Smart Home Technology Adoption: Reality or Fantasy?

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***Abstract*—Smart home refers to a convenient home setup where appliances and devices can be automatically controlled remotely from anywhere with an internet connection using a mobile or networked device. Malaysia is a promising area for the development of Internet-of-Things (IoT) and digitalization strategies especially smart home products. Nevertheless, the penetration level of this product is quite low. Hence, this study analyzed the determinants of user's intention to adopt smart home technology. Data from 334 respondents, which was collected through an online survey, were examined quantitatively. Results indicate that automation and attitude were positively linked to the user's intention to adopt the smart home, while there is no linked between security and smart home adoption intention. This study provides an insight associated with the diffusion of smart home technology in Malaysia. Furthermore, the findings can be used by the developer of smart home in crafting an impactful strategy to increase the user adoption of this product.**

Keywords—Smart home technology, user's intention

I. INTRODUCTION

In recent years, the Internet of Things (IoT) has taken on significance step in providing creative and smart technology and services to people as all the objects around us nowadays are connected to the Internet and can interact with each other. The areas covered by IoT products and services include healthcare, hospitality, transportation, infrastructure, educational and social services. Smart devices, often interconnected with cloud computing, provide convenient access and make customer engagement in this technology more open and global and this include smart home technology.

As stated by [11], smart homes being an IoT, offers access to new services that suit the needs, demands, and desires of a vast number of consumers and households. With a single control unit, remotely or manually, smart homes can control and handle their energy effectively while improving convenience and comfort in a range of household businesses, gadgets, and appliances inside a home.

Smart home technology (SHT) has begun to attract users' interest, particularly in the developed and European world, with the emergency of the Internet and global policy decisions that mandate or promote energy efficiency and climate change. The SHT enables home to be equipped with a range of appliances and household equipment, sensors, and other devices that can be remotely operated, accessed, or monitored and thus provide the services necessary to meet their users' needs.

Although the benefits of SHT are known, the level of adoption among Malaysians is very small compared with other countries in Asia such as China, Philippines, Indonesia, and Singapore. There is a growing interest on this product but it has not widely accepted yet due to many reasons such as high device prices, limited consumer demand and long device replacement cycles [7]. Previous studies mainly centred on adopting SHT by senior citizens, patients and handicapped, studies on normal household, qualified and working people are scarce. Besides, previous studies have not been consistent, especially in domain of Information Technology, suggesting more needs to be done to understand additional factors that can be used to forecast acceptance effectively. Hence, this research seeks to identify the technical and behavioral aspect namely automation, security, and attitude that influence user's adoption of smart home technology in Malaysia.

II. LITERATURE REVIEW & HYPOTHESIS DEVELOPMENT

A. Smart Home Technology Adoption

IoT-based smart homes offer access to new types of services that meet their requirements, expectations, and desires to many consumers and households. With the remote or manual operation of all devices and systems within a household from a single unit, smart homes can allow consumers to track and control their energy consumption while at the same time increasing comfort and convenience for several household activities more efficiently. A smart home's vital technical characteristics include a specified communication network for integrated devices, a level of artificial intelligence for the management and monitoring of smart home automation, built-in sensors for data collection, and smart characteristics, such as smart lighting or heating systems [10].

In most research, theory on technology of acceptance model (TAM) or the unified theory of acceptance and use of technology (UTAUT) have been extended to examine the adoption of SHT on a particular group, such as the elderly, and patients as a focussed. These studies have shown that the acceptance of a Smart home for the elderly is critical for self-efficacy. Patients' quality of life preferences has played an important part in smart home acceptance. It is well mentioned in these studies that the smart home has helped the elderly and handicapped persons; in particular with infectious conditions, to make their lives more independent and increase their well-being. It was also found that in studies that the smart home technology has been perceived as very helpful in telecare services.

Recently, research on the reception of SHT among household has increasingly become popular. Utilizing theory of acceptance model (TAM), [5] discover that perceived compatibility, connectedness, system reliability and enjoyment from SHT has influenced users' intention to embrace the services. Other study has found accessibility and protection are the main factors influencing smart home environments' acceptance. Besides that, [7] has found in their

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study that controllability, interconnectedness, and reliability had a significant impact on the acceptance of a smart home product.

B. Automation

According to [4], automation means that a machine (often a computer) performs a task that was previously performed by a human. The entire idea of smart homes is to build an intelligent and automated environment that will improve its users' quality of life. For the elderly, since most elderly people live alone or have a small number of family members (most of whom work outside during the day), automation is an important aspect for them, as it can reduce their day-to-day activities and provide more convenience for those who have physical disabilities that limit their movements. Currently, with the advancement of smart phone, communication networks and technology, it is expected that more automation features of smart home can be added and this will lead to leveraging of smart home adoption among general users. Hence, this study postulates below hypothesis:

H1: Automation has significant influence on smart home adoption.

C. Security

There are few concerns among potential users of smart home and this include the danger of personal information leaks throughout the collection, storage, use, and disclosure of information, as well as unsolicited marketing. As a result, security issues were thought to have a detrimental impact on the uptake of smart home services. [4] stated, smart home seeks to create an automated environment for users by collecting data about their lifestyles, daily activities and preferences. As a result, user data security is paramount. If users believe that their personal data is at risk, they are less likely to adopt a smart home, regardless of the benefits. Therefore, the following testable hypothesis is developed:

H2: Security has significant influence on smart home adoption.

D. Attitude

The residents' assessment of the efficiency of smart home technology is part of the implementation of smart home technology [13]. For example, a household assessment of the desire for electricity saving and the availability of knowledge has as significant effect on residential energy savings behavior. Studies have shown that views on the utility and environmental consciousness influence people's attitudes towards green buildings. Besides, a market study organized in six different countries on smart domestic appliances found that consumers' intention to implement the device would depend on their financial gain interpretation. Furthermore, predicted monetary benefits and shorter payback periods will boost smart home equipment assessment. Thus, based on previous research, the attitude of residents towards the benefits gains from implementing smart home is expected to affect intention to adopt positively. Therefore, this study posits the following hypothesis:

H3: Attitude has significant influence on smart home adoption.

III. METHODOLOGY

In this study, an online survey was conducted among potential users of smart home in Malaysia in a period from 1st April until 16th May 2021. The 19-item web-based questionnaire was distributed to the social media users through social media influencers in Instagram using the link shared in their personal and business Instagram. Utilizing the non-probability sampling techniques with convenience sampling method, a total of 400 questionnaires has been distributed to the respondents, and at the end of the survey period, a final 334 data sets had been gathered and used for data analysis.

To gauge respondents' response on the adoption of smart homes in Malaysia, a total of four variables which are automation, security, attitude, and smart house adoption were employed. The measurement items for each variable were adapted from previous studies with a total of nineteen items for all variables. Five-point Likert scales, with a range of 1= strongly disagree to 5=strongly agree, were used to evaluate the questionnaire. A sample of measurements and the source of it can be found in appendix.

Prior to the final data collection, a pilot test study was conducted on April 2021 with a total of 26 responses and it was found that all the variables were reliable and consistent. Data from this survey were analyzed using SPSS statistical software. With a final 334 data from respondents, the correlation and multiple linear regression analysis was used to test the model and hypothesis of this study and its result is discussed in the following section.

IV. RESULT AND DISCUSSION

Table 1 below shows the demographic profiles of the respondents.

TABLE I. RESPONDENTS' PROFILE

Characteristics	Frequency	%
Age		
18-24	53	15.87
25-30	70	20.96
31-35	60	17.96
36-40	87	26.05
41-45	55	16.47
46-50	9	2.69
Gender		
Male	312	93.41
Female	22	6.59
Race		
Malay	245	73.35
Chinese	53	15.87
Indian	31	9.00
Others	5	1.00
Education		
SPM/STPM/O-Level/A-Level	6	1.80
Certificate/Diploma	27	8.08
Professional	7	2.10
Bachelor	228	68.26
Masters	55	16.47
PhD	11	3.29
Marital Status		
Marriage	184	55.05
Single	145	43.41
Divorced	5	1.50

Characteristics	Frequency	%
Occupation		
Professional (Engineer, Lawyer, etc.)	75	22.46
Executive	65	19.46
Manager/Senior Manager	59	17.66
Self Employed	62	18.56
Government Officer	27	8.08
Housewife	4	1.20
Non-Executive	20	5.99
Student	22	6.59
Gross Monthly Income		
Below RM1000	21	6.29
RM1001-RM2000	37	11.08
RM2001-RM3000	41	12.28
RM3001-RM5000	76	22.75
Above RM5000	159	47.60

Respondents (n = 334).

Majority of the respondents are male (93.41%) compared to female. The distribution of the samples for this study if according the gender was not really balance for analysis. The largest proportion of the sample (26.05%) falls in the age group of 36 and 45 years old, followed by age group of 25 and 30 years old (20.96%). A total of 245 (73.35%) of the respondents are Malays, 53 (15.87%) are Chinese and 31 (9%) are Indian. Most of the respondents (68.26%) possess a bachelor degree and 184 (55.05%) of them are married. In the aspect of occupation and income level, most of the respondents are in professional and executive level profession, and earning more than RM5000 per month.

As presented in Table 2 below, the findings of reliability test for this study shows that, the Cronbach alpha coefficient of all the three independent variables and dependent variable ranged from 0.877 to 0.942, which are all above 0.70. Hence, the measurements used for this study demonstrates the internal consistency of all variables. This table also shows that the mean for smart home adoption is 4.193 with standard deviation of 0.833. The highest mean among the three independent variables is attitude with value of 4.334 and standard deviation 0.715.

TABLE II. THE RELIABILITY TEST AND DESCRIPTIVE STATISTICS OF THE VARIABLES

Variable	Number of Items	Cronbach's Alpha	Mean	Std. Dev
Smart Home Adoption	5	0.911	4.193	0.833
Automation	6	0.942	4.018	0.944
Security	5	0.927	4.250	0.756
Attitude	3	0.877	4.334	0.715

Table 3 shows that the Pearson's pairwise correlations between all the independent variables and the smart home adoption (dependent variable) are statistically significant at the 1% significance level. Since the coefficient value lies between ± 0.50 and ± 1 for all variables, it can be assumed that all the three independent variables for this study have a strong relationship with the independent variable, with automation has the strongest relationship with coefficient value 0.782. Hence, it is shows that automation plays an important role in influencing user's intention to adopt smart home.

TABLE III. PEARSON CORRELATION ANALYSIS

	Smart Home Adoption	Automation	Security	Attitude
Smart Home Adoption	1			
Automation	0.782**	1		
Security	0.671**	0.722**	1	
Attitude	0.703**	0.710**	0.836**	1

Note: **. Correlation is significant at the 0.01 level (2-tailed).

Table 4 below presents the result of multiple regression model of this study. The R-squared value of 0.656 implies that 65.6% of the variance in smart home adoption intention can be explained by automation, security and attitude factors. The ANOVA result reported the F-value of 209.362 indicates that the model is fit and statistically significant at 1% significance level.

TABLE IV. THE RESULTS OF THE ANOVA AND REGRESSION MODEL

ANOVA Result	Sum of Squares	*df*	Mean Square	*F-value*
Regression	112.249	3	37.416	209.362***
Residual	58.976	330	0.179	
Total	171.226	333		
R-Square	0.656			
Regression Model	**Coefficients**	**Beta**	**Std. Error**	***t*-value**
(Constant)	0.757***	-	0.161	4.686
Automation	0.481***	0.559	0.042	11.494
Security	0.042	0.039	0.067	0.628
Attitude	0.306***	0.274	0.069	4.456

Note: Dependent variable: Smart Home Adoption; *** denotes significant at 1% significance level.

This result also demonstrates that both automation and attitude are statistically significant and positively related to the level of smart home adoption at 1% significance level. However, security is found to be statistically insignificant in improving user's intention to adopt smart home. Hence, hypothesis H1 and H3 are accepted in this study. This result implies that the better automation features provided by the smart home developer, the higher chances that the user will adopt this technology. Moreover, user's positive feeling about smart home will influence them to consider adopting this technology. Consistent with the result of the pairwise correlation in Table 3, with the beta value of 0.559 (B= 0.559), automation is an essential factor influencing smart home adoption in this study.

V. CONCLUSION

This study empirically investigates important factors of user's intention to adopt smart home technology in Malaysia. The key findings of this research show user's attitude toward smart home and their expectations on the automation features will influence their decision to leverage the use of smart home.

According to [2], using the Internet to access one's home is easy, practical, affordable, and adaptive, and there is no additional technology to learn. Laptops, smartphones, PCs, and tablets are readily available on the market, and these technologies already engrained in how individuals live their daily lives. As a result, bringing home automation to these

already-popular user gadgets seems like the obvious next step.

Furthermore, academics have carried out a lot of research to find ways to improve consumer attitudes regarding using smart home services. It is learned that user's perception on the benefits obtained by adopting smart home will definitely increase their intention to use it. Hence, it is vital to widely spread the positive aspect of using smart home in order to encourage a good attitude towards it. Example of benefits that can be emphasized such as improve work life balance, emergency assistance, security purpose, energy saving and many more.

The purpose of this study is to investigate the adoption of IoT-based smart home services, which is where its significance resides. The basic objective of smart home service is to optimize comfort, improve quality of life and increase the convenience environment of homes. While it may be worth displaying advanced technology or making the service easy to use, it is essential to develop product that consumers require. This study highlighted that in order to create smart home entirely, clients have to sense higher value, meaning that perceived benefits have to be enhanced since the beginning. The smart home developer should consider the automation features preferred by the clients especially those features that can be linked to their mobile devices such as smart phones and simplify their hectic life.

It is recommended that for future studies to look at other possible determinants of this smart home adoption such as the characteristics of the individual household. Furthermore, the qualitative study using interviews with open-ended questions may investigate further reason behind the rejecting hypothesis such as security. Moreover, study with a more equal distribution of samples by gender is needed in the future.

In conclusion, whether the idea of smart home will become reality among Malaysians in the future or remain as just a fantasy will depend on many factors and among of it is the automation and user's attitude.

REFERENCES

[1] A. Bhattacherjee, "Understanding information systems continuance: An expectation confirmation model,"' MIS Quart., vol. 25, no. 3, pp. 351_370, Sep. 2001.

[2] A. C. Jose and R.Malekian, "Smart home automation security: a literature review." SmartCR, 5(4), 269-285. 2015

[3] C. Rödel, S. Stadler, A. Meschtscherjakov, and M. Tscheligi, "Towards autonomous cars: The effect of autonomy levels on acceptance and user experience," in Proc. 6th Int. Conf. Automot. User Interfaces Interact.Veh. Appl., New York, NY, USA, pp. 1-8, 2014.

[4] D. Pal, S. Funilkul, V. Vanijja and B. Papasratorn "Analyzing the elderly users' adoption of smart-home services." IEEE Access, 6, 51238-51252. 2018

[5] E. Park, S. Kim, Y. Kim and S. J. Kwon, "Smart home services as the next mainstream of the ICT industry: determinants of the adoption of smart home services." Universal Access in the Information Society, 17(1), 175-190. 2018

[6] H. H. Lee and E. Chang, "Consumer attitudes toward online mass customization: An application of extended technology acceptance model." Journal of Computer-Mediated Communication, 16(2), 171-200. 2011

[7] H. Yang, W. Lee, and H. Lee, "IoT smart home adoption: the importance of proper level automation." Journal of Sensors, 2018.

[8] J. Choi, H. J. Lee, F. Sajjad, and H. Lee, "`The in_uence of national culture on the attitude towards mobile recommender systems," Technol. Forecasting Social Change, vol. 86, pp. 65_79, Jul. 2014.

[9] J.-S. Chou and I. G. A. N.Yutami, "Smart meter adoption and deployment strategy for residential buildings in Indonesia," Appl. Energy, vol. 128, pp. 336_349, Sep. 2014.

[10] J. Dvorak, O. Krejcar, and L. Cheng "Application of universal remote control of nonsmart home appliances for smart home concepts." International Journal Of Digital Enterprise Technology, 1(3), 276. 2019

[11] S. Chen, Y.Liu, and Fang, "Home Networking Technology Applied in Smart Home System. Applied Mechanics And Materials, 468, 141-144. 2013

[12] T. Luor, H.-P. Lu, H. Yu, and Y. Lu, "Exploring the critical quality attributes and models of smart homes," Maturitas, vol. 82, no. 4, pp. 377-386, 2015.

[13] Z. Kalinic and V. Marinkovic "Determinants of users' intention to adopt m-commerce: an empirical analysis." Information Systems and e-Business Management, 14(2), 367-387. 2016

APPENDIX

Construct and Measurement Items	Sources
Automation AM1: I find it convenient to use the auto-adjusted controls provided by my smart home AM2: I can control the electronic appliances in a smart home by myself AM3: Smart homes can simplify my daily life as it helps in reducing human intervention AM4: I find it beneficial to use smart home services when I am away from home AM5: It is advantageous to interact with home environment from anywhere in the world AM6: Smart home makes my life easy	[12], [3], & [8]
Security SP1: I fear to use smart home service due to loss of my personal data and privacy SP2: I find it risky to disclose my personal information the smart home provider SP3: Smart homes provide a strong security SP4: I feel safe about my personal data when I use smart home SP5: If I use the smart home products and services, private information could be misused, inappropriately shared or sold	[9]
Attitude A1: Using a smart home is a good idea A2: I like to use smart device in my home A3: I have a positive feeling towards smart home service	[6]
Smart home adoption SHA1: I will use smart homes if media/government encourage to use them SHA2: I will use smart homes if my friends and family members use them SHA3: I will use smart homes if people whose opinion I value recommend me to do so SHA4: Smart home is beneficial and improves my overall life quality SHA5: I find it useful to use smart home services anytime anywhere	[1]