effects, the '*perceived risk*' negatively affects the *adoption intention* to smart devices with IoT. This result is consistent with the results of the study of Choi B. M (2015), Patil (2016),Kim, Park, and Choi (2017), Mital et al. (2018), In which, the '*perceived usefulness*' factor has the greatest impact on user intention of smart devices with IoT with the same level of impact of 0.345 standard units. This is consistent with the situation in Vietnam, when all respondents said that smart technology products with high-level well-functioning features from famous brands with the highest quality will be the first factor that attracts customers. Therefore, the policy implication is that technology firms want to influence customers using smart products to create advanced features, lead market trends, create a network with various smart devices and meet the needs of users. There is a need for in-depth research on useful features for each group of customers who use IoT smart devices.

An interesting thing is that the "*perceived risk*" has the smallest effect (according to the absolute value) to the adoption intention to smart devices with IoT in 5 factors, the level of impact reaches -0.191 standard unit. That means the level of perceived risk impacts negatively on the user intention to use smart IoT devices. This is consistent with the research results of Jayashankar, Nilakanta, Johnston, Gill, and Burres (2018), Yildirim and Ali-Eldin (2018). This corresponds to the viewpoint that smart devices with IoT need to give users the peace of mind when using. Therefore, the policy implication is that product suppliers want to attract customers using smart devices that need to focus on safety, but do not need to focus much on other factors.

The second most influential to user intention is the '*social influence*' variable with an impact of 0.301 standard units. This result is consistent with the results of the study of Lu (2014). This is consistent with the context of Vietnam, with the rate of Internet development, Internet users, the number of users and the time to use the world's leading social networks. On the other hand, the segment of users of smart devices is mainly young. This result also indicates that the subjects having a great impact on them in their adoption intention to smart technology products such as smart devices with IoT are family, friends, relatives, partners, etc. The policy implications are to influence the intention to use the Smart devices with IoT they need to create a level of trust through individuals with a high degree of influence (brand ambassadors) to influence users.

The variable "*perceived ease of use*" is the third most important variable to user intention of using smart devices with IoT, with an impact of 0.234 standard units. This result is consistent with the research results of Jayashankar et al. (2018), Yildirim and Ali-Eldin (2018). This suggests that smart devices with ease of use of the IoT in operation will encourage customers to use more. The beginning of the research and development of smart devices with IoT to make sense of ease of use will be an important priority in the process of developing devices.

The variable '*personal innovativeness in information technology*' affects '*perceived usefulness*' and '*perceived ease of use*' with an impact of 0.152 and 0.278, respectively. This shows that '*personal innovativeness in technology*' to influence the '*perceived ease of use*' is stronger than '*perceiving usefulness*'. In addition, '*personal innovativeness in technology*' also directly affects the '*adoption intention*' of IoT smart devices. This result is consistent with the results of the study of Lin and Nguyen (2011) which indicates that the '*personal innovativeness in technology*' is a moderator of the relationship between the variable '*perceived ease of use*' and the variable '*perceived usefulness*' to the '*adoption intention*' variable. The personal innovativeness in information technology will motivate individuals to have the need to use, explore and experience smart devices. Therefore, the policy implications for organisations developing smart devices with IoT need to pay attention to the level of innovation of users.

The study approached the use of smart devices with personal IoT on the intended use perspective. In the future, research can develop in the direction of: (1) Research on different user segments according to age, income, regions, etc. (2) The assessment of adoption intention has been measured but there are still many other factors that need research with other additions.

Conclusion

Research results are an empirical evidence showing the strong impact of many factors on accessing IoT technology through smart devices such as smart phones or smart TVs. For the adoption intention to use smart devices with IoT, there are 5 main factors directly affecting the user intention. The factor of '*perceived usefulness*' has the strongest impact on the adoption intention to use smart devices with IoT. Factors of '*social influence*' and '*perceived ease of use*' are the second and third most influential factors to user intention. When developing smart devices towards IoT technology, it requires developers and suppliers to pay attention to the psychological factors of customers towards products with high usefulness, ease of use and many users. Research results are the basis for firms to develop and supply smart high-tech products on the basis of IoT technology with appropriate development policies to orient the design and development of the best customer-oriented products.

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