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# "Smart Home Sweet Smart Home": An Examination of Smart Home Acceptance

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## ABSTRACT

Technology acceptance in private spaces has not received much attention, although users' behaviour may be different due to the space in which usage takes place. To address this gap, the present study proposed a model exploring individuals' values, users' perception of technology performance and attitudinal beliefs in relation to use behaviour and satisfaction when using smart technologies in their homes. The study employed a sample of 422 participants in the USA. Structural equation modelling was utilised to test the proposed hypotheses. The model provided robust results explaining factors underpinning the use of pervasive technology in private settings. Specifically, the study showed that hedonic and utilitarian beliefs are critical for the perception of task fit, whereas privacy and financial factors were found to be not significant. The fit between tasks and technology demonstrated a significant role in predicting perceived usefulness, perceived ease of use, use behaviour, and satisfaction. Lastly, use behaviour showed a positive correlation with satisfaction.

## KEYWORDS

Pervasive Technology, Private Settings, Satisfaction, Smart Home, Technology Acceptance

## 1. INTRODUCTION

Home is a private space, in which residents perform different roles while carrying out their daily routines (Venkatesh, 1996, Kraybill, 2005). Individuals need to feel secure and enjoy emotional and physical comfort when they are inside their house (Kraybill, 2005). This may explain why homes have remained relatively untouched by the advent of online technologies and we have only just started experiencing a significant wave of change, namely their transformation into smart homes. The key attributes of smart home technologies are the ability to acquire information from the surrounding environment and react accordingly (Chan *et al.*, 2008, Balta-Ozkan *et al.*, 2014). On one hand they are capable of encouraging independent living, promoting environmental sustainability and offering financial benefits through daily support, monitoring and consultancy services. On the other hand, they

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raise serious privacy and trust issues that go well-beyond other technologies, due to their pervasive nature (Balta-Ozkan et al., 2013a, Chan et al., 2009). Therefore, technology acceptance can play a relatively more important role compared to others when examined in the context of other digital technologies, especially when it comes to examining potential risks vs the benefits a user may obtain.

Technology acceptance research has typically been considered with regards to technologies that are used in public/mixed settings (Venkatesh and Davis, 2000, Anandarajan et al., 2000, Stam and Stanton, 2010, Schmidthuber et al., 2018). It is very seldom that technology acceptance studies have considered technologies that are utilised solely in a private setting. The use of such technologies may be heavily dependent on the psychological factors of house residents, the perception of outcomes, motives and beliefs (Choe *et al.*, 2011). For example, the perception of hedonic and utilitarian values differs across people using the technology publicly and privately. Values reflect the needs and judgement of technology utility that are peculiar to the context (E. Collier *et al.*, 2014). Similarly, the use of technology in private spaces is connected with the potential risks of personal data leakage and monetary spending (Marikyan *et al.*, 2019, Balta-Ozkan *et al.*, 2013b, Aldrich, 2003), posing higher risks for users. This suggests that the acceptance and use of technology in private spaces may be based on values and beliefs that are manifested differently to those in a public/mixed environment. In terms of services, there is a divergence in tasks and the purpose of technology utilisation in private versus public settings. Technology compatibility acts as a boundary condition in adopting the technology (Shih and Venkatesh, 2004, Brown and Venkatesh, 2005).

Only few studies have examined the technology acceptance in the private context (Brown and Venkatesh, 2005, Venkatesh and Brown, 2001, Balta-Ozkan et al., 2013b, Balta-Ozkan et al., 2014). That research provided prospective qualitative insight into the potential implementation of pervasive technology in houses (Balta-Ozkan et al., 2013b, Balta-Ozkan et al., 2014), without explaining the perception of technology by actual users. The studies adopting the users' perspective ignored the role of the perceived fit of technology capabilities to user demands (Goodhue and Thompson, 1995). The fit is superior when it comes to the private use of technology, because it defines the degree of the situational applicability to the tasks that users may have, in contrast to attitudinal factors measuring the overall usefulness of the technology. In addition, the studies extend the implications beyond residential settings (Brown and Venkatesh, 2005, Venkatesh and Brown, 2001), which limits the understanding of technology utilisation in a purely private context.

Secondly, the role of potential risks pertinent to the use of technology in private spaces has not been tested (Marikyan *et al.*, 2019, Balta-Ozkan *et al.*, 2013b, Aldrich, 2003). The effect of beliefs about potential benefits and costs on use behaviour and the mediating role of technology fit may provide the current literature with much-needed evidence about the factors affecting technology acceptance in private spaces. Given the gaps in the literature, the aim of this paper is two-fold: a) from a technology acceptance point of view, to study smart home acceptance as a case of a pervasive technology used in a private setting and provide more empirical evidence from a user perspective, and b) from a smart home point of view, to present empirical evidence related to the balance of benefits vs the risk users experience.

In the following section, we will present the literature on smart homes, the theoretical framework adopted by the study and put forward a number of hypotheses. Then, the methodology of the study will be described, followed by the results and findings. The paper will conclude with the contributions, limitations and future research suggestions.

## 2. LITERATURE REVIEW AND HYPOTHESES

### 2.1 Smart Homes

The smart home is defined as a "*residence equipped with computing and information technology, which anticipates and responds to the needs of the occupants, working to promote their comfort,* *convenience, security and entertainment through the management of technology within the home and connections to the world beyond*" (Aldrich, 2003). The major focus of the research so far revolves around the benefits that smart homes make possible (Chan et al., 2008, Balta-Ozkan et al., 2014, Lee et al., 2017). Such benefits can be classified into four categories: a) health-related benefits, b) environmental benefits, c) financial benefits and d) psychological wellbeing and social inclusion. At the core of the health-related benefits that smart home technologies can deliver is the support to the ageing population. Smart home devices are capable of providing home care, virtual medical consultancy and the management of residents' health. These services promote independent living, increase the quality of health care and care accessibility for the ageing population, which has been the dominant segment for smart home technology so far (Chan et al., 2008, Dong et al., 2017). In the residential context, smart home technologies can help towards the reduction and monitoring of energy usage (Marikyan et al., 2019, Balta-Ozkan et al., 2013a). These benefits became of interest due to growing environmental concerns of users with regards to emerging threats, such as global warming and climate change. In addition, the interest in the acceptance of smart home technologies is further fuelled due to national and EU policy changes and mandated climate change objectives (Balta-Ozkan *et al.*, 2013b). Recent advances in smart home technologies have enabled individuals to monitor and use energy efficiently, which positively influences the environment (Chan *et al.*, 2008, Marikyan *et al.*, 2019). The financial benefits of smart home technology are associated with environmental and health-related benefits. Specifically, the effect of smart home technology acceptance on environmental sustainability is a long-term goal, while short-term benefits come from the savings in utility bills (Balta-Ozkan *et al.*, 2013a, Marikyan *et al.*, 2019). The last group of potential benefits that is associated with the use of smart home technology is psychological well-being and social inclusion. The use of smart home technology can make individuals overcome the feeling of isolation. This can be made possible given the ability of smart home technologies to support and help users, including vulnerable and elderly people, relate to the outside world (Chan et al., 2008, Marikyan et al., 2019). Despite the fact that an overwhelming number of papers have discussed the potential benefits of smart home technology usage, the promised benefits have not always been manifested. Smart home technologies might not be fully embraced or might be perceived differently by users (Geels and Smit, 2000), which indicates the need for further investigation.

## 2.2 Technology Acceptance in Private Spaces

A review of the literature makes evident that the published research mostly focuses on the technology usage in public and mixed settings. For example, the constructs from the technology acceptance model (i.e. perceived usefulness and perceived ease of use) have been used in a number of studies to explain the utilisation of technology in organisational contexts (Igbaria et al., 1997, Carter and Bélanger, 2005) and investigate the antecedents of the use of mobile technology, personal computers and e-commerce platforms (Agarwal and Karahanna, 2000, Venkatesh et al., 2012, Gefen et al., 2003). To adapt TAM to workplace settings, the model has been extended with intraorganizational and extraorganisational factors, such as internal and external computing support, internal and external computing training and management support (Igbaria et al., 1997). For the examination of the usage of e-learning systems, TAM was extended with context-specific factors, such as network externality, social and system factors. Those were found to have a significant effect on the perceived ease of the system's operationalisation, usefulness and use enjoyment (Cheng, 2011). The adoption of technology in public and mixed contexts was also examined by integrating technology acceptance models with personal factors, such as cognitive absorption, self-efficacy, goal orientations (Wang, 2008, Agarwal and Karahanna, 2000, Cheng, 2011) and subjective norms (Venkatesh and Morris, 2000, Venkatesh et al., 2003), which affect the perception of technology utility and use intention.

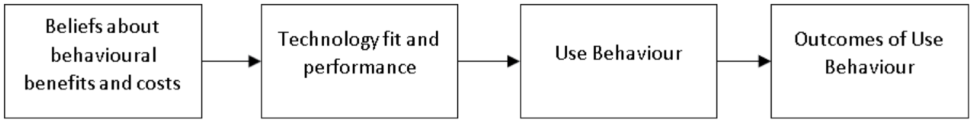
Few studies have examined the utilisation of technology in the private context. Early research on technology adoption in household settings focused on portable and intangible services produced by ICT, such as personal computers and the internet (Venkatesh and Brown, 2001, Brown and Venkatesh, 2005). Some papers focused on the social and personal factors contributing to the adoption, such as self-efficacy, trust and personality traits (Hsieh et al., 2008, Shih and Venkatesh, 2004). Others focused on energy consumption and the adoption of energy-efficient technology (Wunderlich et al., 2019). The review of these studies identified several pitfalls that inhibit the advancement in the domain of technology adoption in private spaces. First, research overlooks the characteristics of private spaces. The studies set a blurry line between private and public spaces since they mostly investigate the utilisation of intangible services and devices which can be used both inside and outside household settings (Venkatesh and Brown, 2001, Brown and Venkatesh, 2005, Hsieh et al., 2008). However, it is important to delineate private and public contexts by setting both physical and virtual boundaries. The lack of physical presence and the applicability of technologies to public settings make the interaction with technologies universal in different contexts, thus decreasing the validity of the analysis of situational behaviour (Shapiro, 1998). Second, due to the inability to recognise the permeability of physical and virtual boundaries of private spaces (Shapiro, 1998), the current research overlooks the potential adverse consequences that the utilisation of technologies implies, such as perceived risks (e.g. privacy). Third, although the prior literature noted that users' roles, behavioural and attitudinal patterns vary in public vs private contexts (Brown et al., 2006, Venkatesh, 1996), the research did not examine to what degree the technology services correspond to the household requirements of users. The examination of the interrelationship between beliefs in the benefits, risks and technology fit would give a better insight into the technology adoption in private spaces. Fourth, the research focuses on particular devices, performing a specific service (Wunderlich et al., 2019). Hence, certain factors can be manifested only in the context of specific behaviour. Given the above, a model is developed in the next section that aims to contribute towards filling these gaps.

## 2.3 Hypothesis Development

This study is based on the Task Technology Fit (TTF) model. The utilisation of the TTF model made it possible to examine whether the use behaviour of residents of private spaces is conditioned by the fit between their tasks and the characteristics of the technology. There are five constructs that represent the model: task characteristics, technology characteristics, task-technology fit, technology utilisation and performance impact. While task characteristics and technology characteristics reflect the specific dimensions of the technology and its utilisation, the general task-technology fit factor captures individuals' perception of task-technology fit (Goodhue and Thompson, 1995). In this paper, we use the "fit" factor as it is argued that it is a crucial construct that is implicit in a lot of research (Goodhue and Thompson, 1995). The rationale for focusing on the TTF construct is that the present research aims to develop an insight into users' perception of fit, rather than identifying task requirements and specific services that facilitate the technology utilisation. A similar approach has been adopted by a number of studies that examined the users' perspective on the adoption of technology (Wu and Chen, 2017, Larsen et al., 2009, Fuller and Dennis, 2009).

TTF is integrated with the constructs that pertain to the users' perception of technology performance, such as perceived usefulness and perceived ease of use from the Technology Acceptance Model (TAM) (Davis, 1989). TTF and TAM factors have been used in a number of studies aiming to explain the acceptance of technology from two different perspectives (Zhou et al., 2010, Goodhue and Thompson, 1995, Goodhue, 1995, Razmak and Bélanger, 2018, Naicker and Van Der Merwe, 2018). While TTF stresses the importance of the "fit" factor when it comes to task-related behaviour, perceived usefulness and perceived ease of use explain the attitudinal underpinnings of the behaviour. The model proposed in this paper reconciles these two approaches. The main justification for combining attitudinal factors with TTF derives from research findings that users can positively perceive the technology, but not adopt it due to a lack of fit (Junglas *et al.*, 2008, Lee *et al.*, 2007). Given that smart home technologies are still not widely utilised, the TTF can shed new light on whether low acceptance of smart home technology is due to the lack of fit and associated beliefs about performance. Additionally, this study analyses whether utilitarian, hedonic values, privacy

Figure 1. The overview of the model




and financial risks influence the users' perception of task-fit. These are the four main groups of behavioural beliefs whose significance has been tested in the combination of various frameworks in the technology acceptance context (Turel *et al.*, 2010, Van der Heijden, 2004, Xu *et al.*, 2012). An overview of the model is presented in Figure 1. The following section will discuss the theoretical foundation of each relationship proposed in the research model.

## 2.4 Beliefs About Behavioural Benefits and Costs

TTF is defined as "*the degree to which technology assists an individual in performing his or her portfolio of tasks*" (Goodhue and Thompson, 1995). Following the underlying theory of task-technology fit, individuals' determination of the technology fit is based on their hedonic or utilitarian needs (Goodhue and Thompson, 1995, Van der Heijden, 2004). Perceived hedonic and utilitarian values matching individuals' needs can affect the perception of the technology (Van der Heijden, 2004, Babin *et al.*, 1994). The achievement of self-fulfilment is the core of the hedonic value. Specifically, hedonic value in the information systems context can be defined as an individual's perception of the enjoyment and fun related to the product (Van der Heijden, 2004, Brown and Venkatesh, 2005). On the other hand, consumers who are concerned with utilitarian value expect to gain instrumental utility, like improved task performance (Van der Heijden, 2004). Therefore, we propose that behavioural beliefs are linked to the individuals' perception of task-technology fit. The first hypothesis is drawn from the findings of the literature on smart homes. Smart home technology can generate utilitarian values for users, such as financial savings on utility bills (Balta-Ozkan *et al.*, 2013b, Marikyan *et al.*, 2019), and hedonic values, such as enjoyment, comfort and fun (Marikyan *et al.*, 2019). Based on the above, we propose that:

**Hypothesis 1:** a) Hedonic and b) utilitarian values have a positive effect on individuals' perceptions of task technology fit.

The literature has paid significant attention to perceived risks (Featherman and Pavlou, 2003, Pavlou, 2003, Bélanger and Crossler, 2011, Li and Huang, 2009, Im et al., 2008, Ozturk et al., 2017, Bourlakis et al., 2008). Privacy and financial risks are considered to be the main categories of perceived risks (Featherman and Pavlou, 2003, Pavlou, 2003). The perception of high risk is associated with the consumer's uncertainty about the outcome of behaviour (Bauer, 1960). A number of studies have highlighted the importance of perceived risk in explaining consumer behaviour in the context of innovative technology usage (Im et al., 2008, Featherman and Pavlou, 2003, Pavlou, 2003, Schaupp and Carter, 2010). Financial and privacy risks can negatively influence individuals' perception of technology, its acceptance and future use (Taneja et al., 2014, Martins et al., 2014). Several scholars have integrated perceived risk constructs with technology acceptance models (Kesharwani and Singh Bisht, 2012, Im *et al.*, 2008). Driven by the definition that the technology is perceived to fit the task if it is consistent with the individual's needs and requirements and it is capable of assisting in a particular task (Goodhue, 1995, Van der Heijden, 2004), high perceived risk can be an inhibiting factor in perceived task-technology fit. Similarly, users have raised concerns about privacy intrusion and expressed distrust about promised savings on utility bills (Marikyan et al., 2019, Aldrich, 2003). Therefore, we hypothesise that:

**Hypothesis 2:** a) Privacy risk and b) financial risk have a negative effect on individuals' perceptions of task technology fit.

### 2.5 Technology Fit and Performance

A number of studies combined various technology acceptance models with TTF to explain individuals' attitudes towards adoption, perceived performance and continuance intention to use (Dishaw and Strong, 1999, Wu and Chen, 2017, Lu and Yang, 2014, Abbas *et al.*, 2018, Oliveira *et al.*, 2014, Tam and Oliveira, 2016, Tarhini *et al.*, 2016). Perceived fit between technology and task is the precondition for the adoption of innovative services offered by online platforms (Dishaw and Strong, 1999, Wu and Chen, 2017). The TTF model has been applied to different contexts, such as mobile banking, online learning systems and mobile insurance (Junglas *et al.*, 2008, Tam and Oliveira, 2016, Lee *et al.*, 2007, Wu and Chen, 2017). Users of online learning courses found TTF to be an important factor preceding perceived usefulness and perceived ease of use (Wu and Chen, 2017). However, not all dimensions of TTF (i.e. data quality, localability, authorisation, timeliness, compatibility, training, system reliability and relationship with users) were shown to be equally significant. Lee *et al.* (2007) concluded that data quality was the only indicator of fit and the predictor of service adoption in the context of insurance services. Another study found conflicting results about the effect of TTF on the performance impacts of mobile banking across younger and older respondents. The effect of the performance of banking services was insignificant for younger users, but not the older ones (Tam and Oliveira, 2016). The purpose of the use of online systems and the level of skilfulness of users may be two possible explanations for the inconsistency among previous findings. The fit of online systems for learning purposes can be more imperative, as users do not have an alternative way to fulfil the task. In contrast, mobile banking is an optional choice that is aimed at increasing the effectiveness of traditional banking services. Secondly, younger people might be more self-efficient and less dependent on the characteristics of the systems used. The literature has also discussed the effect of TTF on the outcomes of use behaviour, such as satisfaction. There is evidence that satisfaction is influenced by TTF both directly and indirectly (Lin and Wang, 2012, Chen *et al.*, 2016, Lin, 2012, Isaac *et al.*, 2017). For example, a study confirmed the effect of perceived fit on the satisfaction mediated by the use of online systems (Lin and Wang, 2012). It explains the situation whereby the performance of services that match pre-use expectation of technology fit is perceived as fair and a rewarding investment of users' resources (Chen *et al.*, 2016). The examination of the direct effect of perceived fit on satisfaction demonstrated that satisfaction is strongly correlated with TTF and acts as a good predictor of the long-term adoption of online learning systems (Lin, 2012, Isaac *et al.*, 2017). Based on the above, we hypothesise that:

**Hypothesis 3:** The perceived task technology fit has a positive effect on a) use behaviour, and b) satisfaction.

TTF has a strong influence on PEOU (Dishaw and Strong, 1999, Chang, 2008). In addition, when comparing the original model and the model integrated with TAM, the effect of TTF as a standalone model predicting use behaviour is not strong enough (Dishaw and Strong, 1999, Shih and Chen, 2013). The same conclusion was reached by a recent study that postulated that the integration of TTF with TAM gives a better explanation for the utilisation of innovative technologies (Wu and Chen, 2017). Also, the strong explanatory power of TTF constructs was examined in other research studies that integrated the TTF framework with performance expectancy and effort expectancy from UTAUT (Abbas *et al.*, 2018, Oliveira *et al.*, 2014, Zhou *et al.*, 2010). Performance expectancy pertains to perceived usefulness, whereas effort expectancy implies the perceived degree of ease directed at the utilisation of information systems (Venkatesh *et al.*, 2003, Davis *et al.*, 1992). The findings of the research suggested that combined behavioural belief constructs and TTF had a strong predictive power in relation to information system adoption. The study confirmed a strong relationship between performance expectancy and effort expectancy, TTF and technology characteristics constructs. The latter construct had an effect on effort expectancy, while TTF had a direct strong effect on perceived usefulness (Zhou *et al.*, 2010). Applying the findings of the research to the smart home literature, there could be a strong relationship between TTF, performance expectancy and effort expectancy. The embedded artificial intelligence in smart homes makes individuals' tasks easier and more effective. Smart home technologies can increase users' productivity and comfort in day to day tasks (Marikyan *et al.*, 2019, Aldrich, 2003). User-friendly smart devices can be perceived as having the potential of high task productivity due to lower effort expectancy.

**Hypothesis 4:** The perceived task technology fit has a positive effect on a) perceived usefulness and b) perceived ease of use.

Perceived usefulness can be defined "*as the degree to which an individual believes that using the system will help him or her attain gains in job performance*" (Venkatesh *et al.*, 2003, Davis *et al.*, 1989). Perceived usefulness and performance expectancy owe their wide implication to TAM and UTAUT theories. The two constructs share a high degree of similarity (Davis, 1989, Thompson et al., 1991). A number of studies stress that perceived usefulness is a significant predictor of an intention and use of technology (Agarwal and Prasad, 1998, Davis et al., 1992, Venkatesh et al., 2012, Al-Gahtani et al., 2007). Moreover, the higher the perception of the usefulness of IT systems the higher the likelihood that the performance will be perceived positively by users. That means that perceived usefulness encourages actual use behaviour and also defines the perceived outcome of performance (Shih, 2004). The construct has been applied and tested in different geographical and cultural settings. The results were consistent with the original findings, confirming the invariant effect of perceived usefulness on intention and use behaviour (Al-Gahtani et al., 2007, Wang and Shih, 2009, Venkatesh and Zhang, 2010). Based on the past literature our next hypothesis is:

**Hypothesis 5:** Perceived usefulness has a positive effect on use behaviour.

Perceived ease of use can be defined "*as the degree of ease associated with the use of the system*" (Venkatesh *et al.*, 2003, Davis *et al.*, 1989). Similar to perceived usefulness, perceived ease of use is a fundamental psychological belief facilitating technology acceptance (Davis *et al.*, 1989, Davis, 1989, Venkatesh and Davis, 2000). A vast number of studies have confirmed the significant effect of the construct on behavioural intention, both in voluntary and mandatory settings (Davis, 1989, Thompson *et al.*, 1991). In addition, perceived ease of use has both a direct and indirect effect on the use behaviour. One stream of research found robust evidence of the predictive power of perceived ease of use on actual use behaviour (Venkatesh et al., 2012, Al-Gahtani et al., 2007, Venkatesh and Zhang, 2010, Martins et al., 2014, Kumar et al., 2016). However, the major thread in the literature shows evidence that the influence of the factor on actual use is mediated by perceived usefulness (Park et al., 2016, Calisir and Calisir, 2004, Miranda et al., 2014). For example, a correlation of perceived ease of use and perceived usefulness was found when examining motivational predictors of the expected relevance of IT systems and subsequent satisfaction (Calisir and Calisir, 2004). Drawing upon the aforementioned findings, this study hypothesises the following:

**Hypothesis 6:** Perceived ease of use has a positive effect on perceived usefulness.

## 2.6 The Outcome of Use Behaviour

Over the years, research has been carried out to study the relation between satisfaction and technology use (Román *et al.*, 2018, Vlahos and Ferratt, 1995, Calisir and Calisir, 2004). In particular, the influence of the technology use on employees' satisfaction in the workplace has been tested (Vlahos and Ferratt, 1995, Isaac et al., 2017). It was found that the use of technology in a work-related environment has a positive influence on decision-making efficiency and operations in organisations, and it increases the employees' satisfaction (Vlahos and Ferratt, 1995, Román *et al.*, 2018). The effect of actual use on user satisfaction was also tested in the context of private use of information systems (Chiu *et al.*, 2007, Deng *et al.*, 2010). It was found that the successful adoption of web-based platforms by consumers is the result of the direct effect of actual use on satisfaction (Chiu *et al.*, 2007). Another study used a multidimensional construct to test the effect of different aspects of user experience on satisfaction with mobile internet services. Experience was measured as the degree to which users meet functional, hedonic and overall performance expectations. The strongest correlation was between confirmed expectations and satisfaction, which in turn affected intention to use mobile internet services again (Deng *et al.*, 2010). Several studies developed conceptual models to explain the individual's satisfaction and antecedents (Calisir and Calisir, 2004, Mawhinney and Lederer, 1990). Recent literature has provided inconsistent findings when investigating the relationship between technology use, satisfaction and stress (Román et al., 2018, Yueh et al., 2016). The findings revealed that technology use had a significant effect on satisfaction, but the effect of the frequency of use was insignificant (Vlahos and Ferratt, 1995). In addition, the satisfaction level among respondents was not consistent. Also, it has been argued that instead of satisfaction the use of technology positively influenced the level of stress (Ahearne *et al.*, 2005, Sundaram *et al.*, 2007, Tarafdar *et al.*, 2014). For instance, the acceptance of technology in higher education can lead to anxiety and it further negatively influenced satisfaction (Lepp *et al.*, 2014). In contrast, another stream in the literature pointed out that the use of technology had a positive effect on satisfaction levels (Wright *et al.*, 2014, Apostolou *et al.*, 2017, Román *et al.*, 2018). Drawing on the literature in the smart home domain, it is more likely that the enjoyment of health-related, financial and environmental benefits of the use of smart home technology (Marikyan *et al.*, 2019) will result in a positive outcome. Therefore, we hypothesise the following:

**Hypothesis 7:** Smart home technology use has a positive effect on satisfaction.

## 3. METHODOLOGY

### 3.1 Data Collection and Sampling

This study adopted a quantitative approach. A pilot study was conducted before starting the distribution of questionnaires with the aim of testing the feasibility of the survey design and approach. The questionnaire incorporated screening questions to filter out individuals who did not use smart home technology at the time of data collection and had never used it in the past. The second part of the questionnaire consisted of general questions with the purpose of having a socio-demographic picture of the respondents. The third part included model-specific questions. The data collection for this study took place online via a consumer panel located in the United States. Due to the developed technological infrastructure of the country, a sample located in the United States was deemed representative for the purpose of the study. Given the objectives of the study, we used a non-probability sampling method and focused only on current and former users of smart homes. 510 participants (current and former smart home technology users) passed the screening questions and were included in the final sample. After deleting responses that did not have satisfactory variance, this study ended up with 422 usable responses. In line with the guidelines provided by Hair et al. (2014), the sample was appropriate to conduct structural path analysis. The demographics of the final sample can be found in Table 1. Demographics were reasonably balanced, in terms of the participants' gender. When it came to age, it was interesting that 60-69 represented a relatively bigger group, which may be an indication of the interest in the benefits that smart homes can provide to such users (Marikyan *et al.*, 2019).

**Table 1. Demographic characteristics**

| Attribute | Type | Frequency (n=422) | Percentages (%) |
|---|---|---|---|
| **Gender** | Male | 195 | 46.20% |
| | Female | 227 | 53.80% |
| **Age** | 20-29 | 29 | 6.90% |
| | 30-39 | 50 | 11.80% |
| | 40-49 | 67 | 15.90% |
| | 50-59 | 96 | 22.70% |
| | 60-69 | 170 | 40.30% |
| | 70-79 | 10 | 2.40% |
| **Employment** | Full time employed | 183 | 43.40% |
| | Part time employed | 46 | 10.90% |
| | Out of Work (but looking for) | 12 | 2.80% |
| | Out of Work (but not looking for) | 3 | 0.70% |
| | Homemaker | 39 | 9.20% |
| | Student | 7 | 1.70% |
| | Retired | 111 | 26.30% |
| | Unable to Work | 21 | 5% |
| **Ethnicity** | Non-Hispanic White or Euro-American | 352 | 83.40% |
| | Black, Afro-Caribbean, or African American | 32 | 7.60% |
| | Latino or Hispanic American | 19 | 4.50% |
| | East Asian or Asian American | 8 | 1.90% |
| | South Asian or Indian American | 4 | 0.90% |
| | Native American or Alaskan Native | 2 | 0.50% |
| | Mixed | 3 | 0.70% |
| | Other | 2 | 0.50% |
| **Education** | Some high school or less | 3 | 0.70% |
| | High school graduate or equivalent | 75 | 17.80% |
| | Vocational/technical school (two-year program) | 49 | 11.60% |
| | Some college, but no degree | 100 | 23.70% |
| | College graduate (four-year program) | 113 | 26.80% |
| | Some graduate school, but not degree | 9 | 2.10% |
| | Graduate degree (MSc, MBA, PhD, etc.) | 67 | 15.90% |
| | Professional degree (M.D., J.D., etc.) | 6 | 1.40% |
| **Geographical location** | Urbanized Area (50,000 or more people) | 175 | 41.50% |
| | Urban Cluster (at least 2,500 and less than 50,000) | 128 | 30.30% |
| | Rural (all other areas) | 119 | 28.20% |

*continued on following page*

**Table 1. Continued**

| Attribute | Type | Frequency (n=422) | Percentages (%) |
|---|---|---|---|
| **Household Income** | $0-$24,999 | 58 | 13.70% |
| | $25,000-$49,999 | 115 | 27.30% |
| | $50,000-$74,999 | 110 | 26.10% |
| | $75,000-$99,999 | 68 | 16.10% |
| | More than $100,000 | 71 | 16.80% |
| **Marital Status** | Single (never married) | 101 | 23.90% |
| | Married | 252 | 59.70% |
| | Separated | 2 | 0.50% |
| | Widowed | 15 | 3.60% |
| | Divorced | 52 | 12.30% |

### 3.2 Measurement Items and Data Analysis

Our research model contained nine constructs measured by multiple items. Table 2 presents all items representing our latent variables, which were adapted from prior literature to ensure content validity. Seven-point Likert scales were utilised to measure the items (strongly agree to strongly disagree). The aforementioned approach offered an effective way to measure the accuracy and precision of the latent variables (Churchill, 2002). To analyse the data for this study we followed the strategy proposed by Hair Jr and Lukas (2014) as well as Gaskin (2016). To examine the developed hypotheses, we employed SPSS v.24 and SPSS AMOS v.24. As a first step, we ran a confirmatory factor analysis to ensure the construct validity and reliability. The main hypotheses were tested by running structural equation modelling.

## 4. RESULTS

### 4.1 Reliability and Validity Tests

The CFA analysis of this model showed a satisfactory model fit (Table 2). The results of the reliability test for each examined variable, including the factor loading (>0.8), construct reliability (C.R. >0.8), average variance expected (AVE > 0.7) and Cronbach's α (>0.8), were satisfactory (Hair *et al.* 2014). A convergent validity test demonstrated no validity concerns (Table 3).

### 4.2 Path Analysis

The proposed model examined the behaviour of smart home technology users and subsequent outcomes of use. The results showed that the tested model satisfied all model fit criteria and explained sufficient variance, represented by the coefficients of the $R^2$ (Table 4). All the hypotheses, apart from 2a and 2b, were supported (Figure 2). Specifically, all the perceived task-technology fit effects were statistically verified and supported (H3a,b,c and H4a,b). Perceived task-technology fit demonstrated a significant positive effect on smart home use behaviour (H3a), satisfaction (H3b), perceived usefulness (H4a) and perceived ease of use (H4b). Two out of four hypothesised antecedents of task-technology fit were not significant, whereas all outcomes had positive and statistically significant effects. Particularly, the effect of privacy risk (H2a) and financial risk (H2b) on task-technology fit were not statistically significant. The influences of both hedonic (H1a) and utilitarian values (H1b) on task-technology fit were positive and statistically significant. The utilitarian value had a stronger effect on task-technology fit than hedonic ones. Task-technology fit

**Table 2. Measurement items and data analysis**

| Measurement Item | Loading | C.R. | AVE | Cronbach's α |
|---|---|---|---|---|
| **Privacy Risk (Featherman and Pavlou, 2003)** | | 0.925 | 0.863 | 0.923 |
| What are the chances that using smart home technologies will cause you to lose control over the privacy of your payment information? | .881 | | | |
| My signing up for and using smart home technologies would lead to a loss of privacy for me because my personal information would be used without my knowledge. | .973 | | | |
| **Financial Risk (Featherman and Pavlou, 2003)** | | 0.869 | 0.769 | 0.866 |
| What are the chances that you stand to lose money if you use smart home technologies? | .820 | | | |
| Using smart home technology services subjects your checking account to financial risk. | .931 | | | |
| **Hedonic Value (Babin et al., 1994)** | | 0.969 | 0.886 | 0.969 |
| Using smart home technologies truly felt like an escape | .938 | | | |
| I enjoyed being immersed in exciting new products. | .943 | | | |
| I enjoyed the use of smart home technologies for its own sake, not just for the items I may have purchased. | .944 | | | |
| During the use of smart home technologies, I felt the excitement. | .941 | | | |
| **Utilitarian Value (Babin et al., 1994)** | | 0.950 | 0.863 | 0.949 |
| I accomplished just what I wanted to during the use of smart home technologies. | .948 | | | |
| I could not use smart home services in regard to what I really needed. | .951 | | | |
| While using smart home technologies, I found just the service(s) I was looking for. | .886 | | | |
| **Task Technology Fit (Goodhue and Thompson, 1995, Wu and Chen, 2017, Jarupathirun, 2007)** | | 0.972 | 0.919 | 0.923 |
| Smart home technologies fit my requirements in daily life. | .969 | | | |
| Using smart home technologies fits my daily routine tasks. | .969 | | | |
| Smart home technologies are suitable to complete my daily routine tasks. | .930 | | | |
| **Perceived Usefulness (Venkatesh and Morris, 2000)** | | 0.966 | 0.876 | 0.965 |
| I would find smart home technologies useful in my daily life. | .904 | | | |
| Using smart home technologies enables me to accomplish tasks more quickly. | .948 | | | |
| Using smart home technologies increases my productivity in the house. | .958 | | | |
| If I use smart home technologies, I increase my chances of achieving things that are important to me. | .931 | | | |
| **Perceived Ease of Use (Venkatesh and Morris, 2000)** | | 0.963 | 0.867 | 0.962 |
| My interaction with smart home technologies is clear and understandable. | .887 | | | |
| It is easy for me to become skilful at using smart home technologies. | .933 | | | |
| I find smart home technologies easy to use. | .951 | | | |
| Learning to operate smart home technologies is easy for me. | .952 | | | |
| **Use Behaviour (Ajzen and Fishbein, 1980, Taylor and Todd, 1995a, Taylor and Todd, 1995b, Riemenschneider and McKinney, 2002, Huang and Chuang, 2007)** | | 0.885 | 0.794 | 0.881 |
| I believe I could communicate to others the consequence of using smart home technologies. | .824 | | | |
| The results of using smart home technologies are apparent to me. | .958 | | | |
| **Satisfaction (Spreng and Mackoy, 1996)** | | 0.950 | 0.863 | 0.949 |
| How satisfied are you with your overall experience with smart home technologies? | .909 | | | |
| How pleased are you with your overall experience with smart home technologies? | .957 | | | |
| How delighted are you with your overall experience with smart home technologies? | .921 | | | |

Note: 7-point Likert scale was employed to measure the items. CFA: Model fit: $X^{(288)}$ =605.198 CMIN/DF= 2.101, CFI = .980, RMSEA = .0.51

**Table 3. Discriminant Validity**

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Use Behaviour** | 0.891 | | | | | | | | |
| 2 | **Privacy Risk** | -0.095 | 0.928 | | | | | | | |
| 3 | **Financial Risk** | -0.086 | 0.821 | 0.877 | | | | | | |
| 4 | **Hedonic Value** | 0.764 | -0.208 | -0.173 | 0.942 | | | | | |
| 5 | **Utilitarian Value** | 0.792 | -0.179 | -0.162 | 0.903 | 0.929 | | | | |
| 6 | **Task Technology Fit** | 0.770 | -0.244 | -0.224 | 0.852 | 0.874 | 0.959 | | | |
| 7 | **Ease of Use** | 0.787 | -0.147 | -0.171 | 0.797 | 0.787 | 0.745 | 0.932 | | |
| 8 | **Perceived Usefulness** | 0.736 | -0.213 | -0.178 | 0.864 | 0.845 | 0.869 | 0.815 | 0.936 | |
| **9** | **Satisfaction** | 0.724 | -0.264 | -0.241 | 0.79 | 0.808 | 0.834 | 0.714 | 0.747 | 0.930 |

Note: Figure in the diagonal represents the square root of the average variance extracted (AVE); those below the diagonal represent the correlations between the constructs.

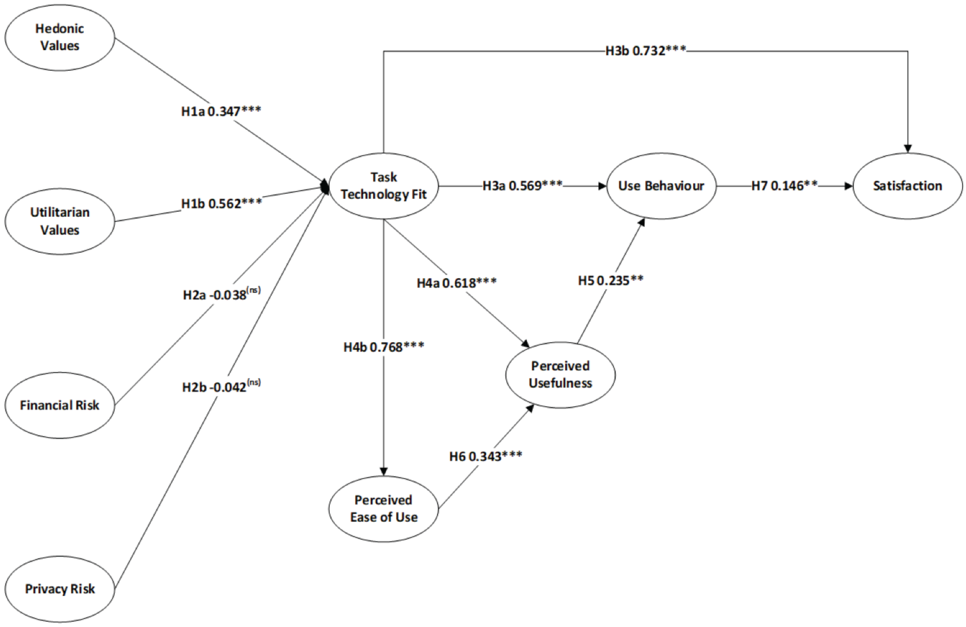
**Table 4. The results of hypothesis testing**

| Hypotheses | $R^2$ | Standardised Path Coefficient | t-values | |
|---|---|---|---|---|
| H1a: Hedonic value → Task technology fit | 0.821 | 0.347 | $5.402^{(***)}$ | |
| H1b: Utilitarian value → Task technology fit | | 0.562 | $8.525^{(***)}$ | |
| H2a: Privacy risk → Task technology fit | | -0.038 | $-0.794^{(ns)}$ | |
| H2b: Financial risk → Task technology fit | | -0.042 | $-0.866^{(ns)}$ | |
| H3a: Task technology fit → Use behaviour | 0.615 | 0.569 | $7.134^{(***)}$ | |
| H3b: Task technology fit → Satisfaction | 0.723 | 0.732 | $13.752^{(***)}$ | |
| H4a: Task technology fit → Perceived usefulness | 0.824 | 0.618 | $15.267^{(***)}$ | |
| H4b: Task technology fit → Perceived ease of use | 0.590 | 0.768 | $20.397^{(***)}$ | |
| H5: Perceived usefulness → Use behaviour | | 0.235 | $2.968^{(**)}$ | |
| H6: Perceived ease of use → Perceived usefulness | | 0.343 | $8.759^{(***)}$ | |
| H7: Use behaviour → Satisfaction | | 0.146 | $2.827^{(**)}$ | |

Note: SEM (H1-7): Model Fit $X^{2\,(307)}$ = 850.025 CMIN/DF = 2.769, CFI = 0.966, RMSEA = 0.065

had a strong and statistically significant effect on both perceived usefulness (H4a) and perceived ease of use (H4b). Perceived ease of use (H6) had a strong and significant effect on perceived usefulness, but perceived usefulness (H5) had a weaker effect on use behaviour. Finally, use behaviour had a statistically significant effect on use satisfaction (H7).

**Figure 2. SEM results**




## 5. DISCUSSION

### 5.1 Findings Elaboration

#### *5.1.1. Beliefs About Behavioural Benefits and Costs*

We examined the effect of hedonic and utilitarian values as antecedents of task-technology fit, with perceived risks (privacy risk and financial risk) as inhibiting factors. The path analysis of the first hypothesis suggests that values have a moderate and significant effect on task-technology fit. In particular, it suggests that prior beliefs about perceived outcomes have a direct effect on the perceived degree of fit between the task and technology and an indirect effect on use behaviour. However, the effect of the utilitarian value is stronger. This can be explained by the fact that the utilisation of smart home technology is mostly related to the satisfaction of needs, such as the reduction of costs on energy, operational convenience and the reduction of waste (Baudier *et al.*, 2018). Only few studies have showed that some users' attitude was underpinned by the hedonic value, such as fun and enjoyment (Van der Heijden, 2004, Babin *et al.*, 1994, Turel *et al.*, 2010). Another explanation of the difference in the effect sizes of hedonic and utilitarian values is suggested by the demographic profile of the sample. Evidence exists that young people are more motivated by hedonic outcomes (Kim and Hwang, 2012). Therefore, the preferences of individuals could be skewed towards the utilitarian outcomes, because the majority of respondents represented the elder cluster between 50 and 69 years old (63%), while young respondents between 20 and 29 years old comprised only 6.9% of the sample. This finding adds to the current literature by presenting the indirect effect of hedonic and utilitarian values on use behaviour through the task-technology fit. Previous research on the task-technology fit domain did not examine hedonic and utilitarian values as antecedents of task-technology fit (Wu and Chen, 2017, Zhou *et al.*, 2010) or focused only on their direct effect on use behaviour (Van der Heijden, 2004, Babin *et al.*, 1994, Turel *et al.*, 2010). This finding gives insight into a more complex relationship between variables, indicating the perceived utility of the technology. The interpretation of the findings can be from the perspective of cognitive theories. The findings suggest that the cognitive consistency between the initial perception of values and performance is the key to determining the success of the technology utilisation in household settings. Therefore, the perceived fit between technology and tasks could be insignificant if utilitarian and hedonic values are not perceived positively.

The second hypothesis about the effect of perceived risks (financial and privacy) was not supported. This means that smart home users do not feel uncertain that the investment in the technology will be returned and the technology represents a good fit to the household tasks in hand. Similarly, the smart home technology users are not concerned with the potential privacy issues, either, but seem to believe that the personal data will not be misused. There are two possible interpretations of the inconsistent findings. First, the technology that house inhabitants used could have been designed to overcome financial losses. Against the backdrop of the significant effect of utilitarian and hedonic values, the findings indicate that the pervasive technology in household settings is associated with the certainty in the technology utility, thus negating the perception of potential risks. The second interpretation is rooted in the profile of the respondents. Considering that almost half of the respondents were full-time employed (43.4%), with an average income level and above (53.4%), they might be less worried about potential financial losses that might incur. These findings provide two contributions. First, the findings add to the literature on the adoption of pervasive technology in the private context, which theorised about the privacy and financial barriers of technology adoption based on the interviews with experts and potential users (Balta-Ozkan et al., 2013b, Balta-Ozkan et al., 2014). In contrast to the prospective view that previous studies provided (Balta-Ozkan et al., 2013b, Balta-Ozkan et al., 2014), the quantitative approach adopted by this study made it possible to measure the actual role of those factors in adoption by users. Second, the study contributes to the existing literature on technology adoption in public and mixed contexts, which has provided evidence of the significant negative effect of perceived risks (Taneja et al., 2014, Martins et al., 2014).

### *5.1.2. Technology Fit and Performance*

This study provided evidence of a strong relationship between task-technology fit, use behaviour, perceived usefulness and satisfaction. By accepting hypotheses 3 and 4, this paper confirmed a strong effect of task-technology fit on use behaviour, which is consistent with the previous literature (Dishaw and Strong, 1999, Zhou *et al.*, 2010). This means that the users of smart home technology expect the technology to satisfy their specific needs/requirements. Similarly, task-technology fit has a strong effect on perceived usefulness. This result is logical considering that previous research found a high correlation between these constructs (Abbas *et al.*, 2018, Oliver, 2014, Zhou *et al.*, 2010). The path analysis of task-technology fit on PEOU was also significant, which corresponds with the finding of the study by Dishaw and Strong (1999). However, the effect of task-technology fit on PEOU is stronger than on perceived usefulness. The interpretation could be that the needs of smart home users are underlined by the desire to increase the quality of living and productivity by simplifying their daily routine (Marikyan *et al.*, 2019, Aldrich, 2003). In addition, considering that the majority of respondents were elderly people, who are considered to have lower technological self-efficacy (Reed et al., 2005), the ease of use factor may play a more important role. Lastly, the path analysis demonstrates that satisfaction is predicted by the perceived technology fit. This is in line with the study by Lin (2012) and in contrast with the paper by Lu and Yang (2014).

This study supported the effect of perceived usefulness on use behaviour and PEOU on perceived usefulness in line with the findings of previous literature (Al-Gahtani et al., 2007, Wang and Shih, 2009, Venkatesh and Zhang, 2010, Martins et al., 2014). The coefficients of the path analysis suggest a moderate effect of PEOU, while the predictive power of perceived usefulness is lower. A higher effect of PEOU can be explained by the context of the study. Given that the essence of the smart homes is to operationalise technology performance and make it more efficient (Marikyan *et al.*, 2019, Aldrich, 2003), the perceived usefulness of users should be strongly associated with the low degree of perceived effort that needs to be employed to perform a task.

### *5.1.3. The Outcome of Use Behaviour*

The literature has extensively discussed the potential outcomes of use behaviour, providing contradictory results (Vlahos and Ferratt, 1995, Isaac et al., 2017, Sundaram et al., 2007, Tarafdar et al., 2014). Based on the path analysis results, this study adopts the stance in the research confirming a positive outcome of use behaviour. In contrast to the stream of research that found the effect of technology use on dissatisfaction and stress (Sundaram et al., 2007, Tarafdar et al., 2014), this paper provides evidence that the effect of use behaviour on satisfaction in the smart home context is significant. One possible interpretation could be the difference in the context and the preconditions of the technology use. For example, it was proved that the use of advanced technologies caused stress in organisational settings (Duxbury *et al.*, 2014, Román *et al.*, 2018). That means that the use of technology was mandatory and not underpinned by an individual's needs or beliefs. Given that smart homes imply the voluntary use and purchase of technology, driven by needs be they hedonic or utilitarian ones, satisfaction of use is a more likely outcome.

## 5.2 Theoretical Contributions and Practical Implications

The paper has examined the acceptance of pervasive technology in private spaces by exploring the effect of behavioural belief factors and task-technology fit on use behaviour and satisfaction. The paper addressed the gap in the literature in the domain of private spaces. The relationship of factors that are imperative in examining the acceptance of technology in private spaces was theorised and validated. The factors relate to individual attitudinal and behavioural beliefs, and the compatibility of technology with users' tasks (Shih and Venkatesh, 2004, Brown and Venkatesh, 2005, Choe *et al.*, 2011). The model provided robust results confirming the correlation between the proposed constructs. The findings of the study give insight into the acceptance of technology in private spaces and contribute to the current literature by focusing on the pervasive technology that is used only in a private context. This approach is different to the current research, which has examined stand-alone devices delivering a specific service or technologies applicable for both private and public settings.

The second contribution of the paper is rooted in scarce evidence in the literature about the user perspective on the acceptance of pervasive technology embedded in private residential areas. With few papers on that front (Anderson and Agarwal, 2010, Brown *et al.*, 2006, Brown and Venkatesh, 2005, Venkatesh and Brown, 2001), there has been no research exploring the technology-based and behavioural determinants of acceptance. This paper combined and examined the effect of task-technology fit, perceived usefulness and perceived ease of use. The individual psychological beliefs have also been examined by testing the correlation of the hedonic value, utilitarian value, privacy and financial risks with TTF. The results confirmed that use behaviour a) is associated with the perceived fit between task requirements and technology capabilities, b) is affected by the belief that technology performance brings utilitarian and hedonic values and c) is indirectly influenced by the perceived degree of effort required to use the technology. In addition, the paper provides an empirical validation of the effect of the potential benefits and barriers that have been discussed in the literature (Marikyan et al., 2019, Chan et al., 2008, Balta-Ozkan et al., 2013b, Balta-Ozkan et al., 2014, Aldrich, 2003). The examination of relationships between perceived values, risks and technology performance beliefs has provided a new insight into the technology adoption in private spaces. The findings enriched the literature by suggesting that users of smart home technology are likely to be motivated by utilitarian outcomes, such as monitoring and reducing energy consumption, support in the daily routine and health care to name but a few. People are less interested in hedonic benefits, such as the enjoyment and fun of using the technology. A new perspective on the attitudinal beliefs underlining adoption is provided by the findings that people are not concerned with the risk that the investment will not be justified, and the use of technology might entail data misuse and privacy intrusion. Also, it was found that the utilisation of technology is most likely to result in the satisfaction with technology, which has long been disputed in the literature.

The findings of this paper have a number of useful practical implications too. Providers and marketers should focus on the potential benefits that smart home technologies can bring. Given that the results showed the significance of hedonic and utilitarian values, it is important for providers to highlight those benefits, which can potentially trigger more interest and increase smart home acceptance. In addition, since task-technology fit was proved to be a significant factor in use and satisfaction, providers should clearly emphasise the characteristics and services when promoting smart home technologies in the market. This will help individuals evaluate the smart home technology relevance and applicability in their daily routines. Finally, providers should develop comprehensive guidelines on the use of smart home technology to increase the perception of products' usefulness.

## 6. CONCLUSION AND FUTURE RESEARCH

The study aimed to test the proposed model on the use of pervasive technology in private spaces. The relationship of integrated task-technology fit and attitudinal factors with use behaviour and satisfaction, as well as the effect of the antecedents of task-technology fit, were tested. The analysis resulted in the majority of the hypotheses being accepted. The strength of relationships in the model in general confirmed that is has a good power in explaining users' factors underpinning the use of technology in private settings, such as smart homes.

Given the research design choices made in this paper, there are a number of limitations that future research can address. Due to the cross-sectional design of the study, the causality between the constructs remains uncertain. Future research could pursue a longitudinal approach to examine the causal effect of perceived values, risks, technology fit and performance on use behaviour and resulting satisfaction. Another potential avenue for future research is to use a comparative design to examine the acceptance from the perspective of different user segments. The segments can be profiled based on the types of services and benefits (e.g. financial, health-related, environmental, psychological) that the utilised technologies provide. Such an examination may help identify the heterogeneity across individuals with regards to the relative strength of behavioural beliefs. Also, future research could look at the moderating effects of psychological traits that have not been tested in the current study. The data for this study were collected in the USA. The geographical context is characterised by high innovativeness and pervasive technological embeddedness, an ageing population and high economic development. The abovementioned factors define the values and risks that might underpin consumer behaviour. Particularly, users with high economic status and early adopters of innovative technologies tend to mitigate the significance of financial and privacy risks (Wilson et al., 2017), while the ageing of the population increases health-related value and operational dependence on smart home technology (Chung, 2017). To ensure the generalisability of the findings, the model could be tested in other contexts, different by demographic, economic and technological profiles. Finally, the effect of antecedents could be tested in relation to behavioural intention, using a sample of prospective users of smart home technology.

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