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Adoption and Acceptance of Smart Home Technology Products for Millennials in Indonesia

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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 other networked device. Indonesia is a promising area for the development of Internet-of-Things (IoT) and digitalization strategies especially smart home products. This study analyzed the core motivations for the implementation of smart home products and discussed the approaches and processes through which motives were integrated into the original technology acceptance model (TAM) and the acceptance of products. The theory of technology acceptance model is implemented in this study to analyze how technology adoption of a smart home product with millennials as the main object of research. Data from 305 respondents, which was collected through an online survey, were examined quantitatively. The results indicated that the perceived system reliability, compatibility, connectedness, and enjoyment of smart home products were positively linked to the user's intention to use the products, although there was a negative correlation between the perceived cost and the intention to use. This study provides an insight associated with the role of core motivation factors in the technology acceptance model which suggests a relevant recommendation for further studies. Furthermore, the findings can be used by companies that want to develop smart home products as consideration for developing an impactful strategy to increase the user adoption level.*

Keywords: smart home technology, technology acceptance model, smart home adoption, internet of things

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1. Introduction

Millennial, preceded by baby boomers, and Generation X, the millennial generation, born respectively between 1980 and early 2000 (Raines, 2002), forms a quarter of the world 's population. That is 1.7 billion people worldwide, and 87 million in Indonesia alone, the biggest generation in history. It is conceivable that millennials are the first generation to be brought up on technology. Technology has always been part of their lives, so it only makes logical sense that it continues to affect how they work, connect with others, travel, shop, do business, and live and work in and around their homes (Arnold A, 2018). It seems sensible that they would search for homes that are-or at least re-configure homes that they purchase to be smart with the Internet of Things (IoT) apps that enable them to save more energy and have a more convenient life.

Indonesia has been the main market in South East Asia, with more than 260 million residents and the biggest archipelago in the country. Indonesia is a promising area for the development of Internet-of-Things (IoT) and digitalization strategies. McKinsey (2012) projected that Indonesia would be the 7th largest economy in the world following business productivity improvements and urbanization by 2030. The Indonesian government understood this and called for digitalization mainly through two main initiatives: "Make Indonesia 4.0" and "Towards 100 Smart Cities." According to IDC data, 20 percent of local and regional governments in Indonesia should introduce IoT in many infrastructures, such as highways, street lights, traffic signals to assets rather than liabilities. The IoT industry in Indonesia is forecast to hit US$ 31 billion (IDR 444 trillion) by 2022 and to rise to US$ 142 billion (IDR 1,620 trillion) by 2025, suggesting enormous economic opportunities that come with IoT developments. The number of PLN customers is currently 71.05 million in Indonesia. This number continues to grow every year.

Figure 1: Smart Home Market Size in Indonesia

Despite the rising, smart home technology has not been widely accepted despite the long history and growing interest. While smart home technology is capable of providing significant benefits to users, the implementation of these benefits on a large scale was unable to be seen as a result of a low acceptance rate (Marikyan et al., 2019). There are many reasons (e.g., high device prices, limited consumer demand, and long device replacement cycles), preventing smart home diffusion. The largest barrier is due to a lack of technology to establish the infrastructure of a smart home.

The movement of smart home technology in Indonesia is still slow when compared to other countries. There are still many people who refuse to use smart home products because they are worried about electricity problems in Indonesia, which often results in interruptions or blackouts. Besides that, Indonesia's infrastructure is not good enough to go beyond outside countries in terms of providing internet of things, because the use of the smart home concept is also fundamental to the use of internet connections (Riadi, 2018).

The primary reason for the reduced adoption rate in Indonesia is the lack of understanding of how users accept smart homes. Relatively few empirical studies have been conducted to explain user acceptance of smart homes in Indonesia. Understanding how and why users accept smart homes is an important issue for their success and will drive the rate of user adoption. Besides that, understanding user acceptance helps companies market and promote smart homes more effectively. Another advantage is providing reliable guidance and significant insight into smart home providers to develop more interesting hardware and software.

2. Literature Review

2.1 Smart Home Adoption

Smart homes, which are part of IoT, are helping a large number of users and households to have access to new forms of services that meet their needs, requirements and preferences. By allowing all devices and appliances within a household to be operated remotely or manually from a single control unit, smart homes will enable consumers to monitor and manage their energy usage more effectively, while at the same time increasing their comfort and convenience for a variety of household activities (Salimon et. al, 2018). The key technological features of a smart home include a well-established connectivity network for integrated appliances, a degree of artificial intelligence that handles and controls the smart home automation framework, embedded sensors that collect information, and smart attributes (e.g. smart lighting or heating systems) that can automatically respond to information gathered by sensors (Balta-Ozkan et al., 2013a).

2.2 Technology Acceptance Model

Technology Acceptance Model (TAM) has been the most commonly recognized and studied approach to the adoption of information technologies for users. The pattern derives its source from TRA, which was originally suggested in 1975 by Fishbein and Ajzen. The TAM model forecasts and demonstrates to consumers how to embrace or implement information technology. This hypothesis emphasizes the reasons why people either accept information technology or do not accept it. Davis (1993), defined in TAM, is a function of attitude and perceived utility (PU). Attitude is "the degree of the evaluative effect associated with using the goal program by a person."

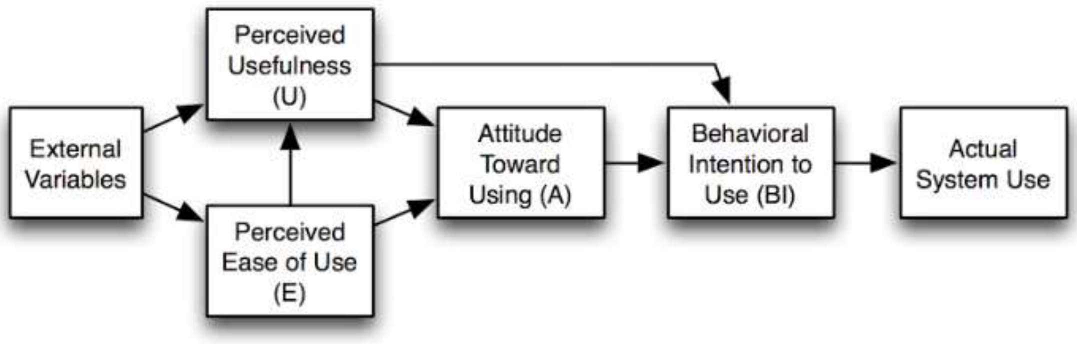

Figure 2: Original Model of TAM (Davis 1989)

2.3 Attitude Toward Using Smart Home Technology

Outlined as "individual's positive or negative feelings regarding performing arts the target behaviour" (Fishbein and Ajzen, 1975, p. 216). completely different theoretical models have conjointly confirmed that attitude may be a key antecedent of the intention to interact in an exceedingly explicit behaviour (Yang et al., 2017). Park and Chen (2007) conducted a study on the acceptance and adoption of smart homes and found that attitude may be a vital predictor of intention. Therefore, the following hypothesis is proposed:

H1: Attitude toward smart home products has a positive effect on the intention to use the products.

2.4 Perceived Usefulness

Perceived usefulness is the subjective opportunity that the use of the generation would enhance the way a user could finish a given task. Previous studies have demonstrated that there is a positive correlation between perceived usefulness and behavioural intention to use innovative technology (Davis, 1989; Zaremohzzabih, 2015; Sepasgozar et al., 2018; Scherera et al., 2019). Vivensius et al. (2019) also indicates that perceived usefulness on consumer’s attitude is positively correlated. Therefore, the following hypothesis is proposed:

H2: Perceived usefulness of smart home products has a positive effect on the intention to use the products.

H3: Perceived usefulness of smart home products has a positive effect on the attitude toward the products.

2.5 Perceived Ease of Use

According to Mathieson (1991), the perceived ease of use is the consumer’s perception that smart home technology can involve a minimum of effort to do something. Gao and Bai (2014) defined the effects of perceived ease of use on the decision to use IoT applications. Moreover, Technology Acceptance Model suggests that perceived ease of use often has a positive effect on perceived usefulness (Hsu & Lu, 2004; Venkatesh et al., 2012; Gao & Bai, 2014; Al-Momani, Mahmoud, & Ahmad, 2016). Therefore, the following hypothesis is proposed:

H4: Perceived ease of use of smart home products has a positive effect on the attitude toward the products.

H5: Perceived ease of use of smart home products has a positive effect on the perceived usefulness of the products.

2.6 Perceived Enjoyment

Perceived enjoyment viewed as a possible determinant of TAM (Davis et al., 1992). Perceived enjoyment is a condition where activities to use a particular system are considered fun in itself, apart from any performance consequences resulting from the system's use. There is evidence of the relationship between perceived ease of use and the perceived enjoyment of using advanced service technologies (Park and del Pobi, 2013). Yi and Hwang (2003) have also found that the perceived enjoyment of the technologies greatly influences the perceived ease of using information-providing systems. Therefore, the following hypothesis is proposed:

H6: The perceived enjoyment of smart home products has a positive effect on the perceived ease of use of the products.

2.7 Perceived Connectedness

Users prefer to communicate with the component services at their convenience, rather than at their physical discomfort (Park et al., 2014). Cho et al. (2019) indicate that perceived connectedness has an indirect effect on attitudes towards social commerce through utilitarian (i.e., ease of use and usefulness) and hedonic perceptions. Thus, the following hypothesis was proposed.

H7: Perceived connectedness of smart home products has a positive effect on the perceived ease of use of the products.

2.8 Perceived Control

Perceived control can be described as the perception that one thinks he or she is in charge of a person's inner state, actions, place or people, events or feelings, or activities. The previous research found that perceived usefulness of smart home technology is significantly influenced by the perceived control and competency of the users on the systems (Park et al., 2014). Thus, the following hypothesis was proposed.

H8: The perceived control of smart home products has a positive effect on the perceived usefulness of the products.

2.9 Perceived System Reliability

Perceived reliability is an important element in the adoption of technology and relates to 'the right technological working of technology' (Gefen, 2000). Research by Moon et al. (2015) proves that perceived reliability influences positively on usage intention. Thus, the following hypothesis was proposed.

H9: The perceived system reliability of smart home products has a positive effect on the perceived usefulness of the products.

2.10 Perceived Security

Security is defined as a "danger that causes situations, conditions or incidents with the potential to cause economic distress to a computer or network infrastructure in the form of damage, leakage, manipulation of data, denial of service and theft, waste and misuse" (Kalakota & Whinston, 1997). Perceived security described as the level of protection of "customers" from these "threats" (Yousafzai, Pallister, & Foxall, 2003). this study proposes the following hypothesis:

H10: Perceived security of smart home products has a positive effect on the perceived usefulness of the products.

2.11 Compatibility

Compatibility refers to the compatibility of technology development with user confidence values with ideas and needs before introducing innovations (Lin, 2011). The research by Wu and Wang (2005) showed that perceived compatibility had both a direct and an indirect impact on the intention to use technology by perceived usefulness, and the research by El-Gohary (2012) showed that compatibility had an indirect effect on the intention to use technology. Therefore, based on evidence from previous studies on perceived compatibility, this study proposes the following hypothesis:

H11: The perceived compatibility of smart home products has a positive effect on the perceived usefulness of the products.

2.12 Perceived Cost

Perceived costs have been widely used in previous research to empirically examine the effect of this measure on users 'intentions to use technology, and it has been repeatedly reported that high perceived costs have a clear but detrimental influence on users' behavioral intentions to use technology (Shin, 2010; Kim and Shin, 2015; Wu and Wang, 2005). The expectations of consumers are primarily dictated by their understanding of the cost of technology.

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H12: The perceived cost of smart home products has a negative effect on the intention to use the products.

2.13 Research Framework

Numerous factors can significantly influence people's decisions to adapt to smart home technology. Park, Kim, Kim, and Kwon (2017) propose that security, cost, perceived control, enjoyment, system reliability, connectedness, and compatibility are the major factors for accepting smart home technologies. The framework of the Davis Technology Acceptance Model (TAM) is being developed here. The author adopted Park et al. (2017) research as an extension of the original TAM, including the suggested motivations and hypotheses.

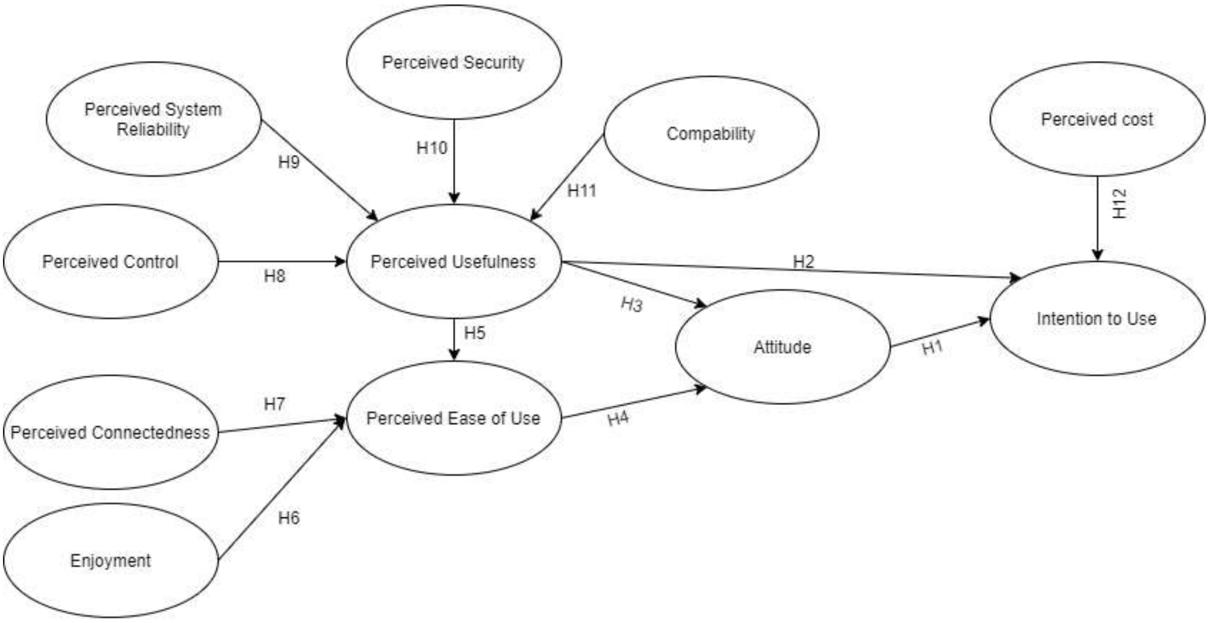

Figure 3: Research Framework

3. Methodology

A quantitative approach will be used to collect the primary data through the distribution of the online questionnaire. The number of Millennial in Bandung and Jabodetabek, Indonesia will be targeted as the population in this study since they are considered as potential users of smart home product. The sample size for this research is 305 peoples. Furthermore, judgment sampling will be used in this study which comprises the respondent who is in the most convenient place to provide the information needed based on the researcher's judgment (Malhotra, 2010). The respondents who can participate in this questionnaire must be eligible in two ways which are lived in Bandung or Jabodetabek and those aged 18-38 years old.

Finally, PLS-SEM analysis will be performed in SmartPLS to analyse the hypotheses produced from the relation between variables in the research model. Since this study is built upon a relatively not yet well defined theoretical foundation and intended for exploring and determining antecedent factors that influence millennial's intention to use smart home products in Indonesia, thus, PLS-SEM is appropriate used in this study. PLS-SEM has higher statistical strength for an exploratory analysis in which the theory is not yet well defined and has the purpose of revealing the effect of constructs (Sarstedt, Ringle, and Hair, 2017).

4. Results and Discussion

4.1 Validity Test

a. Convergent Validity

Convergent validity can be assessed through the Average Variance Extracted (AVE) in each variable. According to (Wong, 2013), the AVE values are accepted if the values are greater than 0.5. The AVE result can be seen in Table 5.4 below.

Table 1: Convergent Validity Result

Variable	Average Variance Extracted (AVE)	Validity
Perceived Security	0.876	Valid
Compatibility	0.867	Valid
Intention To Use	0.843	Valid
Attitude	0.817	Valid
Perceived Ease of Use	0.805	Valid
Perceived Usefulness	0.801	Valid
Perceived Cost	0.753	Valid
Enjoyment	0.745	Valid
Perceived System Reliability	0.745	Valid
Perceived Connectedness	0.740	Valid
Perceived Control	0.677	Valid

4.2 Structural Path Significance

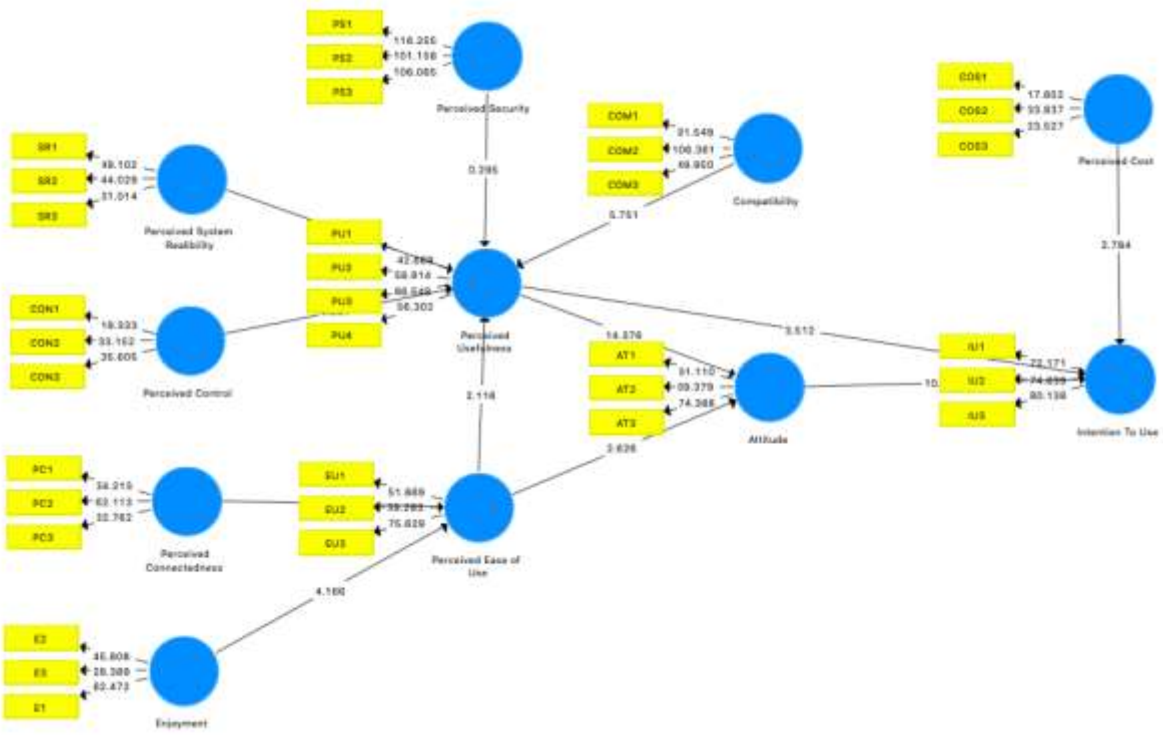

Figure 4: PLS-SEM Result

This current model consists of twelve constructs and 34 indicators. Enjoyment, perceived control, perceived system reliability, perceived connectedness, perceived security, perceived ease of use, compatibility, attitude, perceived cost, and intention to use variables consist of three indicators. Meanwhile, perceived usefulness consists of four indicators.

Table 2: Effects, Variance Explained, and Stone-Geisser

Structural Path	Path Coefficient	T Statistics (|O/STDEV|)	Coefficients of Determination (R square)	Cross-validated Redundancy (Q2)
Attitude -> Intention To Use	0.642	10.192	0.713	0.593
Perceived Cost -> Intention To Use	-0.064	2.784		
Perceived Usefulness -> Intention To Use	0.230	3.512		
Perceived Ease of Use -> Attitude	0.148	2.626	0.575	0.464
Perceived Usefulness -> Attitude	0.663	14.376		
Enjoyment -> Perceived Ease of Use	0.316	4.166	0.341	0.269
Perceived Connectedness -> Perceived Ease of Use	0.318	4.062		
Compatibility -> Perceived Usefulness	0.433	5.751	0.555	0.437
Perceived Control -> Perceived Usefulness	0.040	0.581		
Perceived Ease of Use -> Perceived Usefulness	0.146	2.116		
Perceived Security -> Perceived Usefulness	-0.018	0.295		
Perceived System Reliability -> Perceived Usefulness	0.252	3.386		

Table 2 above shows the result of R2and Q2. According to (Wong, 2013), R square is a measure of coefficients of determination of the model's predictive accuracy. The values vary from 0 to 1, with 1 describing the perfect predictive accuracy. The R2 of intention to use is 0.713, which means the three latent variables (attitude, perceived cost, and perceived usefulness) explain the 71.3% of the variance in intention to use. Then, R2of attitude is 0.575, meaning that two latent variables (perceived ease of use and perceived usefulness) explain the 57.5% of the variance in attitude. R2of perceived ease of use is 0.341, meaning that two latent variables (enjoyment and perceived connectedness) explain 34.1% of the variance in perceived ease of use. Last, R2of perceived usefulness is 0.555, meaning that five latent variables (perceived control, perceived ease of use, perceived security, compatibility, and perceived system reliability) explain 55.5% of variance in perceived ease of use. The R2values ranging from 0.3 to 0.67 indicates moderate level of predictive accuracy (Urbach & Ahlemann, 2010).

4.3 Hyphothesis Testing

Table 3: Hypothesis Testing Result

Hypothesis	Structural Path	T Values	P Values	Result
H1	Attitude -> Intention To Use	10.192	0.000	Accepted
H2	Perceived Usefulness -> Intention To Use	3.512	0.000	Accepted
H3	Perceived Usefulness -> Attitude	14.376	0.000	Accepted
H4	Perceived Ease of Use -> Attitude	2.626	0.009	Accepted
H5	Perceived Ease of Use -> Perceived Usefulness	2.116	0.035	Accepted
H6	Enjoyment -> Perceived Ease of Use	4.166	0.000	Accepted
H7	Perceived Connectedness_ -> Perceived Ease of Use	4.062	0.000	Accepted
H8	Perceived Control_ -> Perceived Usefulness	0.581	0.562	Rejected
H9	Perceived System Reliability -> Perceived Usefulness	3.386	0.001	Accepted
H10	Perceived Security -> Perceived Usefulness	0.295	0.768	Rejected
H11	Compatibility -> Perceived Usefulness	5.751	0.000	Accepted
H12	Perceived Cost -> Intention To Use	2.784	0.006	Accepted

Based on the table above, ten hyphothesis are supported and the other two are not supported. H1, H2, H3, H4, H5, H6, H7, H9, H11 and H12 supported because t-value score > 1,96 at significance level of 0.05 (5%). Meanwhile, H8 and H10 have t-value less than 1,96. Therefore, there is not enough evidence to support H8 and H10.

5. Conclusion

Based on the analysis, intention to use a smart home product is affected by perceived ease of use and perceived usefulness with core motivations which are perceived system reliability, compatibility, perceived cost, enjoyment, and perceived connectedness. The significant variables represent the object in this research, which is the millennial group in Indonesia. However, perceived control and perceived security have found not significantly correlated to intention to use. The rejected hypotheses can only represent the respondents of this research, but not the population in this research. Two motivation factors that greatly affect users to use smart home products are perceived enjoyment and perceived connectedness. Besides, The results show that perceived usefulness is the most influential predictor of intention and attitude. There are recommendations from the research findings that can be used for smart home industry; add features that make people more connected to the product and create attractive display products that make people interested in buying. In addition, the product can also have functions such as monitoring and scheduling to increase people's interest in buying because of its usefulness.

6. Future Research

This study has limitations on the number and scope of the area on the sample size chosen. This study only gathered 305 sample sizes, and the area is limited to Bandung and Jabodetabek region only. Future research should broaden the scope of the area and add more sample size in order to get more perspective. Because this study does not focus on people who already use smart home, in future studies it can use respondents who have used smart home so the results are more accurate. In addition, it can add several variables such as exploring how other emotional and psychological motivations can affect the patterns of the users'.

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