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## Analysis of the barriers that consumers encounter when smart home service is introduced in South Korea

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Analysis of the barriers that consumers encounter when smart home service is  
introduced in South Korea

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Abstract

Recently, smart home services have been highlighted as the Internet of things market grows. Since the smart home services were introduced in the market, they were expected to grow rapidly. However, the smart home market recently experienced chasm, and still remains in early stage. This paper tried to find the possible barriers that consumers encounter when they are faced with smart home services. Based on the resistance theory and perceived risk model, this paper investigates the influence of perceived risk on the resistance using the technological uncertainty and service intangibility as the antecedents of the perceived risk. Dividing the perceived risks into four types of performance risk, financial risk, privacy risk and psychological risk, the empirical results show that these four types of risk are affected by the technological uncertainty and service intangibility on the one hand, and have positive effects on the resistance to smart home on the other hand. When the survey respondents are divided into two groups of postponers and rejecters based on the resistance type, there are no big differences except that the privacy risk becomes unimportant to postpnrs and the financial risk becomes unimportant to rejecters.

## 1. Introduction

The industry related to the Internet of Things (IoT) is expected to grow rapidly. Gartner (2013) expected that the global IoT market grow up to 1.9 trillion dollars by 2022. Especially, the smart home (IoT home) market is currently in its realization stage. Global smart home market is expected to grow from USD 46.97 Billion in 2015 to USD 121.73 Billion by 2022, at a CAGR of 14.07% between 2016 and 2022 (MarketsandMarkets, 2016). Moreover, in the last few years, smart home was the major issues at the global electronics shows like International Consumer Electronics Show (CES) and various global companies have introduced the products related to smart home in these shows. As such, the major global IT companies such as Google, Amazon, Apple, and Samsung, have participated in the smart home market and these four companies lead the sales in smart home devices (Dean, 2017).

And other players like many telecommunication service providers, construction companies, and security service providers, etc. have also expressed interest in this smart home market. These companies are showing various early stage products and services of smart home. For example, in South Korea, the telecommunication service providers launched the smart home service like “IoT@home” or “Giga IoT Home”, which bundles various smart home accessories such as smart plugs, thermostats, door locks, energy meters, gas locks, etc. with communication services for a monthly fee. Also, they are trying to build a smart home in a new apartment in conjunction with construction companies.

However, contrary to optimistic expectation for the future growth, the smart home market has recently experienced chasm. For example, in U.S. market, the sales of smart home products decreased by 15% from the same period of last year, in May 2015 (Argus Insight, 2015). While the demand for smart home products were raised mainly by early adopters, the demand has not been transferred to general consumers (Higginbotham, 2015). One of reason why it is not diffused fast could be consumers' concern. If consumers are not familiar with smart home products and services, they may not feel a big utility from them with some concerns regarding costs, reliability,

privacy, security, etc. According to a report by the Acquity Group (2014), consumers are not familiar with IoT products, and they have some concerns with privacy and/or security problems. And complicated installation process and difficulties in using smart home cause general users' resistance to smart home (Argus Insight, 2015). If this is a case, as a consequence, they might hesitate and resist against using smart home products and services with such concerns. Since this shortage of demands can hamper the growth of the market and the development of related technologies, it should be worthwhile to analyze what factors make consumers hesitant to adopt smart home products and services.

Therefore, the purpose of this research is to find the possible barriers that consumers feel when smart home services are introduced, using the concept of perceived uncertainty, perceived risk and resistance. This research propose two types of perceived uncertainty –technological uncertainty and service intangibility - that affect the perceived risk and in turn resistance to smart home and four types of perceived risks – performance risk, financial risk, privacy risk, and psychological risk – that provoke the resistance. In addition, we divide the survey responses into two groups based on types of resistance: postponement and rejection and analyze the difference between two groups in order to provide further implications to market players and policy makers.

The remainder of the paper is organized as follows. Section 2 presents a literature review about smart home. Section 3 presents theoretical backgrounds and hypotheses of the research model. Section 4 introduces how to collect the data and sample characteristics. Section 5 shows the empirical results, section 6 presents discussion and implication, and section 7 offers concluding remarks.

## 2. Previous studies on smart homes

A smart home is “an expression utilized for dwellings outfitted with technologies that enable proper scrutiny of residents promoting autonomy and upholding of better

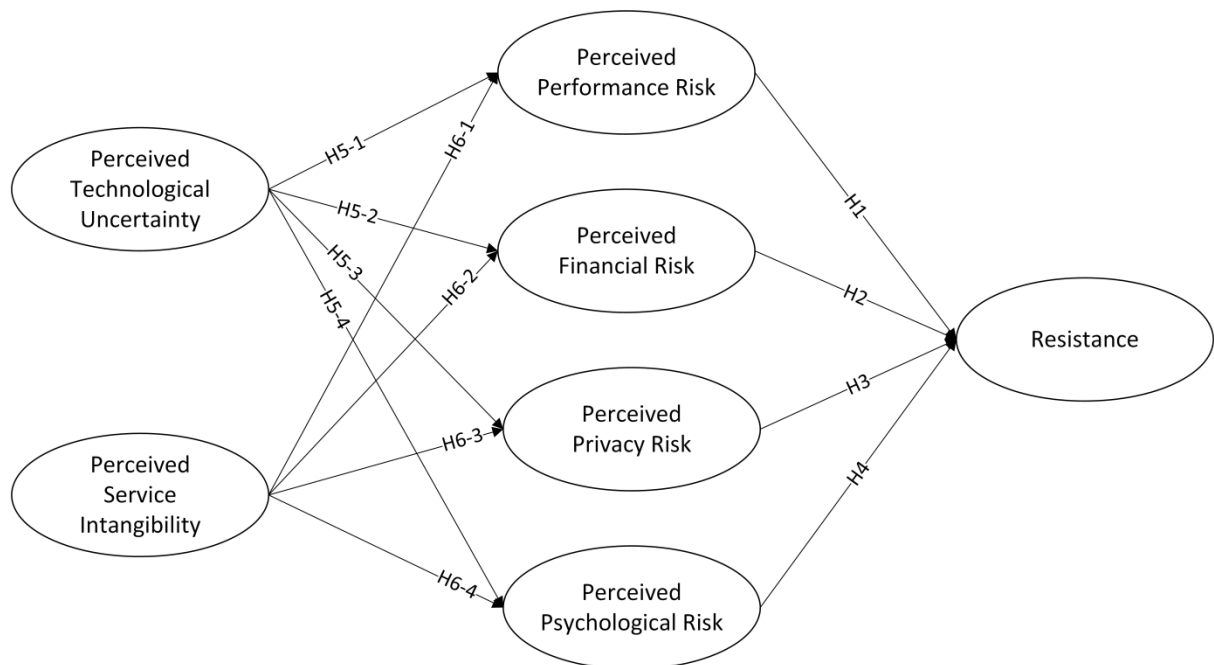
health” (Suryadevara, Mukhopadhyay, Wang, & Rayudu, 2013). Smart home allows the consumers control and manages the home appliances with smart technologies and it means the convergence of appliance for energy efficiency and real-time access for energy consumption data (ITU, 2010). Smart Home includes various types of services such as e-health, entertainment, communications, assisted living, security, energy efficiency, and convenience. And Balta-Ozkan, Davidson, Bicket, and Whitmarsh (2013a) characterizes this smart home as four key aspects: “a communication network through which different devices talk to each other”, “intelligent controls to manage the system”, “sensors that collect information”, and “smart features which respond to information from sensors or user instruction as well as the system provider”.

There are some previous studies that estimate the attitudes or barriers about smart home or similar smart devices. But there have not been any article that estimates the consumers’ resistance and barriers to smart home empirically. Demiris et al. (2004) estimates the older adults’ attitude to smart home technology. They find some benefits and concerns that the older adults feel, using focus group interview. There are eleven benefits such as emergency help, temperature monitoring, automatic lighting, etc. and five concerns such as privacy violation, lack of human responders, a possible replacement of human assistance by technology, user-unfriendliness of device, and the need for training tailored to older learners.

Meyers, Williams, and Matthews (2010) investigate that the monitoring and control technology can reduce the energy consumptions. Lineweber (2011) examine the attitudes of consumers on smart grid investment. The survey of 1100 residents shows that the respondents think what kinds of benefit for smart grid investment exist and what kinds of key questions should be discussed, considering the smart grid investment. Krishnamurti et al. (2012) analyze how consumers think about the smart meter through a behavioral decision research. They estimate eight beliefs about smart meter and these showed that positive beliefs about smart meter is greater than negative ones. Hong, Shin, and Lee (2016) examine the consumer preference for smart key functions and car-home connectivity functions.

Especially, Balta-Ozkan et al. (2013b) investigate and introduced smart home development in the UK through literature reviews, expert interviews, and public workshops (consumer interviews), and further elicited social barriers to smart homes. They find several social barriers like fit to current and changing lifestyle, administration problem, interoperability, reliability, privacy and security, trust, and costs. The consumers are worried about the loss of control or apathy to their home and the experts said that there are differences between what the consumers want and the technology developed. Both of the experts and consumers concern malfunctioning, privacy and security. And the experts also concern whether the devices can communicate with each other and interference between the device, and they said reducing complexity is the biggest challenge to smart home development. Also, consumers concern the installation, maintenance, repair, and energy costs, and they are distrustful of whether smart technologies and services really reduce consumers' costs.

### 3. Theoretical backgrounds and hypotheses



**Figure 1. The model of analysis**

This research is utilizing structural equation modeling, and particularly based on the perceived risk model and innovation resistance model. The perceived risk, which is influenced by perceived uncertainty, increases resistance level. The risk factors are categorized into four types such as performance risk, financial risk, privacy risk, and psychological risk. And the potential consumers' uncertainty about smart home is categorized into perceived technological uncertainty and perceived service intangibility. The model is as follows (Figure 1);

### 3.1. Resistance

Resistance is defined as the attitude of trying to maintain the current state and not to adopt the innovation when facing the pressure to change the current state (Sudha Ram, 1987). Consumers' resistance to new technologies or services has not received much attention in previous researches; most researchers have focused on only adoption and positive aspect of innovations. However, some researchers have begun to focus on and study the concept of innovation resistance. For example, Rogers (1983) uses the term "Discontinuance" to mean "a decision to reject an innovation after having previously adopted it". And Sheth and Stellner (1979) suggest the concept of "innovation resistance". They said that it is important to focus on the individuals who resist change and to understand the psychology of resistance because the majority of the people have no a priori desire to change and they may be more typical and more rational than the minority who seek the change. Also, Sudha Ram (1987) says that innovation resistance is not a concept opposite to adoption but a process that progresses toward adoption. So, for successful adoption of innovative services like smart home, it is important not only to focus on innovative early adopters but also to analyze the resistance of most people who are not active to change.

In addition, previous studies (Sundaresan Ram & Sheth, 1989; Szmigin & Foxall, 1998) further describe the concept of resistance from as simply "not attempting to innovate," to as three distinct types of consumer behaviors: rejection, postponement,

and opposition. Rejection means the active decision not to adopt an innovation; postponement means that the consumers concern an active decision to not take up an innovation at present and postpone their decision; and opposition indicates actual active behavior that opposes the innovation (Kleijnen, Lee, & Wetzels, 2009). Kleijnen et al. (2009) show which factors affect each type of resistance using focus group interviews. They allocate 58 subjects into several groups specific to the resistance type based on the past experience and interview them in order to find which drivers affect each type of resistance. Through this interview, they find that the factors affecting each type of resistance are different. Rejection is affected by economic risk and tradition and norms; Postponement is affected by economic risk and functional risk; and opposition is affected by physical risk, functional risk, social risk, tradition and norms, and perceived image. Even though it deals with a common past experience and it based on the interview of a few subjects, it is worthy of a paper that specifically provides guidelines about factors affecting each type of resistance.

Also, Mzoughi and M'Sallem (2013) and Laukkanen (2016) divided the groups based on type of resistance and analyzed the difference between groups. Mzoughi and M'Sallem (2013) divided the groups into postponer, rejecter, and opponents and estimates the factor affect to resistance to internet banking adoption, using multinomial logistic regression, and estimate differences between groups. Laukkanen (2016) classified the group in to adopter, postponer, rejecter and analyze the barriers to internet banking, using binary logit model.

This research also divides the respondents by two groups – rejecter and postponer like Laukkanen (2016), and shows how the risks that affect the resistance to smart home are different for each group in order to provide more useful implications. Opponent concept is not included in the research because smart home is early-stage service and there are few people who have already used the smart home and resist the smart home.



### 3.2. Perceived risk

Perceived risk is the meaning of the uncertainty and consequences related to consumer behavior (Bauer, 1960). Featherman and Pavlou (2003) also define perceived risk in terms of the extent to which consumers feel uncertainty about the possibility that negative consequences can happen due to using a technology. The perceived risk concept has frequently appeared in research on consumer behavior related to information technology and previous studies show that perceived risk have negative influence to the intention to use (Featherman & Pavlou, 2003; Lu, Hsu, & Hsu, 2005; Martins, Oliveira, & Popovič, 2014; Yang, Liu, Li, & Yu, 2015). Especially, Featherman and Pavlou (2003) subdivide perceived risk into performance, financial, privacy, time, social, and psychological risks, and show that various risks are negatively related to acceptance of Internet service.

In addition, previous researches also show that the perceived risk affect the resistance (Kang & Kim, 2009; Sundaresan Ram & Sheth, 1989; Sheth & Stellner, 1979). Sheth and Stellner (1979) claim that the higher the perceived risk, the bigger innovation resistance, and that perceived risk is the major determinant of innovation resistance. In addition, Sundaresan Ram and Sheth (1989) suggest risk barriers as the reasons that consumers resist innovation<sup>1</sup>; they said that there are physical, economic, functional, and social risks. Kang and Kim (2009) analyzed consumer resistance to participating in multi-hop communication, using the perceived risk model and innovation resistance model. They proposed the four risks – expected network quality concerns, expected privacy concerns, expected lack of cohesion, and expected source of service performance – based on the characteristics of multi-hop communication.

Therefore, this research assumed that the perceived risk is critical reason for the resistance to smart home and propose four types of risks – performance risk, financial risk, privacy risk, and psychological risk – based on the characteristic of smart home

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<sup>1</sup> They detail five barriers that affect innovation resistance: usage, value, risk, tradition, and image barriers.

and literature review.

### 3.2.1. Perceived performance risk

Performance risk means that consumers are uncertain about the performance of smart home services or products. This concept includes concerns about malfunctions and about the quality of product, service, or network being below the expectation of the consumers. Sundaresan Ram and Sheth (1989) suggest functional risk as a barrier that creates resistance, and define this concept as the uncertainty of performance. They claim that consumers wish to know whether an innovation has been fully tested or proved because they think there is a possibility that new devices or services may not function properly or reliably.

Since smart home is still an early stage service, it is not easy to use and unreliable because of unstable network connection, and its service level is also insufficient (NIA, 2016). So the consumers might have some uncertainty about the performance of the smart home and cannot be sure whether the smart home can give the benefits expected. Balta-Ozkan et al. (2013b) said that the consumers concern with the reliability of the smart home. The consumers worry about malfunctioning of smart home such as the sensors accidentally turned off or the whole system being in limbo due to the breakdown of remote controls that operate the home, etc. Therefore, we hypothesized that:

H1. Perceived performance risk have a positive influence on resistance to smart home.

### 3.2.2. Perceived financial risk

Financial risk means the possibility that the product or service will not be valuable for its financial price or investments or that there could be a cheaper alternative somewhere (Lu et al., 2005). In this research, financial risk includes the concerns about both the cost for installation and for maintenance or energy consumption. Sundaresan Ram and Sheth (1989) claim that the higher the cost of an innovation, the higher the perceived economic risk. Because smart home is composed of various related

electronic devices and network system, consumers may worry about various economic burdens such as installation cost and maintenance cost of smart home. According to the Acquity Group (2014), price is one of the barriers toward consumers' adoption of Internet of things device. Survey Monkey found that 58% of responders think smart devices are too expensive, investigating eight hundreds of people in the U.S. (Bloomberg, 2016), and Nakyung Kim and Kim (2015) said that the price is most important factor when the consumers buy the smart home products. Also Balta-Ozkan et al. (2013b) show that consumers are concerned with the cost of installation, repair, maintenance, and energy, so smart home technology makes consumers continue to feel concerns and guilt. Therefore, we hypothesized that:

H2. Perceived financial risk have a positive influence on resistance to smart home.

### 3.2.3. Perceived privacy risk

Privacy risk means that the consumers feel at risk of having their personal data used improperly without agreement or having their information be disclosed to third parties (Kang & Kim, 2009). Privacy issue is the big challenge of the high-tech products or services and this problem can be major barriers to smart home diffusion. Smart home have too much data including very private data like occupants' daily routine or health data. So the consumers may have fear about privacy issue. According to the Acquity Group (2014), the concern with privacy is one of the largest barriers of smart home adoption. Icontrol Networks (2015) found that consumers concern about the smart home is the possibility of a data breach. 71% of consumers have the fear that their personal information may be stolen and 64% of them fears that their data will be collected and sold. Additionally, based on the research of Balta-Ozkan et al. (2013b), many experts, consumers, and literature have said that privacy and security are the barriers toward smart home development. Consumers are particularly concerned with strangers knowing their daily routines, that their personal data could be used by the wrong hands, and that the smart home system can be hacked into. Therefore, we hypothesized that:

H3. Perceived privacy risk have a positive influence on resistance to smart home.

#### 3.2.4. Perceived psychological risk

Perceived psychological risk means that using smart home will have negative effect on the consumers' peace of mind or self-perception (Featherman & Pavlou, 2003). Smart home is not just service or product, but a space the occupants actually live in, so the adoption of smart home can affect the occupants' self-image or lifestyle. Balta-Ozkan et al. (2013b) said that fit to current and changing lifestyle is one of the barriers to smart home development. The consumers concerned that they can lose their control on smart home, lose the daily household routines, and become lazy. Also they think that smart home service makes the people dumb down and complacent. Therefore, we hypothesized that:

H4. Perceived psychological risk have a positive influence on resistance to smart home.

### 3.3. Perceived uncertainty

#### 3.3.1. Perceived technological uncertainty

Technological uncertainty refers to inability to fully understand the functions and consequences of technology or predict some aspect of the technological environment (Song & Montoya-Weiss, 2001; Yang et al., 2015). Yang et al. (2015) said that the perceived technological uncertainty have influence on the executive's or manager's decision and like this the consumers' perception of technological uncertainty may affect their purchase decision about high-tech products or services. So perceived technological uncertainty is defined as the consumer's perception of the uncertainties in the technology development, network system, and security system of the smart home in this research (Yang et al., 2015). Because smart home is a service based on various technologies such as network technology, sensing technology, etc., consumers' perception of technological uncertainty can lead to fear of smart home. So uncertainty

about technology development, network system, and security system can cause consumers to question the performance of smart home, worry about various expenses such as repair cost or maintenance cost, and concern about privacy invasion, furthermore it can make the consumers feel threat to the psychological state of the individual. Therefore, we hypothesized that:

H5. Perceived technological uncertainty have positive influences on each dimension of perceived risk

### 3.3.2. Perceived service intangibility

Intangibility means “impalpable” and “not corporeal” (Shostack, 1977). Property of services such as heterogeneity, perishability, inseparability, and intangibility can increase uncertainty in decision making, thereby lowering consumers' confidence and increasing perceived risk (Mitchell, 1999). Some previous studies shows influence of the service intangibility on perceived risk empirically. Laroche, McDougall, Bergeron, and Yang (2004) shows that the two dimensions of service intangibility – generality and mental intangibility – have influence on the perceived risk. Generality means that the consumers feel difficulty in precisely defining or describing a particular service, and the mental intangibility means that a service or product is difficult to grasp mentally and explain how it works. Featherman and Wells (2004, 2010) shows the intangibility of information system positively affect the perceived risk. Eggert (2006) also shows that the intangibility positively affects the perceived risk and its impact in online context is greater than that in offline context.

Therefore, in this research, the perceived service intangibility means that the consumers feel difficulty in defining, describing, or mentally representing the smart home (Laroche et al., 2004). The smart home is very different from traditional service and very complex service. So the consumers are unfamiliar with the smart home service and the concept or performance property of smart home is too vague and ambiguous to consumers. And this uncertainty can increase consumers' perceived risk about the smart home. Therefore, we hypothesized that:

H6. Perceived service intangibility have positive influences on each dimension of perceived risk

#### 4. Data and research methodology

##### 4.1. Measurement

Table 1 shows the measurement items used in this research. The measurements for each variable in Table 1 are based on previous researches and are slightly modified to fit our research context.

**Table 1. Measurement of construct**

Construct	Item	Measurement question	References
Perceived technological uncertainty	PTU1	I think that the wireless network of smart home is unstable.	Yang et al. (2015)
	PTU2	The security of smart home is questionable.	Yang et al. (2015)
	PTU3	I think that the technologies related to smart home are undeveloped.	Yang et al. (2015)
Perceived service intangibility	PSI1	It is difficult to explain the features and functions of smart home.	Laroche et al. (2004), Yang et al. (2015)
	PSI2	It is difficult to understand how it works.	Laroche et al. (2004), Yang et al. (2015)
	PSI3	It is hard to imagine specifically about smart home.	Laroche et al. (2004), Yang et al. (2015)
Perceived performance risk	PPR1	If I were to use smart home products and services, I become concerned that the smart home will not provide the level of benefits that I would expecting.	Stone and Grønhaug (1993)
	PPR2	The performance of service and products may not match its advertised level.	Yang et al. (2015)
	PPR3	It is uncertain whether the smart home will work as satisfactorily as expected.	Yang et al. (2015)
	PPR4	The entire smart home system may be unstable or get out of control due to breakdown or malfunctioning of sensors and communication network, or due to interference between the devices.	Featherman and Pavlou (2003), Balta-Ozkan et al. (2013b)

Perceived financial risk	PFR1	I think that the financial investment for smart home would not be wise and a bad way to spend money.	Stone and Grønhaug (1993)
	PFR2	I would be concerned that I really would not get my money's worth from smart home.	Stone and Grønhaug (1993)
	PFR3	I would be concerned that it would cost a lot to purchase and install smart home products and services	Balta-Ozkan et al. (2013b)
	PFR4	I would be concerned that it would cost a lot to repair and maintain smart home.	Balta-Ozkan et al. (2013b)
Perceived privacy Risk	PPrR1	If I use the smart home, privacy information could be misused, inappropriately shared, or sold.	Yang et al. (2015)
	PPrR2	If I use the smart home, Personal information could be intercepted or accessed.	Yang et al. (2015)
	PPrR3	If I use the smart home, the chance of losing control over the privacy information is high.	Featherman and Pavlou (2003)
Perceived psychological risk	PPsR1	The smart home will not fit in with my self-image or self-concept.	Featherman and Pavlou (2003)
	PPsR2	The smart home will not fit in with my lifestyle.	Balta-Ozkan et al. (2013b)
	PPsR3	A smart home will make me lose control of my home and become indifferent or lazy at home.	Balta-Ozkan et al. (2013b)
Resistance	RES1	I feel uneasy when I use smart home product and service.	Kang and Kim (2009)
	RES2	The current state is better than using smart home.	Kang and Kim (2009)
	RES3	I am reluctant to use a smart home.	Kim and Kim (2011)
	RES4	If I use the smart home, I will be dissatisfied with smart home.	Kang and Kim (2009)

#### 4.2. Sample

The data were collected through an online survey, using seven Likert scale: strongly disagree to strongly agree. The target of this survey is non-adopters of smart home, and the survey is conducted after short explanation about smart home in order to help the respondents understand the concept of smart home. Before actual survey, the pilot test is conducted and some questionnaires are slightly revised according to tester's comments in order to make the questionnaires easier to understand. The total number

of respondents was 535 and after discarding untrustworthy responses, 533 responses (391 postponers and 142 rejecters) were included in the analysis. Table 2 shows the sample characteristics. The gender and age of sample were almost uniformly distributed. There were 265 males and 268 females, and 131 were in their 20s, 133 were in their 30s, 132 were in their 40s, and 137 were in their 50s.

**Table 2. Sample Characteristics**

Demographic category		Total sample (n=533)		Postponer (n=391, 73.4%)		Rejecter (n=142, 26.6%)	
Gender	Male	265	49.7%	198	50.6%	67	47.2%
	Female	268	50.3%	193	49.4%	75	52.8%
Age	20~29	131	24.6%	104	26.6%	27	19.0%
	30~39	133	25.0%	96	24.6%	37	26.1%
	40~49	132	24.8%	92	23.5%	40	28.2%
	50~59	137	25.7%	99	25.3%	38	26.8%
Monthly income (KRW)	< 1 million or less	31	5.8%	22	5.6%	9	6.3%
	1~3 million	148	27.8%	103	26.3%	45	31.7%
	3~5 million	183	34.3%	139	35.5%	44	31.0%
	5~7 million	102	19.1%	76	19.4%	26	18.3%
	7~9 million	47	8.8%	35	9.0%	12	8.5%
	> 9 million	22	4.1%	16	4.1%	6	4.2%

## 5. Result of the analysis

### 5.1. Measurement model assessment

We used SmartPLS version 3.0. (<http://www.smartpls.de>) as the structural equation analysis tool. PLS is very useful method that is able to handle complex models, shows  $R^2$  value for all endogenous variables, and alleviates the assumption about data distribution (Ruiz, Gremler, Washburn, & Carrión, 2010).



**Table 3. Reliability and convergent validity**

Construct	Item	Loading	t-value	Cronbach's $\alpha$	CR	AVE
Perceived technological uncertainty	PTU1	0.851	50.991	0.795	0.880	0.709
	PTU2	0.849	54.918			
	PTU3	0.826	47.332			
Perceived service intangibility	PSI1	0.860	48.084	0.877	0.924	0.802
	PSI2	0.933	146.493			
	PSI3	0.893	59.889			
Perceived performance risk	PPR1	0.838	49.483	0.876	0.915	0.730
	PPR2	0.866	59.138			
	PPR3	0.914	105.098			
	PPR4	0.796	33.773			
Perceived financial risk	PFR1	0.763	36.348	0.839	0.891	0.673
	PFR2	0.874	77.958			
	PFR3	0.825	37.650			
	PFR4	0.814	37.138			
Perceived privacy risk	PPrR1	0.936	119.767	0.930	0.955	0.877
	PPrR2	0.946	136.068			
	PPrR3	0.927	115.606			
Perceived psychological risk	PPsR1	0.901	77.757	0.842	0.906	0.762
	PPsR2	0.920	114.245			
	PPsR3	0.793	30.962			
Resistance	RES1	0.848	47.092	0.894	0.926	0.759
	RES2	0.849	49.455			
	RES3	0.897	76.741			
	RES4	0.890	77.815			

The validity of the measurement model was evaluated using construct reliability, convergent validity, and discriminant validity. The reliability of individual item is evaluated by examining each item's loading on its corresponding latent variable. The all item loadings in Table 3 are bigger than the criterion of 0.7 (Barclay, Higgins, &

Thompson, 1995). To check the internal consistency, the composite reliability (CR) and Cronbach's alpha are used. CR and Cronbach's alpha in Table 3 are bigger than the criterion of 0.8 and 0.7, respectively (Fornell & Larcker, 1981). And average variance extracted (AVE) is used for checking convergent validity. As shown in Table 3, the values of AVE is bigger than the criterion of 0.5, suggested by (Bagozzi & Yi, 1988). So these results show that the reliability, internal consistency and convergent validity of our model is satisfied.

And in order to check the discriminant validity, we compare square root of AVEs with the correlations among the variables.. As shown in Table 4, the diagonal values, which are square root of AVEs, are higher than the correlations for each construct, respectively and our measurement model achieved discriminant validity (Fornell & Larcker, 1981).

**Table 4. Discriminant validity of the construct**

Construct	PFR	PPR	PPrR	PPsR	PSI	PTU	RES
PFR	<b>0.820</b>						
PPR	0.658	<b>0.855</b>					
PPrR	0.577	0.587	<b>0.937</b>				
PPsR	0.483	0.283	0.327	<b>0.873</b>			
PSI	0.352	0.284	0.206	0.488	<b>0.896</b>		
PTU	0.546	0.688	0.570	0.290	0.235	<b>0.842</b>	
RES	0.545	0.434	0.436	0.741	0.479	0.421	<b>0.871</b>

## 5.2. Structural model assessment

Table 5 shows the results of the structural equation analysis. The SRMR of model is 0.069. The value of SRMR over 0.10 may indicated poor fit (Kline, 2015) and the value under 0.08 tend to indicate good fit for models (Hu & Bentler, 1999). Henseler et al. (2014) introduce the SRMR as a goodness of fit measure for PLS-SEM that can be used to avoid model misspecification. The resistance shows high explanatory power

( $R^2 = 0.617$ ), and perceived performance risk, perceived financial risk, perceived privacy risk, and perceived psychological risk accounts for 49.0%, 35.1%, 33.1%, and 27.1% of the variances ( $R^2$  values) of perceived technological uncertainty and perceived service intangibility, respectively.

**Table 5. Result of hypotheses tests (Total sample)**

Hypothesis	Coefficient	t-value	p-value	Result
H1: PPR → RES (+)	0.136***	3.306	0.001	Supported
H2: PFR → RES (+)	0.101*	2.025	0.043	Supported
H3: PPrR → RES (+)	0.094*	2.379	0.017	Supported
H4: PPsR → RES (+)	0.623***	17.336	0.000	Supported
H5-1: PTU → PPR (+)	0.658***	23.762	0.000	Supported
H5-2: PTU → PFR (+)	0.490***	14.196	0.000	Supported
H5-3: PTU → PPrR (+)	0.552***	17.264	0.000	Supported
H5-4: PTU → PPsR (+)	0.186***	4.330	0.000	Supported
H6-1: PSI → PPR (+)	0.129***	3.791	0.000	Supported
H6-2: PSI → PFR (+)	0.237***	6.320	0.000	Supported
H6-3: PSI → PPrR (+)	0.076	1.877	0.061	Not supported
H6-4: PSI → PPsR (+)	0.445***	10.724	0.000	Supported
SRMR	0.069			

\*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ .

RES = resistance, PPR = perceived performance risk, PFR = perceived financial risk, PPrR = perceived privacy risk, PPsR = perceived psychological risk, PTU = perceived technological uncertainty, PSI = perceived service intangibility

As expected, the perceived performance risk, perceived financial risk, perceived privacy risk, and perceived psychological risk positively affect the resistance to smart home (coefficient are 0.136, 0.101, 0.094, and 0.623, respectively), supporting H1, H2, H3, and H4. Also, the perceived technological uncertainty have positive influence to perceived performance risk, perceived financial risk, perceived privacy risk, and perceived psychological risk (coefficients are 0.658, 0.490, 0.552, and 0.186,

respectively), supporting H5. Perceived service intangibility positively affects perceived performance risk, perceived financial risk, and perceived psychological risk (coefficients are 0.129, 0.237, and 0.445, respectively), but its effect on the perceived privacy risk is not significant at the 5% level (coefficient = 0.076). So H6-1, H6-2, and H6-4 are supported, but H6-3 is not supported.

### 5.3. Group differences between postponers and rejecter

This research divides the respondents into two groups – postponers and rejecters – and compares the difference of the results between two groups. In this research, postponers are the respondents who didn't adopt the smart home now but postpone their decision to adopt, and according to the response of this survey, they are willing to adopt a smart home within an average of 3.5 years (standard deviation = 1.87). And the rejecters are the respondents who didn't adopt the smart home now and are not willing to buy it in the future.

Table 6 shows the results of two groups. The SRMR of the two models is 0.071 and 0.095 respectively. For postponers,  $R^2$  values of resistance is 0.555, and those of the perceived performance risk, perceived financial risk, perceived privacy risk, and perceived psychological risk are 0.466, 0.321, 0.300, and 0.296, respectively. And for the rejecters,  $R^2$  values of resistance is 0.545, and those of the perceived performance risk, perceived financial risk, perceived privacy risk, and perceived psychological risk are 0.537, 0.322, 0.344, and 0.102, respectively.

The results for two groups are slightly different. For postponers, all hypotheses except for H3 are supported. Perceived technological uncertainty and perceived service intangibility positively affects each dimension of perceived risk (H5 and H6) and perceived performance risk, perceived financial risk and perceived psychological risk have positive influence on the resistance to smart home (H1, H2, and H4). However, the influence of perceived privacy risk on resistance is not proven in the case of postpone.

**Table 6. Result of hypotheses tests (postpone vs. rejecter)**

Hypothesis	Postponer			Rejecter		
	Coefficient	t-value	p-value	Coefficient	t-value	p-value
H1: PPR → RES (+)	0.149**	3.112	0.002	0.224*	2.042	0.041
H2: PFR → RES (+)	0.124*	2.292	0.022	-0.039	0.348	0.728
H3: PPrR → RES (+)	0.059	1.169	0.243	0.180*	2.334	0.020
H4: PPsR → RES (+)	0.589***	15.749	0.000	0.574***	6.331	0.000
H5-1: PTU → PPR (+)	0.620***	18.435	0.000	0.732***	11.923	0.000
H5-2: PTU → PFR (+)	0.433***	10.061	0.000	0.548***	8.475	0.000
H5-3: PTU → PPrR (+)	0.514***	12.749	0.000	0.588***	9.809	0.000
H5-4: PTU → PPsR (+)	0.119**	2.587	0.010	0.166	1.583	0.113
H6-1: PSI → PPR (+)	0.171***	4.257	0.000	0.013	0.226	0.822
H6-2: PSI → PFR (+)	0.274***	6.258	0.000	0.105	1.583	0.114
H6-3: PSI → PPrR (+)	0.101*	2.077	0.038	-0.015	0.179	0.858
H6-4: PSI → PPsR (+)	0.502***	12.459	0.000	0.259	1.948	0.052
SRMR	0.071			0.095		

\*\*\* p<0.001, \*\* p <0.01, \* p <0.05.

RES = resistance, PPR = perceived performance risk, PFR = perceived financial risk,

PPrR = perceived privacy risk, PPsR = perceived psychological risk, PTU = perceived technological uncertainty, PSI = perceived service intangibility

For the rejecters, only H1, H3, H4, H5-1, H5-2, and H5-3 are supported. Like the result of postpone, perceived performance risk and perceived psychological risk positively affect the resistance (H1 and H4) and perceived technological uncertainty have positive influence on the perceived performance risk, perceived financial risk and perceived privacy risk (H5-1, H5-2, and H5-3). However, the positive impact of perceived privacy risk on resistance is proven significantly (H3), also perceived financial risk does not have significant influence to resistance (H2), unlike the result of postponer. The perceived service intangibility also doesn't have significant influence on the each dimension of the perceived risk in the case of rejecters.

## 5. Discussion and implication

The result of the analysis offers a number of findings. The perceived risks have a significant positive influence on of non-adopters' resistance to smart home, supporting that the risk is one of the barrier which affect the consumer resistance (Sundaresan Ram & Sheth, 1989). Based on existing literature, we considers four risks – performance risk, financial risk, privacy risk, and psychological risk – as the antecedents of the resistance to smart home. Although the relationship between the adoption and these risks already have proven empirically in many literatures (Featherman & Pavlou, 2003; Lu et al., 2005; Martins et al., 2014; Yang et al., 2015), that between the resistance and these risks had not been proven empirically. But this research shows the positive impact of each risk on the resistance to smart home empirically through the consumer survey.

Furthermore, this research shows the antecedents of these risks that affect the resistance to smart home – perceived technological uncertainty and perceived service intangibility. The perceived technological uncertainty positively affects all of the perceived risks suggested in this research. Smart home is a technology-intensive service, and the more consumers feel uncertain about the technology of smart home, the more consumers will feel the risk about smart home itself. And this perceived technological uncertainty affects the resistance to smart home indirectly, mediating the perceived risks. The perceived service intangibility also affects positively some of perceived risks – performance risk, financial risk, and psychological risk. It does not show the significant influence on the privacy risk in total sample. It does not show the significant influence on the privacy risk in the group of the rejecters, too. Even though privacy risk is affected by service intangibility significantly in the group of postponers, it seems to be less affected by privacy. Privacy risk is more related to technological aspect like security system rather than service features, the influence of service intangibility to privacy risk seems weak.

In this research, we divided the respondents into two groups – postpone and rejecter – and compare the results of those groups. The most obvious difference with two

results is the influence of financial risk and privacy risk to resistance to smart home. For the postponers, the financial risk positively affect the resistance to smart home, but the impact of privacy risk on resistance to smart home is not significant. Contrary to the postponers, for the rejecter, the financial risk cannot show the significant influence on resistance to smart home, while the privacy risk positively affects that. These result means that the postponers care about the cost or price of smart home, not the privacy issue, while the rejecters care about the technological negative aspect like privacy issue whatever the price or the cost of the smart home is. Also, while the perceived service intangibility affect positively the each dimension of the perceived risk for the postponers, it does not show significant influence on the perceived risks for the rejecters. According to these differences, the rejecters seem to be more concerned with technical uncertainty and the resulting problems than with services itself.

So, these results can give some implications to the market players and the policy makers to successfully adopt the smart home in Korean market. In order to reduce the consumers' resistance to smart home, it is important to lower the perceived risk about the smart home such as performance risk, financial risk, privacy risk, and psychological risk.

First, both postponers and rejecters care about performance risk and psychological risk. So it is important to reduce both risks in order to catch both groups. Both risks are affected by both technological uncertainty and service intangibility. Because consumers are unfamiliar and blind to the smart home service and cannot trust the technologies related to smart home, they may receive strong threats that their lives and habits change a lot. and cannot sure the performance and benefit of the smart home. Therefore, it is important for smart home service and product providers to recognize and familiarize consumers with the smart home through the constant promotion and smart home experience program and to decrease the consumers' perception of technological uncertainty through continuous research and development about the technologies related to smart home.

Second, the market players have to provide the smart home products and services at

the reasonable prices in order to catch the postponers in short term. Although smart home products and services are available in various price ranges from low price to high price, smart home requires a lot of related sensors, devices and network system, and smart home appliances are not easily affordable because of their high price. Therefore, it is important to make the consumers use the smart home at a reasonable price line and feel less burden in order to attract the postponers who are currently holding up their decisions.

Third, in the long term, it is important to resolve privacy issues as soon as possible to embrace rejecters for smart homes. Consumers who are willing to purchase a smart home in a short term may not be sensitive to the privacy issue, but privacy issues can make the consumers' strong sense of rejection to the smart home. Especially, smart home is a service closely related to the life of the consumer, so it is hard to be free from concerns about privacy invasion. So the service and product providers had better establish more safe security system that prevent the leakage of privacy information and the policy makers had better create a regulatory policy about privacy issue for a safer smart home.

## 6. Conclusion

This research find the possible barriers that consumers feel when smart home services are introduced, using the concept of perceived uncertainty, perceived risk and resistance. This research propose two types of perceived uncertainty –technological uncertainty and service intangibility - that affect the perceived risk and in turn resistance to smart home and four types of perceived risks – performance risk, financial risk, privacy risk, and psychological risk – that provoke the resistance. And it shows that these perceived risk positively affect the resistance to smart home and that these risks are affected by the technological uncertainty and service intangibility even though service intangibility shows the significant influence on the privacy risk. These results found new theoretical links among perceived uncertainty, perceived risk and



resistance.

Also this research divided the survey respondents into two groups based on the resistance type – postponers and rejecters – and analyzed the difference between the results of two groups. These results shows that privacy risk is not important factor that make the postponers resist the smart home, that financial risk is not important factor that make the rejecters resist the smart home, and that rejecters' perception of service intangibility does not affect the risk about smart home that they feel significantly. Based on these results, we suggested some implications about the smart home market to market players and policy makers.

However, this research has some limitations. First, this research focuses on the Korean context, so it is hard to generalize the findings of this research. But this research can give some insight to other researches or smart home market because Korea shows the relatively rapid progress in IT industry. Second, this research focuses on the influence of perceived risk to resistance, but there may be other factors that affect the resistance. So future research had better considers other factors that influence the resistance.

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