

Research on the Impact of Smart Home Service Innovation on Consumers' Willingness to Use from the Perspective of Privacy Concerns

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Abstract. In order to explore the influence mechanism of smart home service innovation on consumers' willingness to use, this paper constructs a chain mediation model of smart home service innovation on consumers' willingness to use through perceived intrusiveness and perceived value, and explores the moderating role of privacy concerns in the model. The results show that : (1) Smart home service innovation has a significant positive impact on consumers' willingness to use; (2) Perceived value and perceived intrusiveness played a partially mediating role in the positive impact of smart home service innovation on consumers' willingness to use, respectively; (3) Perceived intrusiveness and perceived value play a chain-mediated role in the positive impact of smart home service innovation on consumers' willingness to use; (4) Privacy concerns moderated the two partial mediating pathways, that is, the stronger the privacy concerns, the weaker the positive mediating effect of perceived value, and the stronger the negative mediating effect of perceived intrusive. This paper explores the mechanism of the impact of smart home service innovation on consumers' willingness to use from the perspective of privacy concerns, which is a supplement and enrichment to previous studies, and also provides valuable ideas for the physical retail industry to properly handle consumers' privacy and improve consumers' willingness to use.

Keywords: Smart home; Service innovation; Perceived value; Perceptual intrusiveness; Privacy concerns.

1. Introduction

As an emerging product of the rapid development of artificial intelligence and Internet of Things technology, smart home is increasingly favored by consumers. At the same time, the high coupling of user needs in time, space and emotion also promotes the continuous service innovation of smart home companies relying on the established product technology foundation and product advantages (Burton et al., 2017). As an intangible activity to develop new service components or service models, service innovation also makes consumers have new emotional trends towards products, making consumers' demand for new services clearer and more urgent (Nijssen et al. 2006). Therefore, the mechanism of action and influence of product service innovation on consumer behavior has aroused extensive attention from academia and practice.

At the same time, the rise of smart home has also aroused consumers' concerns about the disclosure of personal privacy information. Privacy concerns refer to individuals' subjective perceptions of personal privacy in the context of privacy collection, acquisition, and processing (Hanus & Wu, 2016). Privacy concerns in the mobile commerce environment have always attracted widespread attention. Liu Bailing et al. (2018) believe that compared with the traditional business environment, the mobile commerce environment makes it easier for enterprises to obtain users' personal privacy. The acquisition, use and processing of personal privacy information by enterprises will cause users to pay attention to the leakage of personal privacy, which often has an adverse impact on users' willingness to adopt products and services (Kaushik et al., 2018). Through the review of the existing literature, it can be found that the relevant research on privacy concerns by domestic scholars at this stage mainly involves the network social platform and e-commerce platform and other fields (Xiang Liuliu et al., 2018), and the research in the field of smart home is still lacking.

Against the backdrop of the rapid development of smart services, to what extent the service innovation of smart home can further stimulate consumers' willingness to use smart home is a

question worthy of further study. On the one hand, the service innovation of smart home provides consumers with more comfortable and convenient home services, and improves consumers' perception of the effect of smart home. On the other hand, the continuous service innovation of smart home has also made consumers feel more intrusive and threatening in the process of using them. Therefore, the first key question explored in this study is to construct two partial mediation models and a chain mediation model to explore the mechanism of action that exists between smart home service innovation and consumers' willingness to use by introducing perceived value and perceived intrusiveness as mediators. In addition, the second key issue clarified by this study is to introduce privacy concerns as a moderator variable, to explore the moderating role of privacy concerns in the two partial mediation paths, and to analyze how consumers' individual concerns about privacy potentially affect consumers mental perception, and ultimately have an effect on the willingness to use smart homes.

To sum up, this study will explore the impact of smart home service innovation on consumers' willingness to use through three mediation paths, and explore the moderating role of privacy concerns in some of the mediation paths. At the same time, this paper collects data in the form of questionnaires by selecting smart home users and potential users, and uses structural equation model to conduct empirical tests. With theoretical support and data support, this paper deeply analyzes the mechanism of action between service innovation and consumers' willingness to use., and provide a reasonable reference for the production and operation of related enterprises.

2. Literature Review and Hypotheses

2.1 Smart home service innovation and consumers' willingness to use

Jan (2005) pointed out that service innovation refers to the process of improving the value of products and services in order to meet the diverse needs of consumers. The core of service innovation is to be oriented to the needs of consumers, which is essentially the innovation of products and services in the interaction with consumers. It can be seen that service innovation is an activity that requires close cooperation between enterprises and consumers, and can achieve "win-win" activities between enterprises and consumers. In terms of the role of service innovation, the research of Jian Zhaoquan and Xiao Xiao (2015) pointed out that service innovation and value co-creation are closely linked and complement each other, which can promote in-depth cooperation between consumers and enterprises and achieve greater value. The research of Lu Junyi and Wang Yonggui (2011) further emphasized that consumer-centric service innovation can further improve innovation performance, better help companies meet consumer needs, and influence consumers' behavioral intentions.

Smart home refers to home products equipped with intelligent technology, which aims to provide users with intelligent, personalized and high-quality services, can anticipate and respond to the needs of occupants, and make people's lives more comfortable and convenient (Aldrich, 2003; Marikyan et al., 2019). The smart home service innovation involved in this research mainly refers to the service innovation of the intelligent aspect of the smart home. According to the research of Henkens (2020), the smart home service innovation is divided into four dimensions: (1) Consciousness, which refers to the Innovate the ability of smart homes to perceive intelligent service system and surrounding environment information; (2) Connectivity, which refers to innovations in the ability of smart homes to connect consumers, enterprises and other devices through the Internet of Things; (3) Motivation, which refers to innovations in the ability of smart homes to independently make decisions and actions based on computing systems; (4) Driving force, which refers to the innovation of the learning and adaptability of smart home. Service innovation for smart home can further consumers' demand for smart home smart services (Henkens, 2020), and will make potential consumers have positive behavioral intentions for smart home services (Yang et al., 2017). Therefore, the following assumption is made:

H1: Smart home service innovation can significantly and positively influence consumers' willingness to use.

2.2 Mediating role of perceived value

Zeithaml (1988) pointed out that perceived value refers to the trade-off between the perceived benefit and the cost paid by consumers when purchasing a product or service, and based on this, the overall utility perception of the product or service is obtained. Consumer demand-oriented smart home service innovation can further improve the intelligence of smart homes and provide consumers with more convenient and comfortable services (Henkens, 2020), thereby enhancing consumers' perceived benefits and improving Consumer perceived value. Therefore, the following assumption is made:

H2: Smart home service innovation can significantly and positively affect perceived value.

According to the value acceptance model VAM proposed by Kim et al. (2007), when consumers choose to accept an information system, they will comprehensively evaluate their perceived benefits and perceived costs, that is, perceived value, and at the same time, perceived value will directly affect consumers' acceptance intentions. The research of Li Zongwei and others (2017) pointed out that perceived value has an important influence on consumers' behavioral intentions (such as adoption intention, use intention, purchase decision, etc.); He Jianmin and Pan Yongtao (2015) and Zheng Chengde et al. (2012) also confirmed that, When consumers' perceived value of a service is higher, it is easier to generate positive adoption intentions for the service. Therefore, the following assumptions are made:

H3: Perceived value can significantly and positively influence consumers' willingness to use smart home

Combined with the above assumptions, this paper believes that when enterprises innovate services for smart homes, their awareness, connectivity, initiative, and driving force will be further improved, which can provide consumers with more comfortable and convenient services and improve the perceived value of consumers, so that consumers have positive behavioral intentions when they choose to use smart home. Therefore, the following assumptions are made:

H4: Perceived value plays a mediating role between smart home service innovation and willingness to use, that is, smart home service innovation enhances perceived value, which in turn increases consumers' willingness to use.

2.3 Mediating role of perceived intrusiveness

Edwards et al. (2002) believed that perceived intrusiveness refers to the sense of intrusion and threat that consumers generate when using smart products or services. Taking the intelligent service system as an example, the research of Bieke et al. (2020) pointed out that with the higher the degree of intelligence, smart homes will increasingly collect, share, and use personal data, thereby enhancing consumers' perceived intrusiveness. According to the theory of technological threat avoidance by Liang and Xue (2009), in the process of using smart home, consumers may obtain personal information without control, resulting in a certain perceived intrusiveness and inducing avoidance behavior intention of consumers. Therefore, the following assumptions are made:

H5: Smart Home Service Innovation Can Significantly Positively Impact Perceived Intrusiveness

According to Brehm's (1996) psychological reversal theory, when individuals perceive that their freedom is violated or threatened, a series of reactions will occur. Rippetoe & Rogers (1987) pointed out that when consumers' sense of threat and intrusion intensifies, they will adopt positive behaviors to get rid of this negative emotion and reduce or avoid behaviors that cause a sense of threat. Based on psychological reversal theory, the study of Quick et al. (2015) also confirmed that consumers will respond to perceived intrusiveness by changing their use and purchasing decisions for a certain commodity or service. The research of Zhang et al. (2017) pointed out that in intelligent services represented by online health consultation, the perceived intrusiveness of personal privacy security will hinder consumers' willingness to use such services. Therefore, this paper proposes the following assumptions:

H6: Perceived intrusiveness can significantly negatively affect consumers' willingness to use.

Combining the assumptions put forward by H1, H5, and H6, this paper believes that when enterprises innovate smart home services, the functions of smart home products are more powerful, and the degree of participation in personal life is further improved. Consumers may concern about information privacy create a sense of intrusion and threat, and this negative perception will prompt consumers to avoid and reject when choosing to use smart homes, thereby reducing their willingness to use smart homes in order to eliminate negative emotions. That is to say, smart home service innovation will enhance consumers' perceived intrusiveness, which in turn will have a negative impact on the willingness to use smart home. Therefore, the following assumptions are made:

H7: Perceived intrusiveness plays a mediating role between smart home service innovation and usage intention, that is, smart home service innovation enhances perceived intrusiveness, thereby reducing usage intention

2.4 Chain mediation role of perceived intrusiveness and perceived value

The advancement of technology and the development of science and technology are a double-edged sword for enterprises. Taking smart home service innovation as an example, on the one hand, enterprises can provide consumers with more comfortable and convenient services according to the needs of consumers, thereby Increasing consumers' willingness to buy. On the other hand, technological advances and innovations have also increased consumers' concerns about the invasion of their own private information by smart services, which may lead to a willingness to avoid behavior in order to combat the sense of intrusion (Inman & Nikolova, 2017).

At the same time, the studies of Hew et al. (2018) and Sun Yongbo et al. (2018) also confirmed that consumers' perceived intrusiveness, as a negative factor, may weaken the perceived value of a product or service. Therefore, when enterprises have innovated services for smart homes, this objective event may make consumers feel the penetration of smart home products into personal life and the threat to personal privacy, thereby strengthening the perception of intrusiveness; at the same time, this negative The sentiment of consumers may make consumers think that smart home service innovation has brought more losses to them, which in turn affects consumers' trade-off between perceived benefits and perceived costs, and also affects consumers' willingness to use smart homes. Therefore the following assumptions are made:

H8: Perceived intrusiveness and perceived value play a chain mediating role between smart home service innovation and intention to use

2.5 Moderating role of privacy concerns

This paper mainly involves the smart home industry, which is closely related to the Internet of Things, big data, etc. The privacy studied mainly refers to the information privacy of consumers. According to the concept of online privacy concerns proposed by Hong and Thong (2013), "Internet users' concerns about the collection, storage, transmission and use of users' personal information by websites", privacy concerns in this paper are defined as the degree to which consumers are concerned about the security of personal information when using smart homes.

In today's smart home use process, consumers must provide personal information before they can use a product or service, which affects consumers' experience to a certain extent. The smart home also has a deeper access to consumers' personal information, not only limited to demographic characteristics, but also includes more detailed personal identification information, daily habits and behavioral preferences. Some studies have pointed out that privacy concerns can affect consumers' perceived benefits, costs, risks and fairness from a service (Krishen et al., 2017). Therefore, privacy concerns for smart homes should be taken seriously. From the perspective of cognitive response, the higher the level of privacy concerns, the higher the risk beliefs of consumers will be (Miltgen, 2016), which may lead to consumers' unpredictability and control over the use of personal information, which in turn makes consumers stronger Behavioral willingness to protect personal privacy (Bansal et al., 2016), resulting in risk-averse psychology or behavior.

Therefore, this study believes that when consumers' privacy concerns are high, the improvement of intelligence brought by smart home service innovation (such as enhanced mobility, enhanced connectivity with other devices, etc.) may not have an excessively positive impact on consumers' perceived value, but may instead strengthen consumers' sense of threat and intrusion due to concerns about information security, and then influence and adjust the willingness to use smart home. That is, the positive impact of privacy concerns on reducing the perceived value of smart home service innovation and the positive impact of enhancing smart home service innovation on perceived intrusiveness. And on this basis, it has a moderating effect on the partial mediation of perceived value and perceived intrusiveness between smart home service innovation and willingness to use. Therefore, this paper proposes the following assumptions:

H9: Privacy concerns partially mediate the relationship between smart home service innovation and willingness to use by reducing the positive impact of smart home service innovation on perceived value.

H10: Privacy concerns partially mediate the relationship between smart home service innovation and usage intention by enhancing the positive impact of smart home service innovation on perceived intrusiveness.

In summary, the research model of this paper is shown in Figure 1.

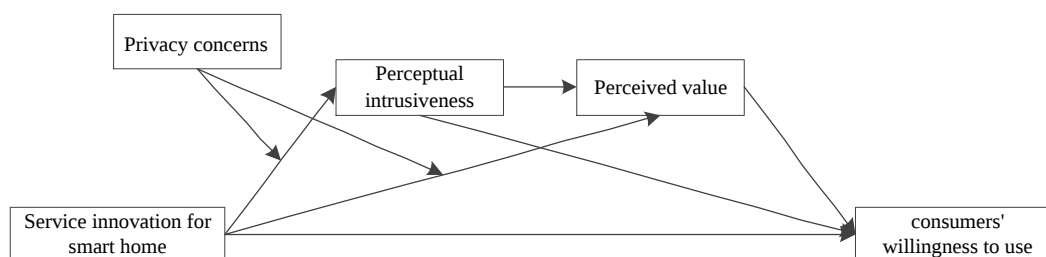


Figure 1. Research model

3. Research Design

3.1 Variable Measurement Tools

In order to ensure the reliability and validity of the questionnaire, this study used mature scales published in mainstream journals at home and abroad and validated in the Chinese context when measuring variables. All English scales use a unified translation-back-translation procedure to avoid unclear meaning or ambiguity as much as possible. All scales are scored using the Likert 5-point scale.

The scale of smart home service innovation is derived from the research of Henkens et al. (2020), including 12 items such as "smart home is innovative in focusing on itself and the environment". The reliability coefficient (Cronbach's α) of the scale is 0.964; the scale of perceived value is derived from the research of Zheng Chengde et al. (2012), including 4 items such as "using smart home and paying for it makes me feel value for money". The reliability coefficient of this scale is 0.874; the scale of perceived intrusiveness is derived from the study of Henkens et al. (2020), including 5 items such as "I think smart home will interfere with my life", the reliability coefficient of the scale is 0.959; The scale of willingness to use is derived from the research of Hsu et al. (2007), including 3 items such as "I think smart home is worth using", and the reliability coefficient of the scale is 0.935; The scale of privacy concerns is derived from studies by Bansal et al. (2016) and Dinev (2006), including "I am worried that the information I submit on my smart home may be abused." and other 4 items, the confidence of the scale The degree coefficient is 0.894. The reliability of the above scales is good.

3.2 Questionnaire Design

The questionnaire of this study consists of two parts, the first part is demographic information; the second part is a scale of five core variables of smart home service innovation, perceived value, perceived intrusiveness, willingness to use, and privacy concerns, including a total of 28 item.

Using the initial questionnaire to conduct pre-research to evaluate its reliability and validity, 121 questionnaires were collected in the pre-investigation stage, and the analysis results are as follows: Cronbach's α coefficients of smart home service innovation, perceived value, perceived intrusiveness, willingness to use, and privacy concerns are all greater than 0.7, indicating that the reliability of each scale is good; KMO value is greater than 0.5, the Bartlett sphericity test results are all significant at the 0.001 level, indicating that the validity of each scale is good. According to the feedback in the pre-investigation, some sentences and words of the questionnaire were fine-tuned again, and finally a formal questionnaire was formed.

3.3 Data collection

The formal survey of this study is distributed through the Questionnaire Star platform. The respondents are mainly from Hubei, Shandong, Zhejiang and other places, and a total of 396 valid questionnaires were collected. The basic information of the samples is shown in Table 1. The proportion of men and women in the survey is moderate, and the gender distribution is balanced; the age is mostly concentrated in 18-45 years old, mainly young and middle-aged, most of them have a bachelor's degree or a college degree; their monthly income or living expenses are mostly more than 6,000 yuan.

Table 1. Distribution of demographic characteristics of the sample

category		sample size	percentage
Gender	male	195	49.2%
	Female	201	50.8%
Age	under 18	20	5.1%
	18-30 years old	179	45.2%
	31-45 years old	147	47.1%
	46-60 years old	39	9.8%
	over 60 years old	11	2.8%
Education	Primary school and below	2	0.5%
	junior high school	6	1.5%
	high school or vocational school	26	6.6%
	Undergraduate or junior college	330	83.3%
	Master degree and above	32	8.1%
Monthly income/living expenses	2000 yuan and below	81	20.5%
	2000-4000 yuan	54	13.6%
	4000-6000 yuan	59	14.9%
	6000-8000 yuan	92	23.2%
	More than 8000 yuan	110	27.8%

4. Data Analysis and Results

4.1 Questionnaire reliability and validity test

By calculating the results of the internal consistency of the scale, it can be seen that the Cronbach's α coefficient value of each variable is greater than the critical value of 0.7, indicating that the reliability of the scale used is good. At the same time, the factor loading coefficients of all items are significant and greater than 0.5; the CR values of each variable are greater than the critical value of 0.7, indicating that the measurement has high combined reliability. And the KMO value of each variable is greater than 0.6 at the significance level of $p < 0.05$, indicating that the scale has good convergent validity.

Table 2. Reliability and validity test results

	Cronbach's α	C.R.	AVE	KMO
Smart Home Service Innovation	0.884	0.827	0.504	0.905
Perceived value	0.820	0.745	0.522	0.803
Perceptual intrusiveness	0.944	0.901	0.694	0.909
Privacy concerns	0.932	0.898	0.689	0.863
Willingness to use	0.855	0.821	0.605	0.733

4.2 Common method bias test

The subjects filling out the questionnaire in a self-assessment way may lead to the problem of common method bias, so it needs to be tested for common method bias. Harman's single-factor method was used to test (Podsakoff et al., 2003), and the results showed that the total variance explained for all factors with eigenvalues greater than 1 is 65.033%, and the variance explained for the first principal component is 26.905%, so it is considered nonexistent Serious common method bias problem.

4.3 Variable Descriptive Statistical Analysis

The mean, standard deviation and correlation coefficient of each main variable are shown in Table 3. It can be obtained from the table: smart home service innovation is significantly positively correlated with willingness to use, significantly positively correlated with perceived value, and significantly positively correlated with perceived intrusiveness; perceived value is significantly positively correlated with willingness to use, and significantly negatively correlated with perceived intrusiveness; perceived intrusion Sexuality is significantly negatively correlated with willingness to use; privacy concerns is significantly negatively correlated with perceived value and positively correlated with perceived intrusiveness. The results of correlation analysis between variables preliminarily verified the research hypothesis of this paper.

Table 3. Correlation analysis results

Variable	1	2	3	4	5	6	7	8	9
Gender	1								
Age	-0.149**	1							
Education	0.081	0.133**	1						
Monthly income	-0.131**	0.507**	0.181**	1					
Smart home service innovation	-0.036	0.046	-0.054	0.082	1				
Perceived value	-0.045	0.078	-0.038	0.188**	0.597**	1			
Perceptual intrusiveness	-0.016	-0.269**	-0.093	-0.278**	0.141**	-0.106**	1		
Willingness to use	-0.017	0.115*	0.042	0.172**	0.485**	0.503**	-0.107**	1	
Privacy concerns	0.073	-0.110*	0.108*	-0.185**	-0.037	-0.114**	0.280**	0.046	1
Mean	1.510	3.280	3.970	3.240	3.862	3.972	2.129	3.485	4.146
Standard deviation	0.501	1.187	0.502	1.498	0.624	0.716	1.081	1.169	0.771

4.4 Hypothesis test

(1) Mediation model test

Before testing the mediation model, the goodness of fit of the model is tested. The basic model (Model 1), the nested model (Model 2) and the surrogate model (Model 3) were constructed by the structural equation modeling method using Amos17.0 software for comparison. In Model 1, there is no direct effect between smart home service innovation and willingness to use; Model 2 adds a direct path from smart home service innovation to willingness to use on the basis of Model 1; there is no mediation effect in Model 3.

First, Model 1 and Model 2 are nested Mediation models and should be compared through the goodness-of-fit index. The results showed that some indicators in model 1 did not reach acceptable levels ($\chi^2/df=2.977$, CFI=0.906, TLI=0.895, RMSEA=0.071, RMR=0.059), and the fitting indicators of model 1 are not as good as those of model 2 ($\chi^2/df=2.650$, CFI=0.923, TLI=0.913, RMSEA=0.065, RMR=0.053). To further compare the chi-square changes of model 1 and model 2, the results show

that the chi-square changes are significant ($\Delta\chi^2(1)=88.846, p<0.05$), and a complex path model with better fitting results should be selected, that is, an increase of The direct effect significantly improves the model fit, and model 2 is better than model 1.

Second, and further compare Model 2 and Model 3. The results showed that the relevant indicators of Model 3 did not reach acceptable levels ($\chi^2/df=3.670$, CFI=0.872, TLI=0.858, RMSEA=0.082, RMR=0.152), Further compare the Bayesian Information Criterion (BIC) of the two models, the BIC of Model 2 is 981.548, the BIC of Model 3 is 1159.680, $\Delta BIC=178.132>10$, therefore, Model 2 with a smaller BIC is better than Model 3 (Vrieze, 2012).

To sum up, in this study, the nested model (Model 2) can more effectively reflect the data relationship between variables than the basic model (Model 1) and the alternative model (Model 3).

Table 4. Structural equation model comparison test

Model	χ^2/df	CFI	TLI	RMSEA	RMR
Base Model (Model 1)	2.977	0.906	0.895	0.071	0.059
Nested Models (Model 2)	2.650	0.923	0.913	0.065	0.053
Alternative Model (Model 3)	3.670	0.872	0.858	0.082	0.152

In order to test the hypotheses proposed above, this study used structural equation modeling on the basis of controlling four demographic variables, including gender, age, education level, and monthly income, combined with the Bootstrap method proposed by Preacher et al. (2004) and Hayes et al. (2013), and used the Process plugin to test the mediating effect, and obtained the following results (see Table 5, Figure 2 for details):

①The path coefficient of smart home service innovation willingness to use is (c) 0.376 ($p<0.001$), indicating that smart home service innovation can significantly positively affect willingness to use smart home, and H1 passes the test.

②The path coefficient of smart home service innovation $\rightarrow$ perceived value is (a1) 0.768 ($p<0.001$), indicating that smart home service innovation can significantly and positively affect perceived value; the path coefficient of perceived value $\rightarrow$ willingness to use is (b1) 0.354 ($p<0.001$), indicating that perceived value can significantly affect consumers' willingness to use smart home. At the same time, the partial mediating effect of perceived value between smart home service innovation and intention to use is significant ($\beta=0.228$), and the 95% confidence interval of Bootstrap=5000 is [0.130, 0.337]. In summary, H2-H4 passed the test.

③The path coefficient of smart home service innovation $\rightarrow$ perceived intrusiveness (a2) is 0.262 ($p<0.01$), indicating that smart home service innovation can significantly positively affect perceived intrusiveness; the path coefficient of perceived intrusiveness $\rightarrow$ willingness to use (b2) is: -0.094 ($p<0.01$), indicating that perceived intrusiveness can significantly negatively affect consumers' willingness to use smart homes. At the same time, the partial mediating effect of perceived intrusiveness between smart home service innovation and intention to use is significant ($\beta=-0.030$), and the 95% confidence interval of Bootstrap=5000 is [-0.083, -0.003]. In summary, H5-H7 passed the test.

④The path coefficient of perceived intrusiveness $\rightarrow$ perceived value (d) is -0.075 ($p<0.01$), indicating that perceived intrusiveness can significantly negatively affect perceived value, that is, when consumers' perceived intrusiveness is higher, their perceived value is lower. At the same time, the chain mediating effect of perceived intrusiveness and perceived value between smart home service innovation and willingness to use is significant ($\beta=-0.006$), the 95% confidence interval of Bootstrap=5000 is [-0.015, -0.001], H8 passes test. (Note: The data in the above figure are obtained from two analyses: the results of the mediation model and the test of the moderating effect of the interactive items of smart home service innovation and privacy concerns on perceived value and perceived intrusiveness)

Table 5. The results of the mediation effect test of the Bootstrap method

Action path	direct effect			indirect effect		
	Effect size	95% confidence interval		Effect size	95% confidence interval	
		Lower limit	Upper limit		Lower limit	Upper limit
X-M1-Y				0.233	0.126	0.338
X-M2-M1-Y	0.397	0.269	0.525	-0.005	-0.014	-0.003
X-M2-Y				-0.026	-0.077	-0.002
Total indirect effect				0.193	0.077	0.320

(Note: X refers to smart home service innovation, M1 refers to perceived value, M2 refers to perceived intrusiveness, and Y refers to willingness to use)

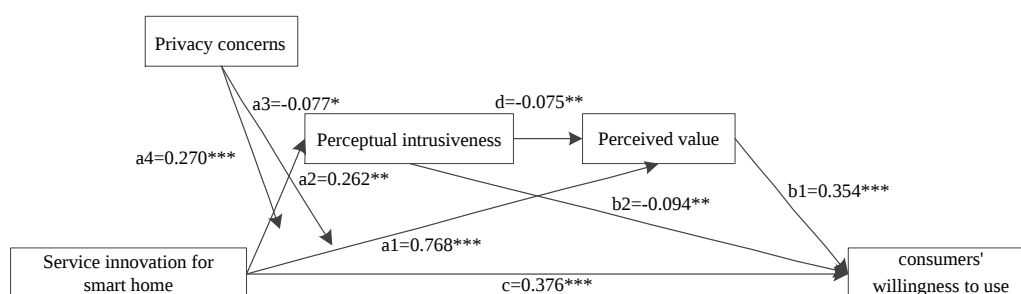


Figure 2. Path coefficient model diagram

(Note: The data in the above figure are obtained from two analyses: the results of the mediation model and the test of the moderating effect of the interactive items of smart home service innovation and privacy concerns on perceived value and perceived intrusiveness)

(2) Moderating effect test

The independent variables and moderator variables are centrally processed to eliminate the collinearity problem, and the first-stage moderating effect test s carried out on the basis of controlling the demographic variables, and the following results are obtained:

①The impact path of the interaction item of smart home service innovation and privacy concerns on perceived value (a3) was significant ($\beta=-0.077$, $p<0.05$), indicating that privacy concerns significantly negatively adjusted the relationship between smart home service innovation and perceived value. According to the method of Aiken et al. (1991), a graph for the analysis of the moderating effect of the first stage was drawn, as shown in Figure 3.the results show that when the degree of privacy concern is low, smart home service innovation has a stronger positive impact on perceived value ($\beta=0.747$, $t=6.985$, $p<0.001$). Conversely, when the degree of privacy concern is higher, the positive impact of smart home service innovation on perceived value is weaker ($\beta=0.567$, $t=6.895$, $p<0.001$), but still reaches a significant level. It shows that when consumers' privacy concerns are stronger, the positive impact of smart home service innovation on perceived value is weakened.

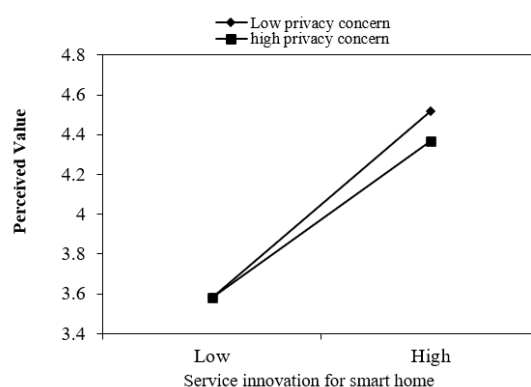


Figure 3. Moderating Effect Diagram (Privacy Concerns on Smart Home Service Innovation and Perceived Value)

②The influence path of the interaction item between smart home service innovation and privacy concern on perceived intrusiveness (a4) is significant ($\beta=0.270$, $p<0.001$), indicating that privacy concerns significantly and positively moderated the relationship between smart home service innovation and perceived intrusiveness. Same as above, draw the analysis diagram of the moderating effect in the first stage, see Figure 4 for details. The results show that when the degree of privacy concern is low, the impact of smart home service innovation on perceived intrusiveness is weak ($\beta=0.030$, $p>0.05$), and it fails the test; on the contrary, when the degree of privacy concern is higher, the smart home service innovation had a stronger positive effect on perceived intrusiveness ($\beta=0.662$, $t=8.047$, $p<0.001$). It shows that when consumers' privacy concerns are stronger, the positive impact of smart home service innovation on perceived intrusiveness will increase.

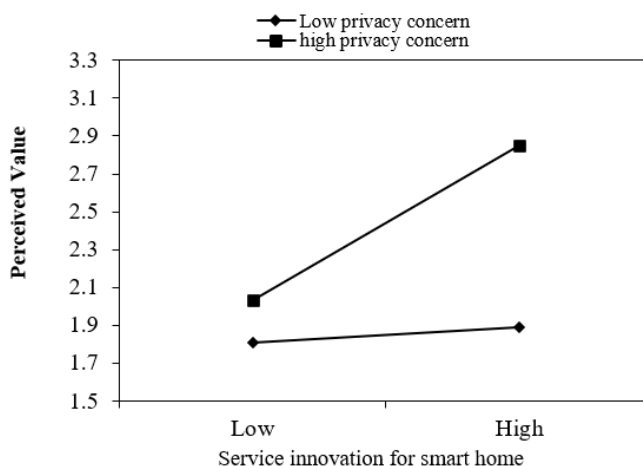


Figure 4. Moderating effect diagram in the first stage (privacy concerns on smart home service innovation and perceived intrusiveness)

To further test H9 and H10, this paper refers to the method proposed by Hayes et al. (2013) to examine the size of the moderated mediating effect, and use the Bootstrap method by running the Process program to obtain the confidence interval at 95% significance when the privacy concern is at three levels of low, medium and high. The results are shown in Table 5.

It can be seen that when consumers' privacy concern level is low, smart home service innovation has a significant impact on the willingness to use through perceived value ($\beta=0.747$, $p<0.001$), with a confidence interval of [0.642, 0.851]. When consumers' privacy concerns are high, smart home service innovation has a significant impact on willingness to use through perceived value ($\beta=0.568$, $p<0.001$), with a confidence interval of [0.440, 0.695], so there is a moderated mediating effect, H9 passed the test. When consumers' privacy concerns are low, the impact of smart home service innovation on the willingness to use through perceived intrusiveness is not significant ($\beta=0.030$, $p>0.05$), and the confidence interval is [-0.153, 0.213], indicating that the indirectly effect is not significant; but when consumers' privacy concerns are high, smart home service innovation has a significant impact on the willingness to use through perceived value ($\beta=0.662$, $p<0.001$), with a confidence interval of [0.439, 0.886]. Therefore, there is a moderated mediating effect, and H10 passes the test.

Table 6. Mediating effects and confidence intervals of Bootstrap method at different levels of moderator variables

Privacy concerns	Conditional Mediating Effects of Perceived Value	willingness to use				
		95% confidence interval		Conditioning Mediating Effects of Perceived Intrusiveness	95% confidence interval	
		lower limit	upper limit		lower limit	upper limit
2.316	0.747***	0.642	0.851	0.030	-0.153	0.213
3.486	0.657***	0.565	0.749	0.346***	0.184	0.508
4.655	0.568***	0.440	0.695	0.662***	0.439	0.886

5. Conclusion and Discussion

5.1 Conclusion

Smart home service innovation has a significant positive impact on consumers' willingness to use, that is, the higher the level of smart home service innovation, the stronger the consumer's willingness to use. Smart home service innovation, as a positive innovative behavior, on the one hand brings consumers a more convenient smart home operating experience, and on the other hand brings consumers a better performance experience and a smarter service environment. This increases the willingness of consumers to accept and use smart homes.

Perceived value and perceived intrusiveness have a mediating role in the positive impact of smart home service innovation on consumers' willingness to use. First, smart home service innovation has a positive impact on the willingness to use by improving consumers' perceived value. Smart home service innovation has brought better services and increased the gap between consumers' perceived benefits and perceived costs. The improvement of perceived value directly affects consumers' positive adoption intentions and increases consumers' willingness to use smart homes. Second, smart home service innovation has a negative impact on the willingness to use by aggravating consumers' perceived intrusiveness. The intelligence of smart homes means more transmission and storage of usage data and personal information, which invisibly increases consumers' perceived intrusiveness and further reduces consumers' willingness to use. Third, perceived intrusiveness and perceived value have a chain mediating role in the positive impact of smart home service innovation on consumers' willingness to use. This penetration into personal life and the threat to personal privacy will make consumers re-evaluate the personal gains and losses brought by service innovation. This affects consumers' trade-off between perceived benefits and costs brought by service innovation, that is, affects consumers' perceived value. Finally, through research, it is found that although perceived intrusiveness reduces consumers' initial willingness to use, consumers still have a high willingness to use smart homes after judging the perceived value.

Privacy concerns play a moderating role in the two mediation paths of perceived intrusion and perceived value to willingness to use. When consumers' privacy concerns are higher, the positive effect on perceived intrusiveness is stronger, while the positive effect on perceived value is weaker. Consumers are more concerned about privacy, and the more vigilant they are about privacy leakage caused by smart home service innovation, the lower the perception of new benefits brought by service innovation, which leads to different adjustment effects of the two mediation paths.

5.2 Theoretical significance

(1) This study re-interprets the mechanism between smart home service innovation and consumers' willingness to use from the perspective of consumer perception, and provides a new perspective for exploring service innovation activities. Existing research focuses on the methods and ways of positive impact of service innovation on consumer behavior intentions, but ignores the negative mechanisms that may be caused by service innovation and related countermeasures. Therefore, this study fills the deficiencies of current related research from a positive perspective to a certain extent, and also helps researchers to explore various inducing mechanisms of service innovation from different research perspectives.

(2) This study verifies the influence of smart home service innovation on consumers' willingness to use by constructing a chain mediation model of "smart home service innovation → perceived intrusiveness → perceived value → consumer willingness to use" and two moderated partial mediation models. It innovatively verifies the logical relationship and conduction mediation between various variables from a theoretical and empirical perspective, which enriches the research on the impact mechanism of service innovation to a certain extent.

(3) By exploring the moderating effect of privacy concerns on the two partial mediation models, this study verifies in detail the different roles of privacy concerns in service innovation → perceived value paths and service innovation → perceived intrusiveness paths. The study confirms the positive

impact of privacy concerns on perceived intrusiveness and negative impact on perceived value, which further broadens the application scope of privacy concerns related theories in service marketing.

5.3 Practical inspiration

(1) Smart home manufacturers should pay attention to the negative impact of perceived intrusiveness on consumers' willingness to use, explore the incentives for intrusive perception, and improve consumers' perception environment. Smart home service innovation should start with a more convenient and comfortable home life to improve the quality of life of consumers. In addition, smart homes should try to avoid consumers' discomfort due to excessive innovation, and should be closer to consumers' daily lives, starting from a humanized home, to trigger consumers' emotional resonance.

(2) Smart home manufacturers should pay attention to the positive impact of perceived value on consumers' willingness to use, improve consumers' benefit perception, and focus on reducing consumers' cost perception. First of all, smart home manufacturers can reduce the time cost of consumers in home life through more convenient operations and smarter use modes. By improving the ecological chain of smart homes, smart home manufacturers can broaden the links between smart homes and improve the convenience of communication between consumers and smart homes. Also, smart home manufacturers should improve the individuation, humanization, intelligence, comfort and other aspects of smart homes to enhance the initiative and awareness of smart homes.

(3) Smart home manufacturers should adopt a variety of methods to ensure the safety of consumers' personal privacy information and usage data. Smart home manufacturers should build a reliable and effective information protection system, strict rules and regulations and management system to ensure non-interference and private use of consumer information and data within the enterprise, and establish a strict accountability system to ensure consumer data security. Smart home manufacturers should strengthen technical means, establish multiple data protection systems, prevent illegal data theft and use, and sign privacy protection contracts with consumers, reduce consumers' concerns about personal privacy leakage, and alleviate consumer resistance to smart homes due to privacy concerns.

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