SMART HOUSEHOLD APPLIANCES - CRITERIA INFLUENCING RESISTANCE AND ADOPTION

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Abstract - The diffusion of smart household appliances worldwide is lower than predicted. The aim of this study is to understand why. Regression analysis based on 1665 consumers from Germany and South Africa found that both resistance and adoption are influenced by how intrusive the smart appliance is, how the consumer perceives its usefulness and whether it is considered novel or new. The perceived price of the smart appliance also played a role in adoption. Adoption is not the inverse of resistance when considering the constructs in their totality. Consumer innovativeness, influenced by uncertainty avoidance, also played a significant role both resisting and adopting smart products.

Keyword - Resistance, Adoption, Smart Products, Perceived Risk, Nostalgia, Spirit of Innovation

I. INTRODUCTION

Internet of things (IoT) are network-connected devices and systems, allowing for the collection and exchange of data (Hsu & Lin 2016; Meola 2016) and are growing into a substantial industry with the opportunity to transform society. Various authors have studied the possible reasons why IoTs have been resisted and not adopted to the predicted levels (Balta-Ozkan, Davidson, Bicket & Whitmarsh 2013; Coughlin, D'Ambrosia, Reimer & Pratt 2007; Hong, et al. 2020; Hsu & Lin 2016; Kim, Park & Choi 2017; Leong, Ping & Mutheveloo 2017; Mani & Chouk 2017; Mayer, Volland, Thiesse & Fleisch 2011; Paetz, Dütschke & Fichtner 2011; Pillai & Sivathanu 2020; Roy, Balaji, Quazi & Quaddus 2018). Some studies have considered the adoption of or resistance to IoT services in homes (Hsu & Lin 2016; Hong, et al. 2020). However, very few have concentrated on smart household appliances specifically (Mani & Chouk 2017) or considered both adoption and resistance in the same study. As most previous studies have focused on the adoption, this study includes exploring both adoption of and resistance to smart household appliances to gain insight into whether adoption is indeed the opposite of resistance. Innovation and consumer characteristics are typically studied to understand why smart household appliances are resisted and not adopted. Other variables, such as the perceived risk of adoption and personality considerations, also play a role in this research.

II. RESEARCH QUESTIONS

The research objectives that guide this paper are:

- To determine whether the innovation characteristics of perceived uselessness, perceived novelty, perceived price and intrusiveness influence consumer resistance to or adoption of smart household appliances.
- To establish whether the consumer characteristics of privacy concerns, dependence, and self-efficacy influence consumer resistance to or adoption of smart household appliances.
- To ascertain whether perceived risk, such as social and security risk, influence consumer resistance to or adoption of smart household appliances.
- To reveal whether the personality constructs of consumer innovativeness and nostalgia influence consumer resistance to or adoption of smart household appliances.

III. THEORETICAL FRAMEWORK

A smart appliance is a material piece of equipment with the ability to communicate. It has a distinctive identifier, basic computing proficiencies and the ability to discover other pieces of equipment connected to the same network. The objects co-operate with humans and other objects or devices over the internet, allowing smart appliances to mix with the internet forming a vast network of related objects. This affords the consumer better suitability in bonding to and interacting with the system (Hsu & Lin 2016). Thus, smart household appliances are equipped with sensors that collect data about the environment and take action based on communication received from other entities through network connectivity, including Wi-Fi, Bluetooth, or Radio-frequency identification (RFID). The smart appliance market is diverse with several sectors such as health, mobility, lifestyle, wearables and smart household appliances, among others (Mani & Chouk 2017).

The theoretical framework of this study is based on the work of Ram and Sheth (1989) and Mani and Chouk (2017). They categorized the resistance to smart household appliances adoption according to functional barriers caused by product (innovation) cha-

racteristics and psychological barriers resulting from consumer characteristics. To understand these barriers, it is essential to consider the various constructs of consumer personality, such as consumer innovativeness (spirit of innovation) and nostalgia. These serve as indicators of buyer behaviour in the smart house appliances context (Aldás-Manzano et al. 2008). Perceived risk is not only multidimensional but is also a potential deterrent to innovation adoption. The two risk dimensions most applicable to a smart house appliance context are security risk (Leong et al. 2017) and social risk (Hirunyawipada & Paswan 2006).

There are various types of resistance to and barriers to adoption. These are reviewed with specific reference to the dimensions of innovation resistance. The dimensions include innovation characteristics such as perceived uselessness, novelty, price and intrusiveness, and consumer characteristics such as privacy concerns, dependence and self-efficacy. However, some authors argue that specific types of perceived risks also influence resistance to innovation (Hirunyawipada & Paswan 2006; Leong et al. 2017; Ooi & Tan 2016). These are specifically social and security risks. While consumer resistance to innovation is influenced by innovation and consumer characteristics and perceived risks, there are two personality considerations or traits that may also affect resistance and adoption. The first trait is domain-specific innovativeness which refers to the inclination to buy new products such as smart appliances. The second trait is nostalgia.

Following, specific dimensions of consumer resistance to and adoption of innovation are discussed.

a) Innovation characteristics

Perceived usefulness is the "degree of improvement in a persons' performance when using a new technology" (Mani & Chouk 2017:83). This perception means that the more useful a smart appliance is to a consumer, the more likely they are to adopt it (Chang & Chen 2021). Perceived usefulness is how the consumer thinks they will benefit from using the smart appliance in the future (Tsourela & Nerantzaki 2020). Perceived novelty refers to how any innovation is considered unique or different, i.e. novel (Venkatraman & Price 1990). The novelty may be a significant change in the product idea or merely a change to the product's attributes. Previous research has found novelty to positively influence a consumer's attitude towards an IT innovation (Mani & Chouk 2017). Perceived price relates to how a consumer feels about the price of a product. It must be noted that the value of the new product influences how the price is perceived (Mani & Chouk 2017). The price value is a mental compromise between the smart appliance's perceived benefits and the cost of using them. When the benefits of using the smart appliance outweigh the monetary cost, the value derived from using the smart appliance positively influences how the monetary cost (price) is perceived (Leong et al. 2017). Intrusiveness typically has an adverse influence on consumers' behaviour as it causes unfavorable emotive responses such as irritation. Intrusion refers to the process whereby a product enters a consumer's life without permission. Smart appliances may be seen as intrusive as they can perform actions without the user's consent (Hoffman & Novak 2015). This ultimately leads to the question of whether the innovation characteristics of perceived uselessness, perceived novelty, perceived price and intrusiveness influence consumer resistance to or adoption of smart household appliances comparing. We posit that innovation characteristics negatively influence consumer resistance and positively influence consumer adoption of smart household appliances.

b) Consumer characteristics

Consumer data privacy is a challenge (Mani & Chouk 2017) which is particularly evident in online transactions and which, in turn, will increase with the development of smart appliances. The characteristics of smart appliances include ubiquity, invisibility, pervasiveness and invasiveness. This is because they collect and manage private data and sensitive information (Sicari, Rizzardi, Grieco & Coen-Prisini 2015; Slettemeås 2009). Consumers develop a dependence on the internet and computer-related technology (Hoffman, Novak & Venkatesh 2004), leading to 'technostress'. In the context of this study, dependence refers to consumers' reliance on technology to reach their goals. Self-efficacy refers to the perception a person has of their capability to use a technologically innovative product (Compeau & Higgins 1995), affecting resistance to technological innovation.

c) Perceived risk

Perceived risk may be detrimental to the adoption of innovation (Conchar, Zinkham, Peters & Olavarrieta 2004; Hirunyawipada & Paswan 2006). It is a function of the unexpected adoption results, followed by an outcome different from what was expected. The perceived risk may negatively influence the adoption of smart household appliances as consumers may seek more information to alleviate the sensitivity towards risk or manage the perceived risk. Perceived risk is multidimensional, consisting of various categories of risks, such as financial, performance, privacy, psychological (Hong et al. 2020), and social (Hirunyawipada & Paswan 2006). For consumer electronics, such as smart appliances, social risk for example, may be very salient. This is because high-tech consumer electronics are used with friends and colleagues, and

having the right appliance may be crucial for some consumers (Hirunyawipada & Paswan 2006).
Similarly, security risk may be prevalent in the smart environment (Leong et al. 2017). Security risk 'refers to the perception of protection against risk' (Ooi & Tan 2016:37) 'associated with IoT applications in a smart environment' (Leong et al. 2017: 445).

d) Personality indictors

Consumer innovativeness increases innovation adoption (Foxall 1995; Aldás-Manzano et al. 2008; Seyed Esfahani & Reynolds 2021), and is a personality trait, also referred to as the spirit of innovation (Ailawadi, Neslin & Gedenk 2001). This is a personality trait whereby a person's behaviour towards a product is predicted by understanding the extent to which they are willing to try new things (Mowen 1999). Innovativeness is associated with independence, extraversion, impulsivity, risk-taking, tolerance of ambiguity and flexibility. It is an individual's predisposition towards experimenting with new technologies (Ali, Khalid, Javed & Islam 2021).

Nostalgia is typically a longing for the past, a desire for former times, and a love for belongings and activities connected with earlier years. As such, it is an important phenomenon that affects the preference patterns of consumers (Holbrook 1993). Holbrook & Schindler (1991:330) defined it as "a preference (general liking, positive attitude or favourable effect) toward objects (people, places, or things) that were more common (popular, fashionable, or widely circulated) when one was younger (in early adulthood adolescence, in childhood, or even before birth)." Seifried & Meyer (2010) found harmony between IT innovations and nostalgia. Nostalgia is linked to a nation's identity, in that an intangible display of the nation's identity is promoted by nostalgia (Pajoutan & Seifried 2014). The dimensions and constructs associated with this research are presented in Figure 1.

IV. RESEARCH STRATEGY

A quantitative online research approach was adopted for this study. Non-probability sampling was applied using purposive sampling to reach a total of 1665 respondents. Of this, 974 respondents were from Germany and 691 were from South Africa.
This study adapted the scale of resistance to smart appliances developed and tested by Mani & Chouk (2017). The constructs measured include the seven variables based on the conceptual framework developed by Mani & Chouk. The constructs are privacy concerns, perceived uselessness, self-efficacy, perceived price, intrusiveness, dependence, perceived novelty and resistance, and measuring consumer resistance as a construct (scale items adopted from the Mani & Chouk study). From their research, each of the constructs provided an acceptable or high Cronbach's Alpha score. The scale developed by Aldás-Manzano et al. (2008) was adopted for perceived risk, and only the variables of social and security risk were included. The scales for the personality constructs, consumer innovativeness and nostalgia, were adapted from Ailawadi, Neslin & Gedenk, (2001) and Holbrook (1993), respectively. Adoption was measured by asking respondents to provide the number of smart connected products they owned. According to this method, the actual adoption behaviour is reflected and has high reliability (Lastovicka & Joachimsthaler 1988; Hirunyawipada & Paswan 2006).

V. RESULTS

a) Descriptive statistics, Cronbach's Alphas and CFA

Considering the mean scores in Table 1, most of the respondents saw a smart refrigerator as useful, novel, priced high, and not intrusive. They had concerns regarding privacy and security but remained confident that they were self-efficient in using the appliance and were not concerned that they would depend on the technology. These respondents demonstrated a spirit of innovation, were somewhat nostalgic and had some resistance to the smart refrigerator, although they are likely to consider adopting it. Regarding Cronbach's Alpha all scores but 'perceived novelty' were above 0.57, considered acceptable.

The suitability of CFA was assessed prior to analysis. The inspection of the correlation matrix showed nine variables that had at least one correlation coefficient greater than 0.3 (see Table 2). The two variables that could not be measured were privacy concerns and dependency and were therefore not included. Removing those variables from the CFA resulted in nine clear components with the overall Kaiser-Meyer-Olkin (KMO) measure of 0.93. According to Kaiser (1974), this measure is considered 'marvellous'. Bartlett's test of sphericity was statistically significant ($p < .0005$), indicating that the data was likely factorizable.

b) Regressions

Multiple regression analysis measured the extent to which resistance to and adoption of smart appliances are explained by the independent variables applicable to this study.

Resistance to smart household appliances
With an adjusted r^2 of 64,7%, the statistics for resistance are robust (see Table 3). With the exception of the dimension of social risk (0,093), the total regression and the predictors are highly significant. Similar to adoption, the most substantial influence can be found for intrusiveness (+0,392**) and perceived

uselessness (0,207**), whereas social risk (0,114**), price (+0,066**) and nostalgia (+0,037**) show much lower β-values. As an analogue of adoption, the personal spirit of innovation (-0,160**) and perceived novelty (-0,101**) also have the most substantial adverse influence on resistance. All premises of the regressions are fulfilled. The plot of the standardized residuals against the standardized predicted values shows only a very slight indicator of heteroscedasticity, and the Durbin-Watson value is 1,90. Therefore, autocorrelation and tolerance values are all above 0,49 with no multicollinearity, and the plot of the standardized residuum shows a nearly normal distribution.

Adoption of smart household appliances

The regression with all seven dimensions as independent variables and adoption as dependent variable (table 4), shows a satisfying adjusted r^2 of 48,6%. The complete regression and all Beta values show significant or highly significant results, apart from security risk, which is slightly insignificant (0,056). All β-values show plausible results. Intrusiveness has the most significant negative influence on adoption, followed by perceived price (-0,123**) and perceived uselessness (-0,107**). The most substantial positive impact is identified in the personal spirit of innovation (+0,252**), followed by perceived novelty (+0,197**). All premises of the regressions are fulfilled.

VI. DISCUSSION

Product-specific barriers create resistance caused by innovation (represented by smart appliances) and consumer characteristics. Although it was expected that consumer characteristics (namely privacy concerns, dependence and self-efficacy) might influence the resistance to and adoption of smart appliances, privacy concerns and dependence did not yield satisfactory results, indicating that they are more complex than initially thought. Self-efficacy did yield satisfactory results, but the regression analysis did not significantly influence either the resistance to or adoption of smart appliances in the combined analysis. Intrusiveness had the most significant influence on both their resistance to the smart household appliance and their resultant adoption. Hoffman & Novak (2015) found that intrusiveness typically negatively impacts the behaviour of consumers and makes them feel irritated.

Intrusiveness, perceived uselessness, and perceived novelty, as innovation characteristics, are overall the most important reasons for the resistance to and the adoption of smart household appliances. An individual's personality toward specific buying behaviour is portrayed through a combination of personality characteristics (Mowen 1999). For this reason, personality characteristics need to be explored to understand the barriers caused by innovation and consumer characteristics. These characteristics are measured through a consumer's personality constructs. The personality constructs applicable to this research are consumer innovativeness (spirit of innovation) and nostalgia. Persons with a strong spirit of innovation are risk-takers who increase innovation adoption (Aldás-Manzano et al. 2008). The spirit of innovation negatively influenced consumer resistance and positively influenced adoption. This means that consumers have a strong spirit of innovation (consumer innovativeness) and are likely to adopt smart appliances based on this personality construct.

VII. CONCLUSION

The emergence of smart appliances as part of the growing IoT industry is changing how we interact with the world. However, the uptake of smart household devices is slower than expected. Some of the reasons for this resistance to and adoption of smart appliances are located in the characteristics of both the smart appliance and the consumers. For the consumers, these include those characteristics related to personality. Insights from consumers revealed that the features of the smart appliance influence both the resistance to and adoption of the smart appliance. Resistance is influenced by how intrusive the smart appliance is, how the consumer perceives its usefulness and whether it is considered novel or new. Adoption is influenced by how intrusive the smart appliance is, how it is perceived in terms of usefulness, whether it is deemed novel, and how the consumer perceives the price.

Overall, it was found that adoption is not the inverse of resistance. Although the influence of consumer characteristics on the resistance to and adoption of smart appliances is inconclusive, the personality construct of consumer innovativeness (spirit of innovation) plays a significant role. Uncertainty avoidance also influenced the spirit of innovation.

The importance of the research is fourfold. Firstly, although all of the innovation characteristics were found to influence the resistance to and adoption of smart household appliances, intrusiveness was found to be more significant all around. Further research is needed to understand this particular construct, thereby providing insight to IoT organizations in finding ways to overcome this. Secondly, uncovering that smart household appliances adoption is not merely the inverse of resistance, and especially discovering the particular reasons for each of these, is significant. As some of the results for consumer characteristics were inconclusive, further research is needed to understand the complexities of privacy concerns and dependence. Thirdly, discovering that the personality construct of the spirit of innovation significantly influences resis-

tance negatively and adoption positively recognizes that personality may influence consumer characteristics and warrants further exploration.

It is recommended that the industries associated with smart household appliances, take cognizance of their innovations' characteristics to curb the resistance to these innovations and encourage adoption. The intrusiveness of technological innovations needs to be limited, allowing consumers to feel more comfortable using and adopting smart appliances. The seamless integration of these appliances with a consumer's life is necessary for increased adoption. Similarly, the uselessness, price and novelty need to be balanced with limiting the smart appliance's intrusiveness. Understanding consumers remain pivotal in encouraging the adoption of smart appliances. Apart from the needs of consumers such as protecting their privacy, ensuring they remain independent from the technology and their ability to handle the technology, their propensity to take risks and try new things are likely to play a significant role in acquiring smart appliances.

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		N	A	Mean	Std. Dev
Adoption	Suppose you need a new refrigerator how likely is it that you choose a smart fridge? I think smart refrigerators are generally good Willing to spend more on smart fridge compared to another fridge	1662	.729	4.07	1.81
Resistance	I'm likely to be opposed to the purchase of a smart fridge. I'm more critical of the promises of a smart refrigerator. The smart fridge is not for me.	1659	.775	3.99	1.58
Perceived uselessness	The features of a smart refrigerator offer few advantages. The functions of a smart refrigerator provide little added value.	1658	.573	3.99	1.47
Perceived Novelty	This smart fridge is unique The smart fridge is different compared to other fridges.	1657	.465	5.12	1.35
Perceived Price	The price of the smart fridge is high The price of the smart fridge is low (Recoded)	1152	.667	5.39	1.31
Intrusiveness	A smart fridge is intrusive i.e it is annoying. A smart fridge irritates me. The smart fridge is indiscreet i.e revealing things that should remain private. I'm not comfortable with the smart fridge. The smart fridge is disturbing i.e. causing anxiety.	1656	.867	3.43	1.48
Privacy Concerns	I am worried that my privacy will be affected. I am worried that my personal data will be collected from a smart fridge without my permission.	1664	.767	4.45	1.72
Dependence	I'm afraid of becoming dependent on the smart fridge. A smart fridge will limit my autonomy i.e. being independent. A smart fridge will limit my addiction to technology. I think my social life will suffer from the use of a smart refrigerator.	1657	.706	3.00	1.30
Self-Efficacy	I know how to use a smart fridge. I am confident that I can understand the use of the smart refrigerator. I think I am able to operate the smart fridge, although I've never used it before.	1658	.689	5.13	1.20
Security Risk	I worry about giving my personal data or login to smart connected product companies. When I send data to smart products companies, I am concerned that my data may also reach unauthorised third parties or hackers.	1660	.789	5.04	1.60
Social Risk	Using smart, internet-connected products degrades the picture my friends or relatives have of me. I'm afraid smart products do not offer the benefits promised on the website or by the manufacturer. It is very likely that smart products will not meet my expectations.	1658	.601	3.26	1.15
Innovativeness	If I see a product that differs from the conventional products, I try this out. I am often among the people who test a new product first. I like to try things that are new and different.	1659	.810	4.51	1.12
Nostalgia	Things used to be better in the good old days. Technological change will not secure a better future. Internet-connected products do not improve your daily life. The reliability of products used to be generally better.	1657	.590	3.58	1.14

Table 1: Cronbach's Alpha, Mean scores and Standard Deviations

Resistance	*B*	95% CI for B		*SE B*	β	t	Sig.	R^2	ΔR^2
		LB	UB						
Model								.649	.647
Constant	1.949	1.507	2.392	.226		8.641	.000		
Perceived uselessness	.212	.175	.249	.019	.207	11.237	.000		
Perceived novelty	-.161	-.160	-.072	.022	-.101	-5.177	.000		
Perceived price	.076	-.037	.115	.020	.066	3.817	.000		
Intrusiveness	-.419	.368	.471	.026	.392	16.006	.000		
Self-efficacy	-.069	-.121	-.018	.026	-.054	3.653	.000		
Security risk	.069	.032	.106	.019	.073	4.845	.000		
Social risk	.147	.087	.206	.030	.114	1.683	.093		
Spirit of innovation	-.175	-.222	-.128	.024	-.160	-7.345	.000		
Nostalgia	.048	-.008	.104	.029	.037	-2.636	.008		

Table 2: Item loadings

Note. Model – "Enter" methods in SPSS Statistics; B – unstandardized regression coefficient; CI = confidence interval; LB = Lower Bound; UB = Upper Bound; *SE B* = standard error of the coefficient;
β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2.

		Factor								
		1	2	3	4	5	6	7	8	9
Intrusiveness	A smart fridge is intrusive i.e it is annoying.	.663								
	A smart fridge irritates me.	.699								
	The smart fridge is indiscreet i.e revealing things that should remain private.	.749								
	I'm not comfortable with the smart fridge.	.752								
	The smart fridge is disturbing i.e. causing anxiety.	.648								
Innovativeness	If I see a product that differs from the conventional products, I try this out.		.802							
	I am often among the people who test a new product first.		.831							
	I like to try things that are new and different.		.706							
Self- Efficacy	I know how to use a smart fridge.			.623						
	I am confident that I can understand the use of the smart refrigerator.			.710						
	I think I am able to operate the smart fridge, although I've never used it before.			.808						
Social Risk	Using smart, internet-connected products degrades the picture my friends or relatives have of me.				.616					
	I'm afraid smart products do not offer the benefits promised on the website or by the manufacturer.				.484					
	It is very likely that smart products will not meet my expectations.				.499					
Nostalgia	Things used to be better in the good old days.					.785				
	Technological change will not secure a better future.					.538				
	Internet-connected products do not improve your daily life.					*				
	The reliability of products used to be generally better.					.739				

Security Risk	I worry about giving my personal data or login to smart connected product companies.	.783				
	When I send data to smart products companies, I am concerned that my data may also reach unauthorised third parties or hackers.	.850				
Perceived Price	The price of a smart refrigerator is high		.831			
	The price of a smart refrigerator is low.		-.861			
Perceived uselessness	The features of an intelligent refrigerator offer few advantages.			.803		
	The functions of a smart refrigerator offer little added value.			.749		
Perceived Novelty	This smart fridge is unique.				.467	
	A smart refrigerator is different from other refrigerators.				.881	

*Loading below 0.3

Table 3: Multiple regression results for Resistance

Adoption	***B***	**95% CI for B**		***SE B***	**β**	**t**	**Sig.**	**R^2**	**ΔR^2**
		LB	**UB**						
Model								.489	.486
Constant	3.312	2.684	3.941	.320		10.339	.000		
Perceived uselessness	-.128	-.181	-.076	.027	-.107	-4.801	.000		
Perceived novelty	.267	.205	.329	.032	.197	8.411	.000		
Perceived price	-.166	-.222	-.110	.028	-.123	-5.851	.000		
Intrusiveness	-.438	-.511	-.365	.037	-.348	-11.774	.000		
Self-efficacy	.116	.042	.189	.037	.077	01.909	.056		
Security risk	-.051	-.104	.001	.027	-.046	2.021	.044		
Social risk	.087	.003	.171	.043	.057	2.227	.026		
Spirit of innovation	.323	.257	.390	.034	.252	9.557	.000		
Nostalgia	.090	.011	.170	.041	.059	3.090	.002		

Table 4: Multiple regression results for Adoption

Note. Model – "Enter" methods in SPSS Statistics; B – unstandardized regression coefficient; CI = confidence interval; LB = Lower Bound; UB = Upper Bound; *SE B* = standard error of the coefficient; β = standardized coefficient; R^2 = coefficient of determination; ΔR^2 = adjusted R^2.

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