Unlocking the smart home: exploring key factors affecting the smart lock adoption intention

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Abstract

Purpose – This study examines the factorial structure of salient user beliefs associated with smart locks. We also examine the predictive value of the identified constructs on the smart lock adoption intention and we evaluate gender differences in the predictive value of the identified constructs.

Design/methodology/approach – The study assumes pragmatic epistemological stance and it leverages mixed-methods research design. The research progresses through three stages: belief elicitation, exploratory factor analysis and confirmatory factor analysis within a nomological network. New groups of participants were recruited for each stage of the study.

Findings – We find that while potential adopters express a broad range of perceived benefits and concerns associated with smart locks, only the perceived relative advantage of smart locks vis-à-vis conventional locks in providing safety and security is significantly correlated with adoption intention for both genders. We also find that perceived novel benefits are a significant predictor of the smart lock adoption intention for women, but not for men.

Research limitations/implications – Our results indicate that perceived relative advantage can be the singular critical consideration in the adoption of smart home technologies that replace incumbent solutions. The results also demonstrate that gender-specific models can better capture gender effects that influence technology adoption and use.

Practical implications – Smart home technology vendors would need to convince prospective users that new technology is better than the incumbent solutions on the core affordances of the incumbent technology. Men and women differ in the consideration of novel benefits afforded by novel technologies.

Originality/value – This is among the first studies to examine salient beliefs that affect smart home technology adoption. The findings suggest that the traditional models (TAM, UTAUT) do not capture the key salient beliefs that can influence innovative smart home technology adoption. The study also suggests that gendered models are needed to understand technology adoption in contexts where technology adoption intersects with gender roles.

Keywords Innovation, End users, Adoption, IT artifact, Access control, Ubiquitous system

Paper type Research paper

Introduction

Smart home technologies (SHTs) reside within the larger concept of Internet of things (IoT), which refers to the new generation of “smart” objects equipped with tags or sensors that collect data and connect to the internet (Internet Society, 2015). SHTs are one of the four major areas of application of IoTs, along with individual devices (wearables), smart cities and industrial applications. A 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

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of technology within the home and connections to the world beyond" (Aldrich, 2003). SHTs include sensors, monitors, interfaces, appliances and other types of connected devices.

As one of the fastest growing areas of application in the IoT domain, SHTs span a broad range of innovative "smart" products that give users the ability to control items around the house including lights, temperature, domestic appliances, security and entry systems (Markets and Markets, 2017). While these smart products are able to function independently from each other, a "smart home" is equipped with a network that connects all the sensors, appliances, and devices, to allow remote monitoring, access, and control by the home owner or occupant (Balta-Ozkan*et al.*, 2013). Despite the practical importance of this market, there has been relatively little academic research on the factors that influence SHT adoption in the United States. Most of the extant literature to date reports on studies conducted in other countries; and with a few exceptions (e.g. Wilson *et al.*, 2017) applies constructs from traditional technology adoption models.

SHTs promise to offer a unique combination of potential functional, experiential and aesthetic benefits to prospective owners. At the same time, these technologies also expose potential adopters to novel risks such as hacking and electronic surveillance. Therefore, in this study, we consider the *ambivalent* nature of these new technologies to offer a more comprehensive view of key factors affecting the adoption of SHTs. This breadth of benefits and novel concerns is unlikely to be captured by traditional technology adoption models that evolved primarily in the organizational context. The factors are also likely to be very different from those identified in industrial IoT research, which is conducted at the organizational level and whose adoption decisions seek to achieve operational improvements in industrial contexts (Lee and Lee, 2015). To address the research gap in ambivalent technologies operating at the individual level, and in recognition of recent calls for context-specific theory development (Hong *et al.*, 2013), we draw on the theory of reasoned action (TRA) as the foundation and we conduct a three-phase, mixed-methods study on user adoption of SHTs by focusing on smart locks.

From the theoretical point of view, smart locks are a key example of smart home technology wherein the smart tech necessarily replaces the existing solution (i.e. traditional key-based locks) with enhanced functionality, while offering the same core benefits. Compared to conventional locks, smart locks integrate sensors and Internet connectivity to provide new functionality (Elliott, 2018). These added capabilities also increase the potential risks associated with smart locks by making them vulnerable to unwanted unlocking, privacy risks, and unauthorized monitoring of physical premises. In the SHTs ecosystem, smart locks are an important device to study because they not only improve the individual experience with home access control, but also enable new forms of services, e.g. in-home delivery (Amazon, 2018). The commercial market for smart locks is expected to reach $24.4 billion by 2024 (Grand View Research, 2018).

To develop a contextually valid and empirically grounded theoretical model (Hong *et al.*, 2013), we draw on the TRA that posits that individual beliefs and perceived social norms influence behavioral intentions (Fishbein and Ajzen, 1975). TRA is a high-level context-independent framework that requires identification of the key salient considerations within each context. To develop an empirically grounded set of factors that influence the smart lock adoption intention, we assume a pragmatic epistemology stance (Goldkuhl, 2012), and we conduct a mixed-methods study (Venkatesh *et al.*, 2013). Our research progresses through (1) the elicitation of salient perceived benefits and concerns associated with smart locks, (2) exploratory factor analysis (EFA) of the elicited perceived benefits and concerns and (3) confirmatory factor analysis (CFA) within a broader nomological network, where we evaluate the effects of the emergent constructs on the smart lock adoption intention.

We find that perceptions related to functional performance (*perceived usefulness*), which are traditionally emphasized in information technology adoption research (Venkatesh, Thong and Xu, 2016a, b), have no statistically significant effect on the adoption intention of smart locks. Effort expectancy (*perceived ease of use*) is not among the salient considerations voiced by the prospective adopters. We also find that while the prospective smart lock users indicate that privacy and security concerns may affect their adoption intention, neither of these factors had a statistically significant effect on this intention when we examined them within a broader nomological network. Focusing on the gender-specific factors, our results reveal that *perceived relative advantage* of smart locks vis-à-vis traditional locks in assuring security and safety of a home is the most important factor that influences smart lock adoption intention for both men and women. We also find that the consideration of novel benefits offered by smart locks is a significant predictor of adoption intention for women, but not for men.

Our study makes important contributions to theory and practice. First, to the best of our knowledge, this study is among the first to develop a comprehensive, context-specific model of factors that influence smart home technology adoption. The elicited factors include well-established constructs, for example, *perceived usefulness* and *privacy concerns*, as well as novel constructs, e.g. *concern about the negative effects of technology on others*. The analysis of the effects of these factors on smart lock adoption intention revealed that constructs traditionally emphasized in technology adoption research (*perceived usefulness* and *perceived ease of use*) are not the most salient influences on adoption intention in this context. Our findings show that *perceived relative advantage* compared to the incumbent technology is the key consideration to predict adoption intention for smart locks. Moreover, this is also one of the first studies to demonstrate that relevant factors leading to technology adoption decisions are different between women and men. We find that while men narrowly focus on the perceived relative advantage afforded by smart locks, women also consider perceived novel benefits offered by the new technology. This finding has important theoretical implications. Whereas all prior research has treated gender as a moderator in gender-invariant models, our results suggest that gendered models may offer a more accurate perspective on the key factors in research on technology adoption and use in the contexts where technology adoption intersects with gender-specific roles or perceptions.

Theoretical background

Theoretical foundations of dominant theories in technology adoption research

Factors influencing technology adoption are a central theme in information systems research (Straub, 2009; Venkatesh *et al.*, 2016a, b). Technology acceptance model (TAM) (Davis, 1989) and its successor, unified technology acceptance and use theory (UTAUT) (Venkatesh *et al.*, 2003; Venkatesh *et al.*, 2012a, b; Venkatesh *et al.*, 2016a, b), are the dominant theoretical frameworks in technology adoption research. The original TAM article (Davis, 1989) has been cited over 48,000 times and a full review of the TAM and UTAUT is beyond the scope of the current study. In this section, we focus on the theoretical foundations of TAM and UTAUT.

TAM and UTAUT are both theoretically grounded in TRA (Ajzen and Fishbein, 1977; Fishbein and Ajzen, 1975). TRA posits that individual beliefs and attitudes as well as perceived social norms influence behavioral intention. TAM was developed by drawing on TRA and examining the key beliefs predictive of enterprise systems adoption (Davis, 1989; Davis *et al.*, 1989). UTAUT is built on the TAM foundation through integration of published research on additional considerations that may influence technology adoption (Venkatesh *et al.*, 2012a, b; 2016b). Whereas TAM offers a very parsimonious model by focusing on just two considerations (perceived usefulness and perceived ease of use) in technology adoption (Davis, 1989), UTAUT elaborates on TAM by adding social influence, facilitating conditions, hedonic motivation and price value perceptions as additional constructs that can help explain technology adoption and continued use intentions in voluntary contexts (Venkatesh *et al.*, 2003; Venkatesh *et al.*, 2012a, b).

TRA is a general framework and it requires identification of context-specific beliefs that influence specific behavioral intentions (Montano and Kasprzyk, 2015). Although TAM and UTAUT have proven their value across different technology adoption domains (Alomari *et al.*, 2012; Naranjo-Zolotov *et al.*, 2018; Park *et al.*, 2016; Venkatesh *et al.*, 2016a, b), a number of studies have demonstrated that alternative salient perceptions have higher predictive value in explaining technology acceptance in specific contexts. For example, Lee and Larsen (2009) revealed that perceived severity of the threat and perceived response self-efficacy were the key determinants of the intention to install anti-malware software. Hsiao (2003) showed that *fear* and *distrust* were the key factors that helped explain the adoption intention in an e-marketplace. Baird *et al.* (2012) demonstrated that a complex set of *contingencies* influenced the adoption of electronic patient portals by healthcare providers. In summary, although TAM and its successor, UTAUT, offer general frameworks encompassing factors influencing technology adoption intention, research within specific contexts has found that context-specific factors afford a better, more contextualized, understanding of the phenomenological drivers in the respective contexts. In the next section, we review smart home technology adoption research.

Smart home adoption research

Initial research on the adoption of SHTs was focused on home healthcare applications for the elderly (Vichitvanichphong *et al.*, 2018). A number of studies conducted focus groups and surveys with older adult samples to assess the perceived benefits and concerns associated with in-home monitoring technologies such as portable blood pressure monitors, fall sensors or cameras (Coughlin, D'Ambrosio *et al.*, 2007; Courtney, 2008; Demiris *et al.*, 2008; Townsend *et al.*, 2011). The consensus emerging from these studies is that older adults generally view their homes as sanctuaries, and they are concerned about the loss of autonomy that may result from the installation of monitoring technologies (Ziefle *et al.*, 2011). Furthermore, although the elderly appreciate the potential benefits offered by in-home monitoring technologies, they generally express concern over the loss of privacy associated with the use of monitoring technology (Liu *et al.*, 2016).

More recent studies on non-medical SHTs have largely been conducted outside of the United States and they often treated smart home technologies as a generic concept, without differentiating among the various types of technologies (Kim *et al.*, 2017; Hsu and Lin, 2018; Shin *et al.*, 2018; Pal *et al.*, 2018). TAM is the dominant theoretical model in this stream of research (de Boer *et al.*, 2019; Pal *et al.*, 2018; Park *et al.*, 2018; Shin *et al.*, 2018). There are also several studies grounded in marketing literature that apply the perceived value framework and argue that the *perceived value* construct fully mediates the effects of perceived usefulness, and perceived ease of use on adoption intention (Hsu and Lin, 2018; Kim *et al.*, 2017). Table 1 summarizes journal articles on non-medical smart home adoption that we identified through exhaustive literature search.

In contrast to the theory-driven empirical results conducted in Asia and reported in (Hsu and Lin, 2018; Kim *et al.*, 2017; Pal *et al.*, 2018; Shin *et al.*, 2018), an exploratory study in the United Kingdom found that consumer adoption intention of smart home technologies in the UK was primarily influenced by the expected energy, time, and money savings (Wilson *et al.*, 2017). These results suggest that salient factors influencing SHT adoption are likely to be different from those outlined in the dominant theoretical models (e.g. TAM or UTAUT).

Men and women often assign different meanings to their homes (Mallett, 2004). Consequently, we may expect that salient perceptions that influence SHT adoption may be different across genders. In the next section, we review prior literature on gender effects in technology adoption.

Reference	SHT type/ Context	Theoretical framework	Methodology/Key results
Kim *et al.* (2017)	General SHT concept/China	Perceived value framework	A cross-sectional survey of Chinese consumers suggests that *perceived value* fully mediates the effects of *perceived usefulness*, *perceived ease of use*, *cost*, and *enjoyment* on *adoption intention*
Yang *et al.* (2017)	General SHT concept/South Korea	Theory of Planned Behavior	A cross-sectional survey of South Korean consumers suggests that *attitude toward smart homes*, *subjective norms* and *perceived behavioral control* are positively associated with *intention to use*
Wilson *et al.* (2017)	General SHT concept/UK	No *a priori* theory	Explorary descriptive study. The key considerations in the adoption of smart home technology are energy, time and money savings
Wang *et al.* (2018)	General SHT concept/ Australia	Risk/rewards framework	A cross-sectional survey of Australian users suggests that they tend of overlook *potential risks* and focus on *potential benefits* offered by smart home technologies
Shin *et al.* (2018)	General SHT concept/South Korea	Incomplete TAM DV: attitude toward smart homes	A cross-sectional survey of consumers in South Korea suggests that *perceived usefulness*, *perceived ease of use*, *compatibility concerns* and *privacy concerns* are correlated with the *attitude toward smart home technology use*
Pal *et al.* (2018)	General SHT concept/ South Korea	Incomplete, altered UTAUT, enjoyment is an antecedent of perceived usefulness	A cross-sectional survey of Korean consumers suggests that *attitude toward the smart home technology* as well as *perceived cost* and *perceived usefulness* would influence *intention to use*
Hsu and Lin (2018)	General SHT concept/Taiwan	Perceived value framework	A cross-sectional survey of consumers in Taiwan suggests that *perceived value* fully mediates the effects of *perceived usefulness*, *perceived enjoyment*, *perceived privacy risk* and *cost concerns* on *adoption intention*
Pal *et al.* (2018)	General SHT concept/Thailand	Altered TAM, attitude toward smart home technology is added as a predictor	A cross-sectional survey of elderly consumers in Thailand about smart homes suggests that *attitude toward the smart homes*, *perceived usefulness* and *perceived ease of use* are correlated with *adoption intention*
Wunderlich *et al.* (2019)	Smart meters/ Germany	Locus of control	A mixed-methods study suggests that *locus of control* (*self-efficacy*) may affect smart meter *adoption intention*
de Boer *et al.* (2019)	General SHT concept/ Netherlands	TAM	A cross-sectional survey of Dutch users shows that *technical skills* are positively correlated with *perceived usefulness* and *perceived ease of use*

Table 1.
Summary of non-medical smart home adoption research

Gender effects in technology adoption

Prior interdisciplinary research has found that women and men think about their homes differently (Mallett, 2004). While both genders are likely to consider comfort, privacy and security as key considerations affecting the choice of home, the genders are different in the core psychological evaluations of one's home. Men are known to perceive the home as a symbol of status and achievement, whereas home is more generally viewed by women as a haven, i.e. a place that offers safety from outside interference (Mallett, 2004). In light of the distinct psychological functions that the two genders ascribe to the home, it is of interest to investigate whether adoption intention of smart locks, as a flagship application in SHT, also exhibits gender differences.

Gender has been long noted as an important factor in technology adoption research (Venkatesh and Morris, 2000). Although UTAUT argues that gender is a moderator of the key factor effects in the model (Venkatesh *et al.*, 2012a, b), much of the research on technology adoption has treated gender as a control variable (Venkatesh *et al.*, 2016a, b). Here, we focus our review on studies that examined gender as a moderator in technology adoption research, potentially highlighting the differences that may exist between genders in technology adoption decisions.

Venkatesh and Morris (2000) are among the earliest authors to examine the moderating role of gender and they found that the effect between perceived usefulness of technology and actual use is stronger for men than for women in the enterprise system context. A study of mobile chat service use in Norway showed that the effect of enjoyment on continued use was stronger for women than men, whereas the effect of perceived usefulness on actual use was stronger for men than women (Nysveen and Pedersen, 2005). Overall, the results on the effects of gender have not been consistent across all studies. Alam *et al.* (2020) have recently found that the effect of performance expectancy (perceived usefulness) on the mHealth service adoption was stronger for women than men. Further, several studies showed no gender effects within TAM/UTAUT models (Aguirre-Urreta and Marakas, 2015; Baker *et al.*, 2007; Li *et al.*, 2008). Table 2 summarizes the studies we identified through extensive search focusing on the role of gender as a moderator in technology adoption decisions in Information Systems journals.

Gaps in extant research

Integrating prior studies on SHT adoption and the role of gender in technology adoption we find a number of substantial gaps. First, we find that much of prior research on SHT adoption is narrowly grounded in TAM and related frameworks, generally ignoring the innovative nature of smart home technologies and the capacity of SHTs to deliver a complex mix of potential aesthetic, experiential and utilitarian benefits. The one exploratory study conducted in the United Kingdom (Wilson *et al.*, 2017) suggests that extant literature does not account for the key salient considerations influencing smart home adoption intentions. The second gap in extant literature is that published studies on SHT adoption have generally neglected interdisciplinary insights on differences in gender roles and beliefs associated with one's home. The third significant gap in prior research is that all published studies on non-medical SHT adoption were done outside of the United States, thus ignoring an important commercial market for SHTs. These gaps in extant literature reveal a need for context-specific theory development focusing on identifying practically-relevant salient factors that influence SHT adoption in the United States (Hong *et al.*, 2014). In the next section, we discuss the methodology of our study.

Methodology

Given the novelty of smart lock characteristics, as a digital control to a physical space, and its context of use (home instead of workplace), we argue that generic theoretical models might be

Reference	Context	Theoretical framework	Key results
Venkatesh and Morris (2000)	Enterprise	TAM	Gender moderates the effect of perceived usefulness on actual use. The effect is stronger for men
Venkatesh *et al.* (2000)	Enterprise	TPB	Gender is a moderator. The effect of attitude on actual use is stronger for men. The effect of subjective norm on actual use is stronger for women
Nysveen and Pedersen (2005)	Mobile chat services in Norway	TAM+	Gender is a moderator. Intrinsic motivations (enjoyment) are more important for females, extrinsic (usefulness and expressiveness) are more important for males
Ahuja and Thatcher (2005)	Enterprise	TRA	Gender moderates the interaction between work autonomy and work overload in promoting innovative IT use
Baker *et al.* (2007)	Enterprise in Saudi Arabia	TPB	No gender effect found
Li *et al.* (2008)	Mobile commerce in China	UTAUT	No gender effect found
Im *et al.* (2008)	Messaging applications	UTAUT	Gender is a moderator of perceived usefulness on the adoption intention
Sanchez-Franco *et al.* (2009)	ISP	Commitment-Trust-Loyalty	Gender is a moderator of the effects of commitment and trust. Commitment is the more important factor affecting female loyalty towards ISPs. Trust is the more important factor for males
Aguirre-Urreta and Marakas(2015)	General computer use	TAM + psychological constructs	No gender effect found
Riquelme and Rios (2010)	E-commerce	TAM + relative advantage, risk	Gender is a moderator. Social influence effect on the actual use is stronger for females
Wang and Wang (2010)	Mobile Internet in Taiwan	UTAUT	Gender is a moderator. Perceived usefulness has a stronger effect for males
Dong and Zhang (2011)	Enterprise system in China	TPB	Gender is a moderator. Subjective norms are a stronger factor for men. This is in contrast to prior results from the US.
Lin *et al.* (2017)	Social network site continuance in China	TAM+	Gender is a moderator. The effects of satisfaction and perceived usefulness on the continuance intention are stronger for men. The effect of community identification on the continuance intention is stronger for women
Shao *et al.* (2019)	Mobile payment platforms	Incomplete UTAUT	Gender is a moderator. The effect of trust on the continuance intention is stronger for men than for women. The effect of perceived risk is significant for women, but not for men

(*continued*)

Table 2.
Summary of moderating gender effects in technology adoption research

Reference	Context	Theoretical framework	Key results
Park *et al.* (2019)	Multimedia technology adoption in learning	TAM	Gender is a moderator. The effect of perceived usefulness on the adoption intention is stronger for men
Alam *et al.* (2020)	mHealth service adoption/China	UTAUT	Gender is a moderator. The effect of performance expectancy on the behavioral intention is stronger for women than men. The effects of effort expectancy, facilitating conditions and perceived value are stronger for men

Table 2.

unable to capture key contextual factors. Following the recommendations by Hong *et al.* (2014) for context-specific theory development, we draw on the TRA as the overarching theoretical framework and we seek to understand the drivers of smart lock adoption (Ajzen and Fishbein, 1977; Fishbein and Ajzen, 1975). TRA posits that individual beliefs, attitudes and perceived social norms influence behavioral intentions (Ajzen and Fishbein, 1977; Fishbein and Ajzen, 1975). TRA further advocates elicitation of context-specific attitudes and social norms as a key step in the adaptation of TRA to a specific context. For this purpose, we conduct a multi-phase, mixed-methods study to develop a comprehensive model of salient factors influencing smart lock adoption.

To identify the salient beliefs and attitudes that may affect the adoption intention of smart locks, our study progresses through three phases. First, consistent with the ambivalent nature of this technology, we elicit salient perceived benefits and concerns associated with smart lock technology adoption. Second, we conduct an EFA to inductively identify the latent constructs that capture the diverse set of beliefs and concerns elicited in the first phase. Third, we conduct a CFA, wherein we also evaluate the effects of the emergent constructs on the intention to adopt smart locks.

We recruited a new set of participants using Amazon's Mechanical Turk (AMT) for each phase of the study. AMT is an online labor market for micro tasks that has received support as a valuable source of research participants in Information Systems (Steelman *et al.*, 2014; Lowry *et al.*, 2016) and other disciplines (Buhrmester *et al.*, 2011; Holden *et al.*, 2013). To avoid potential cross-cultural effects, we limited the participation to AMT "workers" from the United States. We also restricted the participation in the study to AMT Masters. AMT "grants the Masters Qualification based on statistical models that analyze Worker performance based on several Requester-provided and marketplace data points" (Amazon AMT, 2018). We relied on a commercial survey platform (Qualtrics) to capture participants' responses to our surveys in each phase of the study. The phases proceeded consecutively with each one providing input for the next.

In the first phase (elicitation of perceived benefits and concerns), we recruited 24 participants from AMT. We collected basic demographic data and asked participants to indicate ownership of different smart home technologies. Since this was a study on adoption intention of smart locks, it was important that all subjects had not yet adopted smart locks. None of the participants in this phase indicated ownership or use of a smart lock. We exposed participants to a 5-min commercially produced video describing smart locks and then asked them to share their opinion on the top 5 potential benefits and top 5 concerns associated with smart locks. We paid $3 per completed response in this stage. There were no incomplete responses in this stage.

Based on the elicited perceived benefits and concerns identified in this phase, we developed a list of 52 non-duplicated items. These items included statements such as "Having a smart lock in your home would enable you to verify that your house is locked," "Having a smart lock in your home would enable you to let family in remotely in case of emergency," and "I am concerned that a smart lock may malfunction and lock me out." Following the recommendations in (MacKenzie *et al.*, 2011), the list of items was reviewed by three scholars with expertise in technology adoption and survey-based research methodologies.

In the second phase (EFA), we recruited a new group of 150 participants from AMT. Five participants did not complete the survey and they were excluded from the analysis. We also excluded two participants who indicated ownership of a smart lock, since the focus of our study is on the pre-adoption stage. Following the recommendations by Meade and Craig (2012), we include two attention control questions in the survey. The questions were in the form recommended by Meade and Craig (2012) – "To monitor quality, please respond with a two for this item." The other question was similar but asked the respondent to enter a different number. The questions were presented in different parts of the survey. All of the participants answered the attention control questions correctly in phase 2. We collected basic demographic information and exposed participants to the same smart lock video used in the previous phase. We then asked them to indicate their agreement or disagreement with the items generated in the first phase. We used seven-point Likert scales with "1 = Strongly disagree" and "7 = Strongly agree." We performed an exploratory factor analysis and inductively developed a list of latent constructs capturing the themes that emerged from the analysis. Details of this analysis are provided in the results section. We paid $1.50 per completed survey in stage 2.

In the third phase (CFA), we recruited a new group of 574 AMT participants who did not own a smart lock. We paid $1.50 per completed survey in this phase. We excluded 27 responses that did not complete the survey. As in phase two, we included two attention control questions in the survey in the third phase. We excluded 16 due to incorrect responses to one or both attention control questions. In the third phase, we collected basic demographic information and after showing the smart lock video, we surveyed participants on the constructs that emerged in phase 2, as well as their adoption intention using the established scale from UTAUT (Venkatesh *et al.*, 2012a, b). The scale is provided in Appendix A. We confirmed the factorial structure of the constructs identified in phase two and we tested the relationships between all the constructs in a theoretically based nomological network. Figure 1 below summarizes the phases in our study.

Results

Elicitation of perceived benefits and concerns

The characteristics of the sample of participants in the elicitation phase was 41.3 ± 7.6 years of age, ranging from 25 to 54 years old, with 48% male and 52% female. In terms of level of education, 41.7% of the participants had at least a four-year college degree, while 25% of the participants had only completed high school education.

To develop the list of items for the next phase, we followed the process outlined by Lederer and Sethi (1992) and analyzed the content of participants' responses to questions about perceived benefits and perceived concerns related to smart locks. For example, a participant's

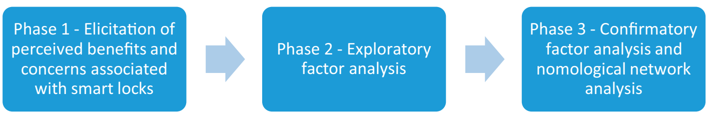


Figure 1.
Mixed-methods methodology

response related to the perceived benefits offered by smart locks that read "You can lock your door when you are away" was reworded as "Having a smart lock in your home would enable you to lock the home while away." In addition to rewording, and following the recommendations of our panel of IS researchers, several items were slightly edited to assure content clarity and validity.

Exploratory factor analysis

In the second phase, the sample was 39.8 ± 10.8 years of age, ranging from 19 to 67 years old, with 44% male. About half (48%) of the participants had at least a four-year college degree, while 14.8% of the participants had only a high school diploma.

With the items generated in the first phase and the responses collected from the sample in the second phase, we conducted an exploratory factor analysis following the recommendations of Muthen and Muthen (2012). We performed a principal axis factor analysis with oblique rotation using Mplus software version 8.1. We chose to use the oblique rotation to allow for potential correlations among the latent constructs reflected in the responses to individual survey items. The results suggested a seven-factor solution shown in Table 3. Item wordings are included in the next table. The seven-factor model showed a good fit to the covariance patterns in the data: RMSEA = 0.061, CFI = 0.967, TLI = 0.952, SRMR = 0.016.

Table 3.
Exploratory factor analysis – factor loadings

	1	3	2	4	5	6	8
B1	*0.829*	0.28	0.168	0.04	−0.055	−0.007	−0.07
B2	*0.771*	0.259	0.201	0.149	−0.071	−0.002	−0.093
B15	*0.89*	0.281	0.196	−0.051	−0.11	−0.127	−0.293
B17	*0.864*	0.206	0.143	0.086	0.01	0.016	−0.24
B18	*0.876*	0.237	0.129	0.029	−0.089	−0.063	−0.239
B19	*0.77*	0.182	0.178	0.096	−0.102	−0.041	−0.213
B20	*0.782*	0.206	0.103	0.041	−0.034	−0.036	−0.204
B22	*0.799*	0.248	0.13	0.007	−0.011	−0.016	−0.202
B9	0.355	*0.882*	0.313	−0.287	−0.305	−0.279	−0.224
B11	0.247	*0.869*	0.324	−0.265	−0.287	−0.267	−0.17
B14	0.278	*0.937*	0.256	−0.236	−0.291	−0.237	−0.05
B6	0.199	0.305	*1.01*	−0.092	−0.105	−0.186	0.035
B16	0.223	0.347	*0.817*	−0.178	−0.165	−0.311	−0.008
C01	0.034	−0.299	−0.075	*0.933*	0.515	0.667	0.396
C02	−0.035	−0.293	−0.1	*0.945*	0.541	0.7	0.382
C04	−0.046	−0.327	−0.148	*0.931*	0.611	0.677	0.376
C05	0.051	−0.24	−0.109	*0.868*	0.456	0.689	0.258
C06	−0.018	−0.331	−0.116	*0.922*	0.561	0.689	0.384
C17	−0.061	−0.329	−0.11	0.487	*0.871*	0.609	0.295
C18	−0.097	−0.236	−0.01	0.489	*0.877*	0.507	0.291
C19	−0.05	−0.276	−0.091	0.478	*0.914*	0.522	0.202
C20	−0.076	−0.265	−0.094	0.494	*0.95*	0.534	0.244
C21	−0.153	−0.321	−0.067	0.49	*0.72*	0.637	0.336
C22	−0.155	−0.322	−0.161	0.524	*0.868*	0.603	0.241
C23	−0.136	−0.259	−0.07	0.514	*0.91*	0.563	0.342
C24	−0.07	−0.298	−0.133	0.51	*0.948*	0.554	0.261
C08	−0.092	−0.239	−0.125	0.638	0.5	*0.806*	0.306
C09	−0.11	−0.283	−0.198	0.621	0.62	*0.89*	0.212
C11	−0.084	−0.306	−0.225	0.685	0.609	*0.864*	0.275
C12	0.06	−0.33	−0.15	0.683	0.675	*0.785*	0.232
C13	−0.151	−0.36	−0.246	0.623	0.556	*0.826*	0.343
C25	−0.205	−0.275	−0.042	0.507	0.453	0.408	*0.727*
C27	−0.16	−0.239	−0.006	0.443	0.35	0.375	*0.762*

Following the recommendations of Fabrigar *et al.* (1999), we examined the content of individual constructs to develop a theoretical foundation for the latent factors that can affect the adoption of smart locks. The first factor emerging from the analysis captures statements related to *perceived usefulness* reflected in the specific functional affordances of the smart locks. While this is a firmly established factor in technology adoption research (Venkatesh *et al.*, 2016a, b), it is notable that participants in our study emphasize the specific affordances of the technology rather than general perceptions of usefulness.

The second factor emerging from the analysis reflects the *perceived relative advantage* of smart locks compared to traditional locks. Relative advantage is a core construct in the Rogers' technology diffusion model (Rogers, 2010). However, this construct has been generally overlooked in the analysis of factors affecting individual technology adoption intention (Venkatesh *et al.*, 2016a, b).

The third factor captures perceptions related to the specific *perceived novel benefits* afforded by the smart locks. Among other functions, smart locks can enable remote video monitoring either as a part of the device itself or as an add-on. It is noteworthy that prospective users appear to be separately evaluating novel benefits of smart technology independently from the more general *perceived usefulness* of the locks.

The fourth factor captures *reliability concerns*. Smart locks control access to people's homes. Hence, the possibility of a person being locked out because of a smart lock malfunction can be an important consideration. Reliability concerns have been noted as a potential impediment in technology adoption across different contexts, e.g. online banking (Lee, 2009) and electronic medical record systems (Ajami and Bagheri-Tadi, 2013).

The fifth factor captures privacy related concerns, ranging from personal information collection, e.g. *I am concerned that a smart lock would be collecting data about my habits*, to unauthorized commercial appropriation of the collected information – *I am concerned that data collected by the smart lock may be sold*. Information privacy concerns are well established in IS research and research has found that they can impede technology adoption (Hsu and Lin, 2016; Xu and Gupta, 2009).

The sixth factor captures concerns about the potential weaknesses of smart locks that may expose the owner to additional *physical security threats*. These concerns span a broad range of potential causes from hard wiring to hacking.

The seventh factor captures concerns related to the potential *negative effect of technology on others*. While technology usefulness for others has been noted previously in the technology adoption research (Brown and Venkatesh, 2005), *negative effect of technology on others* resulting from one's adoption of technology represents a novel construct.

A summary of the emergent factors and the corresponding items is provided in Appendix B.

Confirmatory factor analysis

The factor structure resulting from the second phase provided the foundation to test the effects of the emergent constructs on adoption intention in a nomological network grounded in TRA in the third phase. The results presented below are based on the sample recruited for this phase (558 responses, 574 participants who completed the surveys minus 16 who failed attention control questions in the questionnaire). The average age of the participants was 40.5 ± 11.4, with 48% male and 52% female. A little over half (55%) had at least a four-year college degree.

We estimated the model parameters using the Mplus software version 8.1 employing the MLR algorithm, which is robust to non-normally distributed observations (Muthén and Muthén, 2012). The measurement model showed a good fit: RMSEA = 0.052, CFI = 0.957, TLI = 0.953, SRMR = 0.046. All item loadings on the theorized latent constructs were significant at the $p < 0.001$ level and no modifications were warranted. Item loadings on the respective constructs are summarized in Table 4.

Table 4.
Item loadings and measurement reliability assessment

	PU	PRA	NB	MC	PC	SC	NEO	INT	CA	CR
B1	0.85								0.906	0.948
B17	0.899									
B18	0.873									
B9		0.912							0.936	0.934
B11		0.92								
B14		0.891								
B6			0.79						0.821	0.821
B16			0.878							
C01				0.907					0.946	0.945
C02				0.919						
C04				0.943						
C17					0.909				0.948	0.948
C18					0.872					
C19					0.933					
C20					0.916					
C21					0.793					
C08						0.808			0.929	0.930
C09						0.871				
C11						0.909				
C12						0.917				
C25							0.869		0.829	0.801
C27							0.764			
Int1								0.95	0.977	0.978
Int2								0.971		
Int3								0.983		

Note(s): PU = perceived usefulness, PRA = perceived relative advantage, NB = novel benefits, MC = malfunction concerns, PC = privacy concerns, SC = security concerns, NEO = negative effects on others, INT = adoption intention. CA – Cronbach's alpha, CR – composite reliability

Scales measuring individual constructs had good reliability, convergent and discriminant validity. Cronbach's alphas (CA) and composite reliability (CR) scores were above the recommended threshold of 0.7 (Alwin, 2007). CAs and CRs for the respective scales are also provided in Table 4.

The square root of average variance extracted (AVE) for the individual constructs exceeded the recommended level of 0.7 (Gefen *et al.*, 2011), and it was higher than any of the inter-construct correlation coefficients. The correlation coefficients and the square root of AVE (in the diagonal) are shown in Table 5.

TRA posits that positive evaluations of expected benefits associated with a specific behavior will increase the behavioral intention, whereas negative perceptions associated with the behavior will decrease the behavioral intention (Ajzen and Fishbein, 1977; Fishbein; Ajzen, 1975). Drawing on TRA, we expected that perceived usefulness, perceived relative advantage and perceived novel benefits would have positive effects on the smart lock adoption intention, whereas malfunction concerns, privacy concerns, security concerns and the expectation of negative effect on others would have negative effects on the smart lock adoption intention. Accordingly, we formulate the following hypotheses:

H1. Higher perceived usefulness will have a positive effect on the smart lock adoption intention.

H2. Higher perceived relative advantage vis-à-vis incumbent technology will have a positive effect on the smart lock adoption intention.

	PU	PRA	NB	MC	PC	SC	NEO	INT
PU	0.935							
PRA	0.258	0.908						
NB	0.603	0.259	0.835					
MC	−0.009	−0.419	−0.042	0.923				
PC	−0.054	−0.379	−0.050	0.579	0.886			
SC	0.078	−0.507	−0.041	0.840	0.780	0.818		
NEO	−0.153	−0.142	−0.151	0.648	0.529	0.557	0.818	
INT	−0.050	0.453	0.086	−0.080	−0.115	−0.042	0.018	0.968

Note(s): PU = perceived usefulness, PRA = perceived relative advantage, NB = novel benefits, MC = malfunction concerns, PC = privacy concerns, SC = security concerns, NEO = negative effects on others, INT = adoption intention

Table 5. Construct correlations and square root of AVE (in the diagonal)

H3. Greater perceived novel benefits offered by smart locks will have a positive effect on the smart lock adoption intention.

H4. Greater malfunction concerns will have a negative effect on the smart lock adoption intention.

H5. Greater privacy concerns will have a negative effect on the smart lock adoption intention.

H6. Greater security concerns will have a negative effect on the smart lock adoption intention.

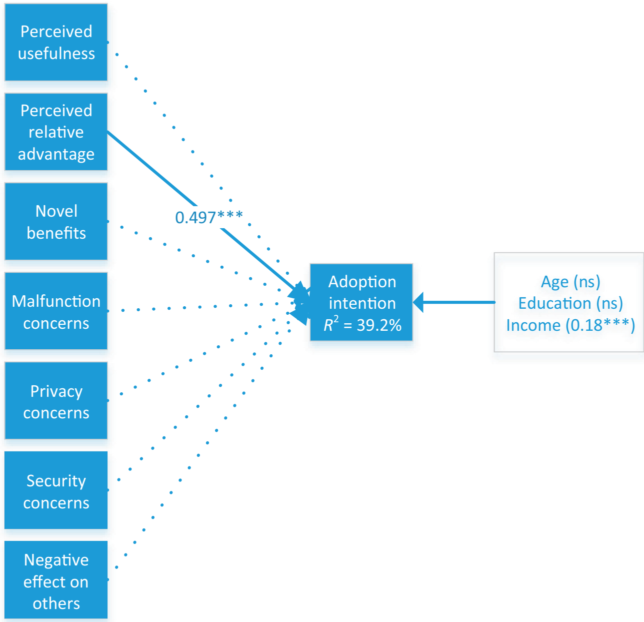
H7. Greater concerns about the negative effect of smart locks on others will have a negative effect on the smart lock adoption intention.

To evaluate the significance of the effects of perceived usefulness, perceived relative advantage, perceived novel benefits, malfunction, privacy and security concerns as well as perceived negative effects of technology on others on the adoption intention, we assessed the specified structural model and examined the statistical significance of the paths in the model. The structural model showed a good fit: RMSEA = 0.048, CFI = 0.963, TLI = 0.960, SRMR = 0.041.

Evaluating the structural paths in the specified model, we found support for a positive relationship between perceived relative advantage and adoption intention ($\beta = 0.497$, $p < 0.001$), but we found no support for statistically significant relationships between the other factors (perceived usefulness, perceived novel benefits, malfunction concerns, privacy concerns, security concerns and potential negative effects of technology on others) on the adoption intention. Among the control variables, only income has a statistically significant positive effect on the adoption intention ($\beta = 0.18$, $p < 0.001$). Figure 2 below summarizes the results of the path analysis in the model.

Gender differences evaluation. To evaluate whether the relationships in the nomological network were invariant in relation to gender, we compared model fit for the constrained multi-group model, i.e. the model in which all the effects are assumed to be constant across the two genders, versus an unconstrained model. The χ^2 difference test to assess the model fit difference indicated that the unconstrained model showed a better fit to the data ($p < 0.01$, $\chi 2$ difference = 18.723, df = 7). This result suggests that the effects of factors differ across genders. The $\chi 2$ values and degrees of freedom for the respective constrained and unconstrained models are provided in Table 6.

In the next step of the analysis, we evaluated the models for each gender. The unconstrained two-group model showed a good fit to the data: RMSEA = 0.042, CFI = 0.96,



Note(s): *** - significant at $p < 0.001$

Figure 2.
Structural path model analysis summary

Table 6.
Model difference assessment

	Constrained model	Unconstrained model	Difference
$\chi 2$	931.474	912.751	18.723
df	679	672	7

TLI = 0.955, SRMR = 0.046. All item loadings on the theorized latent constructs were significant at the $p < 0.001$ level. Scales measuring individual constructs had good reliability, convergent and discriminant validity. Cronbach's alphas (CA) and composite reliability (CR) scores were above the recommended threshold of 0.7. The square root of average variance extracted (AVE) for the individual constructs exceeded the recommended level of 0.7 (Gefen *et al.*, 2011) and it was higher than any of the inter-construct correlation coefficients. The correlation coefficients and the square root of AVE (in the diagonal) are shown in Table 7.

Focusing on the effects of individual factors on the smart lock adoption intention, we find that while the perceived relative advantage of the smart locks is a significant factor influencing adoption intention for men and women (women: $\beta = 0.394$, $p < 0.001$, men: $\beta = 0.480$, $p < 0.001$), novel benefits afforded by smart locks have a significant effect on adoption intention only for women ($\beta = 0.275$, $p < 0.05$), but not for men. We also find different effects of control variables for men versus women. Whereas income is a significant correlate with the adoption intention for both women and men ($\beta = 0.8$, $p < 0.001$ and $\beta = 0.13$, $p < 0.05$ respectively), age has a statistically significant negative correlation with the adoption

Men								
	PU	PRA	NB	MC	PC	SC	NEO	INT
PU	0.926							
PRA	0.258	0.908						
NB	0.603	0.259	0.904					
MC	−0.009	−0.419	−0.042	0.916				
PC	−0.054	−0.379	−0.050	0.579	0.885			
SC	0.078	−0.507	−0.041	0.840	0.780	0.853		
NEO	−0.153	−0.142	−0.151	0.648	0.529	0.557	0.886	
INT	−0.050	0.453	0.086	−0.080	−0.115	−0.042	0.018	0.960
Women								
	PU	PRA	NB	MC	PC	SC	NEO	INT
PU	0.947							
PRA	0.258	0.909						
NB	0.603	0.259	0.862					
MC	−0.009	−0.419	−0.042	0.929				
PC	−0.054	−0.379	−0.050	0.579	0.888			
SC	0.078	−0.507	−0.041	0.840	0.780	0.900		
NEO	−0.153	−0.142	−0.151	0.648	0.529	0.557	0.803	
INT	−0.050	0.453	0.086	−0.080	−0.115	−0.042	0.018	0.977

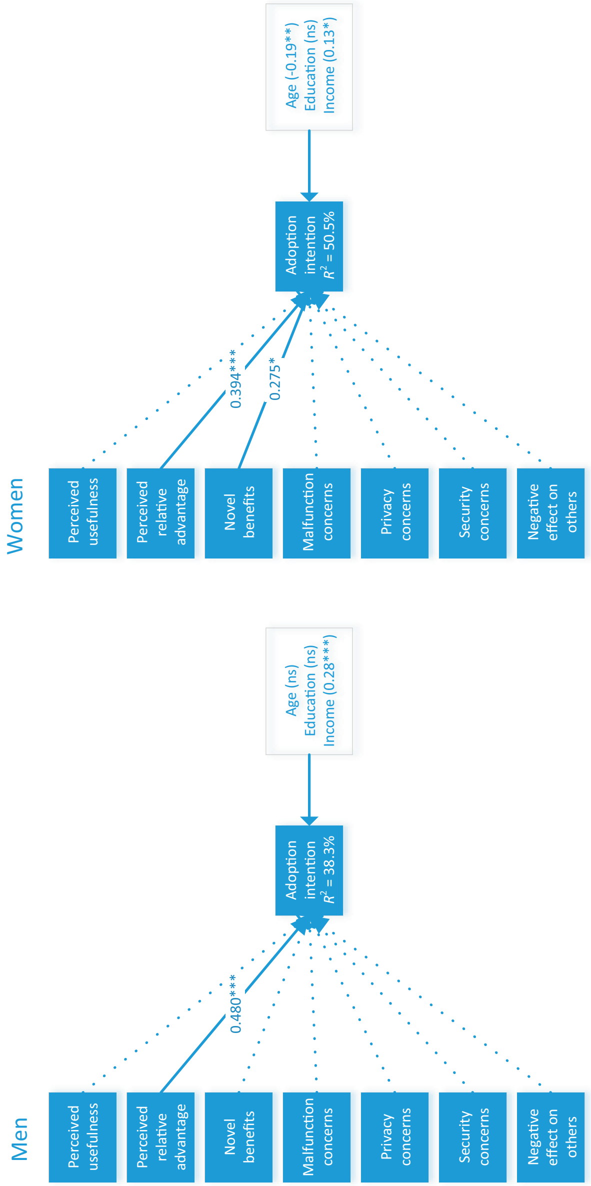
Table 7.
Construct correlations and square root of AVE (in the diagonal) for gender-specific models

intention for women ($\beta = -0.19$ $p < 0.01$), but not for men. Figure 3 below summarizes the results.

Discussion

Smart home technologies encompass a diverse set of innovations that promise to transform the experience within our homes, yet relatively little is known about the salient factors that may influence the adoption of such technologies. While smart home advances include a wide range of applications, this study is focused on smart locks because of their primary function to control access and secure a home. As such, this innovation is the most likely to exhibit the countervailing forces of benefits and risks. Given the calls for context-specific theory development (Hong *et al.*, 2013), and cognizant of the ambivalent nature of smart technologies, we drew on TRA (Ajzen and Fishbein, 1977; Fishbein and Ajzen, 1975) and we conducted a three-phase study focusing on the salient perceptions that can affect the adoption of smart locks. In the first phase, we elicited perceived benefits and concerns related to smart locks. In the second phase, we conducted an exploratory factor analysis to gain insights into the key latent factors that may affect smart lock adoption. In the third phase, we conducted a confirmatory factor analysis and we evaluated the effects of the factors identified in a nomological network.

Through the exploratory factor analysis in the second phase, we identified the following seven factors as potential drivers of smart lock adoption intention: *perceived usefulness*, *perceived relative advantage*, *novel benefits*, *reliability concerns*, *privacy concerns*, *security concerns*, and *negative effect of technology on others*. Only one of these factors – *perceived usefulness* – appears in the UTAUT model that is the dominant theoretical perspective in technology adoption research (Venkatesh, Thong, *et al.*, 2016a, b). Notably, *perceived ease of use*, which is a core construct in the UTAUT model was not among the salient considerations voiced by the participants in our study. This is perhaps not very surprising because these technologies are developed for mainstream consumers, and thus ease-of-use might be expected. The differences between the factors we elicited in the second phase and those typically present in



Note(s): ***- significant at $p < 0.001$, **- significant at $p < 0.01$, *- significant at $p < 0.05$

Figure 3.
Gender differences in factors influencing the smart lock adoption intention

generic adoption models, originally developed for organizational contexts, suggest the need to consider more specific drivers for the adoption of novel smart home technologies.

Our analysis of the effects of the identified factors (*perceived usefulness*, *perceived relative advantage*, *novel benefits*, *reliability concerns*, *privacy concerns*, *security concerns*, and *negative effect of technology on others*) on the smart lock adoption intention revealed unexpected results. We found no statistically significant effect for *perceived usefulness*. The only factor that had a statistically significant effect on the adoption intention when we examined data from both men and women was *perceived relative advantage*. This construct reflects the belief that smart locks would offer greater safety and security vis-à-vis conventional locks.

It is worth noting that the *perceived relative advantage* construct that emerged in our analysis is distinct from the *relative advantage* that is a part of the Rogers model of innovation diffusion in one important respect. Rogers defines relative advantage as "the degree to which an innovation is perceived as better than the idea it supersedes" (Rogers, 2010). Rogers' definition does not distinguish between *better on the core functions* of the incumbent technology and *better in offering novel functionality*. This caused confusion in the past studies that attempted to adopt the construct in Information Systems (Al-Jabri and Sohail, 2012). The results of the elicitation of salient beliefs and exploratory factor analysis in our study show that *perceived relative advantage* and *perceived novel benefits* are two distinct constructs. Whereas *perceived relative advantage* captures the perceptions that the new technology performs better on the core functions offered by the incumbent solution, perceived *novel benefits* construct captures novel functionality offered by the new technology.

When analyzing the differences by gender, we find that perceived relative advantage affects adoption intention for both men and women, whereas perceived novel benefits only has a statistically significant effect among women. This insight further supports the need to separate these two constructs in the study of smart home technology adoption. We also find that the gender-specific models improve model quality. Variance explained for the adoption intention in the model focusing on women improves to 50.5% versus 39.2% for the non-gender specific model.

Contributions to theory

Our study makes a number of contributions to theory. First, whereas much of prior research on smart home technology adoption has been limited to the application of TAM/UTAUT theories (Table 1) that necessarily limited the factors that were considered in prior studies, we pursued more holistic empirically-grounded understanding of the key salient factors that can affect smart home technology adoption. We elicited key considerations that may affect smart lock adoption among the potential users, conducted factorial analysis of the elicited beliefs, and evaluated the effects of the elicited factors on the smart lock adoption intention. Table 8

TAM	UTAUT	Salient factors elicited in this study
Perceived usefulness*	Performance expectancy (perceived usefulness)*	Perceived usefulness
Perceived ease of use	Effort expectancy (perceived ease of use)	Perceived relative advantage*
	Social influence	Perceived novel benefits
	Facilitating conditions	Malfunction concerns
	Hedonic motivation	Privacy concerns
	Price/value	Security concerns
		Negative effect of technology on others

Note(s): * - dominant factors influencing adoption intention

Table 8. Key emergent constructs vis-à-vis TAM and UTAUT

summarizes the key constructs that emerged in our work vis-à-vis TAM and UTAUT theories.

Our findings are in sharp contrast to extant TAM/UTAUT-based research. We find that *perceived usefulness* which is at the core of TAM/UTAUT (Davis, 1989; Venkatesh and Davis, 2000; Venkatesh *et al.*, 2012a, b) has no statistically significant effect on the smart lock adoption intention. Further, we did not find *effort expectancy* (*perceived ease of use)* among the salient considerations of adoption intention in our context. These results reveal two important limitations of TAM/UTAUT in relation to novel technology contexts. First, the key constructs emphasized by TAM/UTAUT are not the key relevant salient considerations influencing technology adoption that emerged in study. Second, the two key salient factors (*perceived relative advantage* and *perceived novel benefits*) that do influence smart lock adoption intention are not a part of TAM/UTAUT.

In the case of smart locks, notwithstanding the potential novel features and services that may be afforded by the smart devices, we find that prospective smart lock adopters focus on whether smart locks are better than traditional locks at the core functions of securing one's home. This result reveals that the replacement of critical home technology (locks, smoke detectors, etc.) with smart alternatives is likely to trigger an evaluation of the comparative advantage offered by the smart technology in relation to the core affordances of existing solutions (traditional locks, smoke detectors, etc.). Hence, in the contexts wherein smart technologies replace critical existing infrastructure, the *perceived relative advantage* of smart technologies over the incumbent technology is a dominant consideration in the adoption of the new technologies.

Further, several additional factors that have not been considered in prior SHT adoption research have emerged in exploratory factor analysis (phase two) in our study. These include *malfunction concerns*, *security concerns*, and *concerns about potential negative effects of technology on others*. While we did not find statistically significant effects of these factors on the smart lock adoption intention in our study, we do expect that these considerations will play a role in other contexts. Specifically, the negative effect of technology on others, a novel construct in IS research, would be important in social technology use.

Whereas, there have been several calls for context-specific theory development (Hong *et al.*, 2014, 2013), there has been relatively little research in response to these calls (Venkatesh *et al.*, 2016a, b). This may be in part due to the challenge in formulating a theoretical foundation and developing a complementary methodological approach for context-specific theory development. Our study provides a theoretical and methodological blueprint for developing context-specific frameworks of key factors influencing technology adoption in other contexts. Our work is grounded in TRA (Ajzen and Fishbein, 1977; Fishbein and Ajzen, 1975) that argues that beliefs, attitudes and perceived social norms affect behavioral intentions. Although the original TRA model emphasized the key mediating role of attitude towards a behavior (Ajzen and Fishbein, 1977; Fishbein and Ajzen, 1975), subsequent interdisciplinary research demonstrated that salient beliefs play the key role in affecting the behavioral intentions (Davis *et al.*, 1989; Sniehotta *et al.*, 2014). Consequently, TRA provides a useful theoretical lens as a starting point for the examination of context-specific salient factors that can influence technology adoption. TRA is a high-level framework that requires the elicitation of context-specific factors. Methodologically, the mixed-methods design that combines qualitative and quantitative analyses that is implemented in the current study can guide the research in other contexts (Venkatesh *et al.*, 2013; Venkatesh *et al.*, 2016a, b).

Another important contribution of our work is to the stream of research addressing the role of gender in technology adoption and use. Prior research on the role of gender in technology adoption and use has largely been limited to gender-invariant models that argue that the key factors that affect technology adoption are the same for men and women (Venkatesh *et al.*, 2016a, b). Venkatesh and Morris (2000) were among the earliest researchers to show that in the context of mandated enterprise system adoption the relationship between perceived usefulness and actual use is stronger for men, whereas the relationship between the subjective norms and actual use was stronger for women. Much of the subsequent research on the role of gender in technology adoption and use has treated gender as a moderator variable in the TAM/UTAUT models (see Table 2).

A moderator variable is expected to systematically modify the form and/or strength of the relationship between a predictor and a criterion variable (Sharma *et al.*, 1981). Our results suggest that gender plays a much more significant role in technology adoption. We find that men and women consider different factors when they contemplate smart lock adoption. While for men only the consideration of perceived relative advantage is significantly correlated with adoption intention, for women both perceived relative advantage and perceived novel benefits offered by the technology affect adoption intention.

Our results showing that men and women may respond to different factors when considering smart home technology are consistent with research in Information Systems applying neural imaging. This stream of research has shown that men and women display different patterns of brain activities in response to the same stimuli, and women tend to consider more factors than men (Riedl *et al.*, 2010). One possible explanation for why men and women may consider different factors in SHT adoption emerges from studies in psychology and sociology showing that men and women assign different meanings and significance to one's home (Mallett, 2004). Men often see the home from a symbolic perspective, as an indicator of status and achievement. In contrast, women tend to view home as a place that offers comfort, privacy and security from the outside world. The differences in the meanings ascribed to individual homes likely influence the key considerations in the adoption of SHTs that can reshape the experience within one's home. Our results suggest that gender-specific models are likely to yield better predictive value in the contexts that are affected by different gender roles, such as smart home technologies. It will be important to consider gender differences in the key factors that may influence technology adoption in other contexts that may involve different gender roles and gender-specific perceptions.

Our study also has implications for research on the ambivalent effects of technology on its users. Prior work has highlighted findings that while technology may have a positive effect on productivity, it may also lead to negative health outcomes (Rosen *et al.*, 2014) and addiction to technology (Turel and Qahri-Saremi, 2016). Our results suggest that in the initial stages of the potential technology adoption evaluation, prospective users may underemphasize the consideration of the potential negative consequences associated with the technology adoption and use. We find that while information privacy and security concerns are elicited among potential adopters, these factors do not appear to influence the initial adoption intention consideration.

A further contribution of our study to the research on ambivalent effects of technology is the recognition that in addition to having a negative effect on the user herself, there is a need for consideration of the negative effects of technologies on others. While prior research noted that the consideration of positive benefits of technology for others can be an important factor in technology adoption (Venkatesh and Brown, 2001), our research draws attention to the fact that the negative effects of technology on others is also an important consideration. We find that concerns that smart locks may be difficult for others to use is a potential factor that may affect the adoption intention among some prospects.

Implications for practice

The findings in this study also have important implications for practice. Smart locks are expected to be a $24.4 billion commercial opportunity by 2024 (Grand View Research, 2018). Much of the marketing of smart locks has focused on touting the unique new features offered by different vendors. Our results suggest that such efforts are likely to fail in promoting smart lock adoption unless they first convince prospective users that smart locks perform better in securing one's home than conventional locks. The perceived relative advantage is likely to be a focal consideration for other smart home technologies, wherein the smart alternatives are replacing incumbent solutions, e.g. smoke detectors.

The second important implication of our research for practice is that men and women likely think differently about smart home technologies. This insight is in contrast to the dominant theoretical models of technology adoption that suggest a gender-invariant set of factors (Venkatesh *et al.*, 2003; Venkatesh *et al.*, 2012a, b, 2016a, b). Our results suggest that men narrowly focus on the evaluation of perceived relative advantage of smart locks in assuring security of a home, whereas women are also influenced by the perception of substantial novel benefits offered by smart locks. These insights suggest a need to focus the persuasion strategies in marketing communications relating the benefits associated with smart lock adoption by gender.

The third important insight for practice that emerges from our study is the need to consider a broader group of people that may be affected by technology adoption. Although much of prior research has emphasized the importance of individual factors in technology adoption (Venkatesh *et al.*, 2016a, b), the potential negative impact of technology on others has emerged as a novel factor in our study. In as much as homes house multiple inhabitants, installation of smart technologies needs to account for the expected benefits and potential negative effects of smart technology on all inhabitants of a home.

Opportunities for future research

The insights that emerged in our study have to be evaluated in light of several potential limitations. The first key limitation of our work is the selection of smart locks as the focal SHT type that is the subject of our study. While smart locks are an important type of SHTs from both theoretical and practical perspective, further research would be need to (1) assess the effects of the constructs that emerged in our work in the adoption of other SHT types and (2) explore additional constructs that may play a role in the adoption of other types SHTs.

Another important consideration in the evaluation of our work is the reliance on Amazon's Mechanical Turks labor market for recruiting study participants for our research. While the depth of AMT subject pool (estimated at over 500,000 participants) has been touted as a major advantage of AMT in subject recruitment(Steelman *et al.*, 2014; Lowry *et al.*, 2016), it is possible that AMT panel does not fully reflect the broader population. Further evaluation of the theoretical framework we developed in our study with a general consumer panel would be a natural extension of our work.

The third potential limitation of our work is the focus on the United States as the geographic restriction in our study. While we purposefully sought to address the gap in extant literature that largely ignored the salient considerations that may affect smart home technology adoption in the United States, this creates an opportunity to evaluate and extend the research model that emerged in our study in other countries and cultures, or conduct cross-country comparative studies. We expect that cultural values will have an effect in moderating the effects of some constructs in our model. For example, collectivist orientation (Im *et al.*, 2011) would likely affect the influence of the negative technology impact on others on the SHT adoption. We would expect that the effect of this factor would become significant in collectivist cultures.

Conclusion

This study was motivated by recent calls for context-specific theory in Information Systems (Hong *et al.*, 2014, 2013) and the emergence of smart locks as an important Smart Home Technology. Smart locks promise to reshape one's experience with a home and open the door to new service opportunities, e.g. in–home deliveries. The adoption of smart locks may also create new potential risks for the technology adopters. For example, smart locks may be hacked, potentially compromising security of one's home. The breadth of potential new benefits and risks that may influence smart home technology adoption is unlikely to be captured in the extant dominant theoretical models (TAM, UTAUT). Consequently, we engaged in context-specific theory development applying a mixed-methods approach advocated for theory building (Hong *et al.*, 2013; Venkatesh *et al.*, 2016a, b).

Our examination of the salient user beliefs affecting the adoption of smart locks revealed that the dominant models in information systems are unlikely to capture the most salient user considerations in this context. We find that *perceived relative advantage* of the new technology in relation to the core benefits afforded by the incumbent technology is the main predictor of smart lock adoption intention for men and women. In contrast, *novel benefits* only influences adoption intention for women but not for men. These results suggest an important boundary condition on the applicability of the dominant theories (TAM, UTAUT) in technology adoption. In contexts where a novel technology replaces incumbent solutions with the same core benefits, researchers should carefully examine not only the perceived relative advantage of the new technology but also the potential impact of gender differences on adoption intention.

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Appendix A

Adoption intention scale

We measured the smart lock adoption intention using a scale based on Venkatesh *et al.*(2003). Items were measured using a 7-point Likert scale, anchored in 1 – Extremely unlikely and 7 –Extremely likely.

Int1	I Intend to adopt a smart lock at home
Int2	I predict that I would adopt a smart lock at home
Int3	I expect to adopt a smart lock in the near future

Appendix B

Factors and the corresponding survey items that emerged in exploratory factor analysis

Factor 1: Perceived usefulness	
B1	Having a smart lock in your home would enable you to let family in remotely in case of emergency
B2	Having a smart lock in your home would enable you to let in service people when you are at work
B15	Having a smart lock in your home would allow you to verify that your house is locked
B17	Having a smart lock in your home would enable you to check the status of the lock
B18	Having a smart lock in your home would enable you to lock the home while away
B19	Having a smart lock in your home would enable you to make sure kids have door locked
B20	Having a smart lock in your home would enable you to lock the door even if you forgot about it
B22	Having a smart lock in your home would enable you to lock the doors far away from home
Factor 2: Perceived Relative Advantage	
B9	Having a smart lock in your home would offer better protection versus conventional locks
B11	Having a smart lock in your home would make you feel safer compared to conventional locks
B14	Having a smart lock in your home would increase the overall security of your home compared to conventional locks
Factor 3: Perceived Novel Benefits	
B6	Having a smart lock in your home would enable you to see who's at the door
B16	Having a smart lock in your home would enable you to see who enters and leaves
Factor 4: Reliability Concerns	
C01	I am concerned that a smart lock may not work and I would be locked out
C02	I am concerned that a smart lock may malfunction and lock me out
C04	I am concerned that a smart lock may fail and lock everyone out
C05	I am concerned that a smart lock may stop working and make it impossible to lock the door
C06	I am concerned that a smart lock may refuse to open
Factor 5: Privacy-Related Concerns	
C17	I am concerned that a smart lock may be storing my personal information
C18	I am concerned that a smart lock would be knowing too much about our comings and goings
C19	I am concerned that a smart lock would be collecting data about my habits
C20	I am concerned that data collected by the smart lock may be sold
C21	I am concerned that a smart lock may make it possible to predict hours when people are home or not
C22	I am concerned that a smart lock can lead to information being stolen
C23	I am concerned that a smart lock may lead to sale of information about my location
C24	I am concerned that a smart lock may lead to sale of information about when I am at home
Factor 6: Physical Security Threats	
C08	I am concerned that someone can hardwire a smart lock somehow
C09	I am concerned that a smart lock can give unauthorized access to my house
C11	I am concerned that a smart lock might have security flaws
C12	I am concerned that a smart lock might get hacked
C13	I am concerned that a smart lock can allow someone to break into my house
Factor 7: Negative Effect of Technology on Others	
C25	I am concerned that a smart lock would make it difficult for guests to figure out the temporary keys and be locked out
C27	I am concerned that a smart lock might be hard to use for some people

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