Internet of Things 24 (2023) 100944

Contents lists available at ScienceDirect

Internet of Things

journal homepage: www.sciencedirect.com/journal/internet-of-things

Empowering homes with intelligence: An investigation of smart home technology adoption and usage

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ARTICLE INFO

Keywords:
IoT
Smart home technology
Adoption
Behavioral intention
UTAUT2

ABSTRACT

The increasing interconnectedness of the world, coupled with the proliferation of connected devices, networks, and intricate systems, has paved the way for unparalleled opportunities in automation and sophisticated digital transformation. This has also led to a global rise in the adoption of smart and intelligent technologies within the smart home market. Norway, being a technologically advanced country with digitally skilled citizens, presents a potential market for the widespread adoption of smart home technologies. However, there is a lack of research on the adoption of smart home technology (SHT), specifically in Norway. Hence, this study aims at investigating the factors that influence Norwegian consumers' intentions to adopt smart home technologies, as well as the diffusion of smart home adoption in the Norwegian market. Employing a mixed-methods research design, this study gathered insights from both consumers and vendors through ten qualitative interviews and a survey with 100 participants over the period of seven months. The findings of this study provide empirical evidence supporting the significance of hedonic motivation, perceived price value, and social influence in relation to the use and adoption of SHT.

1. Introduction

The world's population has continued to grow and has increased by over one billion people since 2007, with predictions from the United Nations (UN) indicating that the global population will reach 9.7 billion and the urban population will reach 6.7 billion by 2050 [1]. The increasing interconnectedness of the world and the development of smart technologies are also playing a significant role in various sectors, including logistics, healthcare, manufacturing, education, and daily life. This growth in technology has led to the generation of more data than ever before, allowing for increased use of artificial intelligence (AI), machine learning, and the Internet of things (IoT) [2]. The development of smart technologies for households is also changing the way people live, with smart homes becoming increasingly common and involving devices and sensors connected via the Internet, offering unprecedented capabilities for the automation, control, and real-time monitoring of various household tasks, routines, and applications [3]. While research on smart homes is on the rise, however, the definition of smart homes is still a topic of debate among researchers and professionals.

In Norway, smart home applications have become relatively prevalent, with smart meters being the most used, followed by digital TV and smart multimedia [4]. The country has a well-developed digital infrastructure and is ranked well above average in digital skills, Internet use, and bandwidth expansion compared to other European countries [5]. However, smart homes are still not a standard for

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https://doi.org/10.1016/j.iot.2023.100944

Available online 30 September 2023

most Norwegian households, and most electrical home-system installation companies in Norway do not offer smart home installations as a standard service [6]. The Norwegian government is also investing in advancing and expanding digitally and technologically-based systems and infrastructures for cities, municipalities, and communities [5].

Despite the contributions of existing studies on smart home technology (SHT) and user adoption, there is still a gap in the literature, particularly concerning the landscape of IoT in Norway. This gap extends to specific aspects of the Norwegian smart home technology market, including the key driving forces and barriers influencing its adoption, as well as the diffusion patterns of smart homes within the country [7]. Additionally, the mixed-methods approach employed in this research, incorporating both consumer and professional perspectives, provides a holistic view that enriches our knowledge on the factors influencing the adoption of smart home technologies in Norway. The empirical evidence gathered from interviews, surveys, and in-depth analysis further strengthens the validity and reliability of the findings, offering valuable insights for both researchers and practitioners in the field. In addition, smart home technologies are continuously developing and advancing, maintaining the importance to study the market conditions and their developments progressively. By gaining insight into people's awareness, attitudes, and behaviors related to IoT and SHT, stakeholders can improve their understanding of the market, including its tendencies, trends, variations, and changes. Such insights might provide practical importance for future product- and service development of IoT-based SHT, the diffusion of consumer adoption of SHT, and possibly national opportunities and incentives for energy management. Moreover, studies on smart homes have generally focused on topics such as security and privacy, costs, social influence, home energy management, usefulness, enjoyment, and ease of use [8,9]. Although previous research has made valuable contributions to the understanding of smart home technology and its adoption by users, this study identified several areas in the literature that require further attention. Specifically, there are gaps in knowledge related to the Norwegian market for IoT-based SHT, including the factors that drive or impede adoption, as well as the diffusion of these technologies. Based on the aforementioned issues in the literature, the research questions for this study were defined as follows:

- What drivers and barriers affect SHT adoption in Norway?
- How can the diffusion of SHT use in Norway be expanded?

This study attempts to develop an enriched understanding of the drivers and barriers of smart home technology adoption in Norway and explore the diffusion of adoption and market conditions, through the lens of the unified theory of use and acceptance of technology 2 (UTAUT2) by [10]. Furthermore, this study aims at providing recent insights into the Norwegian SHT, from both stakeholders, the consumer's, and the vendor's perspectives.

The remainder of the paper is organized as follows. Section 2 provides a review of the literature. Section 3 presents the method and research design of this study. Section 4 illustrates the study's findings, while Section 5 comprises a discussion about the respective findings. Section 6 presents the implications of this study for practice and the body of knowledge, followed by Section 7 that provides a conclusion, research limitations, and proposed directions for future research.

2. Literature review

2.1. Smart cities and smart homes

The 21st century has seen a significant shift in societal living, as technological advancements have led to improved access to products and services, resulting in a better quality of life [11]. However, the consequences of massive urbanization and industrialization in cities pose challenges such as population density, city administration complexity, and planning challenges [12]. Cities also harm the environment due to increased resource consumption and higher levels of waste and emissions, and to address these challenges, cities must be equipped to tackle demographic changes, climate changes, social inequalities, population growth and mobility, globalization, and other factors [12]. One potential solution to such challenges is the transformation of traditional and ageing cities to smart cities. Smart cities are defined by infrastructures that facilitate economic, social, and sustainable growth [13].

Energy conservation is a crucial aspect of smart cities, and smart homes play a critical role in this regard. Smart homes are equipped with connected networks of devices, machines, sensors, and systems that can digitally access, control, sense, and share information and data [11]. The distinction between smart homes and high-tech homes lies in the interconnected networks of devices and sensors that define the former [14]. Although definitions of smart homes are not consistent in the literature, most definitions emphasize the benefits and services provided by the technology, the hardware and software components, and the changes in users' behavior [15]. Smart grids can support the decentralization of energy systems and generate electricity within a city, providing balance and flexibility in energy supply and demand [16]. Microgrids, on a smaller scale, can improve energy efficiency by providing real-time information about energy consumption, allowing for the utilization and trading of surplus energy [17]. The literature recognizes the significant role that smart homes play in the interrelationship between urban life and smart technologies, and the sustainability of smart cities, as smart homes have the potential to contribute to sustainable practices in areas such as water and energy consumption, smart healthcare, safety, and others [18]. Recent quantitative studies have also explored the drivers and detractors influencing smart home technology adoption in other contexts. For example, a study by Marikyan et al. [19] employed the cognitive dissonance theory to examine how dissonance resulting from negative disconfirmation can lead to a positive outcome in adoption of smart homes. Additionally, it investigated the impact of negative emotions (e.g., anger, guilt) on the selection of dissonance reduction mechanisms. The analysis utilized structural equation modeling (SEM) to test their proposed hypotheses, with a sample of 387 smart home users, however the geographical location of the respondents was not provided in the study. The findings indicate that post-disconfirmation dissonance elicits emotions such as anger, guilt, and regret, which influence the choice of dissonance reduction mechanisms [19]. In addition, these mechanisms significantly impact satisfaction and overall well-being, highlighting the intricate relationship between dissonance, emotions, reduction strategies, and their influence on individual outcomes [19]. Another study [20] focusing on Europe, explored the different theories related to the acceptance of technology and their interconnected constructs. The research findings suggest that predictors from innovation diffusion and risk theory indirectly affect technology acceptance through various variables [20]. For example, the study highlights the significant role of risk perception in inhibiting the intention to use technology, which is mediated by perceived usefulness. The most notable indirect effects were found for security risk (63 %), overall risk (57 %), and results demonstrability (50 %). Additionally, their results revealed that perceived security risk has a negative impact on both behavioral intention ($\beta = -0.16$, $p < 0.05$) and perceived ease of use (PEOU) ($\beta = -0.28$, $p < 0.05$), while positively affecting perceived usefulness (PU) ($\beta = 0.33$, $p < 0.05$). Moreover, perceived performance risk has a positive influence on usage intention ($\beta = 0.10$, $p < 0.05$) but a negative impact on perceived usefulness ($\beta = -0.10$, $p < 0.05$). Furthermore, perceived time risk was found to negatively affect perceived ease of use ($\beta = -0.47$, $p < 0.05$) [20]. Thus, the quantitative results demonstrate that compatibility and usefulness of the application are the key determinants influencing the intention to use technology [20]. This is also in line with the literature that underscores the paramount role of perceived usefulness in predicting SHT adoption [21].

Despite these advancements in SHT research, however, several research gaps exist. The current body of knowledge on SHT adoption almost predominantly focuses on the elderly population, given the rising life expectancy and its implications on care facilities and resources [22]. This narrow focus neglects other demographic groups, particularly the working class and younger generations in general. Hence, future research should address this gap and explore the adoption patterns of SHT among diverse demographic segments, thus aiding in understanding adoption patterns among younger generations, working-class individuals, and different cultural contexts can provide a more holistic understanding of the factors influencing smart home adoption. Such research will be invaluable in formulating inclusive strategies for promoting SHT adoption across a wider spectrum of the population [22]. In addition, although several studies have explored the influence of individual factors such as perceived usefulness and perceived ease of use, there is a limited focus on the interaction between these factors and the broader socio-cultural context. Investigating how cultural norms, societal expectations, and peer influences intersect with these individual perceptions can offer deeper insights into the adoption dynamics. Lastly, with the rapid technological advancements and the emergence of new smart home devices and services, there is a need for up-to-date research that considers the latest innovations and their impact on adoption behaviors. Addressing these gaps will contribute to a more comprehensive and nuanced understanding of SHT adoption.

2.2. *Home energy management*

The literature on home energy management and its association with smart homes is divided and offers conflicting perspectives on the impact of SHT on sustainability. While some researchers believe that SHT plays a crucial role in promoting sustainable living and urban environments [16], others argue that these technologies may not necessarily improve sustainability, as some technologies may lead to energy savings while others result in energy waste [23,24]. Furthermore, the authors of these studies raise concerns that the integration of technology into society may lead to unintended effects that counteract energy efficiency [25]. Additionally, [24] found that smart homes were not significantly associated with sustainability in various countries, suggesting a dualistic tension between the perception of smart homes and sustainability. On the other hand, other researchers have argued that SHT can enhance sustainability by providing consumers with data and information about energy and water consumption, SHT can support efficient energy management, reducing domestic over-consumption and carbon emissions [18]. In addition, the energy management functionality in smart homes has been argued to have a positive effect on consumers' perspectives on SHT, with energy savings seen as one of the top benefits [11].

Smart grids, combined with smart devices and monitoring systems, can enable real-time energy consumption management, reducing overall energy and water consumption, costs, and improving household sustainability [16]. The use of green energy, waste recycling, and energy-saving systems can also play a significant role in promoting sustainability [13]. In addition, it is argued that energy savings were a strong motivator for adopting SHT, if they did not compromise comfort [11]. Li et al. [9] and Kim et al. [17] suggest that SHT can enable consumers to achieve energy efficiency while maintaining comfort through the transparency of energy consumption and forecasting. However, there may be a tradeoff between comfort and energy savings, as achieving both can be challenging.

2.3. *Usefulness of smart home technology*

The field of smart home research has seen significant growth in recent years due to advancements in IoT technology [26]. Whether there is a cloud-based or local sensing device, smart solutions intend to streamline domestic chores and processes, provide valuable insights, improve cost and energy efficiency, and provide long-term convenience and advantages to users [24]. Smart home solutions are designed to simplify household tasks, provide useful insights, increase energy efficiency, and offer long-term benefits to users [24]. Common applications include heating, ventilation, and air conditioning (HVAC) systems, lighting, security, entertainment, and voice recognition devices [23]. The more advanced the smart devices that are implemented, the greater the range of intelligent tasks and sophisticated interactions that become possible [27]. However, some research suggests that SHT vendors must better understand consumer needs and effectively communicate the benefits of their products and services [18], as consumers' perception of usefulness is critical to their intention to use and attitude towards smart home technologies. For instance, a longitudinal study [21], which explored SHT pre and post adoption and employed unified theory of use and acceptance of technology (UTAUT) in combination with partial least squares structural equation modeling (PLS-SEM) for hypothesis testing, collected survey data from 60 senior citizens in Australia. The findings underscored the crucial role of perceived usefulness in predicting SHT adoption among Australian seniors [21], as the analysis indicates significant relationships between perceived usefulness and behavioral intention (BI) ($\beta = 0.308$, $t > 1.96$, $p < 0.05$), as well as between trust (TR) and perceived usefulness ($\beta = 0.362$, $t > 1.96$, $p < 0.05$) in the pre-usage phase, and significant relationships among (PU) and (BI) ($\beta = 0.435$, $t > 1.96$, $p < 0.05$), as well as between (TR) and (PU) ($\beta = 0.495$, $t > 1.96$, $p < 0.05$), in the post-usage phase.

Awareness and understanding of SHT by consumers are also crucial factors for the successful adoption of SHT. On the other hand, unfamiliarity with the technology and lack of trust may hinder SHT adoptions, while familiarity and ease of use can increase the intention to adopt the SHT [11]. Thus, providers must be aware of the socio-technical aspects of smart home technologies and prioritize market communication and consumer education to build trust among users [11], as trust was found to indirectly influence SHT adoption by impacting perceived usefulness in other research contexts (e.g., [21]).

2.4. Ease of use and technological literacy

The perceived ease of use of smart home technologies has been widely examined in academic literature, and its positive impact on SHT adoption has been argued (e.g., [8,28]). Despite the advantages offered by IoT and SHT, however, these technologies may not be accessible to individuals who have difficulty adapting to new technologies, or who lack a sufficient technological understanding or awareness to recognize the potential benefits of smart home solutions [29]. Despite the ongoing innovation and development efforts, the adoption of smart homes remains relatively limited among the general public due to factors such as high costs, complexity, and a lack of awareness [30]. As a result, there is a significant need for research focusing on SHT usability and awareness [31]. For example, a study by Li et al. [9] on the motivations and barriers to smart home adoption found that technological anxiety may be an obstacle, particularly for the elderly and those with low technical literacy or experience with the technology. To overcome this, researchers have emphasized the need for smart home applications that are automated, inter-operative, and user-friendly [32]. For example, a study [14] has suggested implementing self-learning technologies that make the core technologies invisible to users to reduce their complexity. Guo et al. [27] investigated how AI could be integrated into smart home systems to manage various devices and achieve centralized intelligent control through data analysis of user behavior and patterns. Despite these advancements, some consumers remain concerned about errors or complexity in the use of SHT [29].

2.5. Facilitating conditions of smart home technology

The literature on SHT adoption highlights the significance of the technology's infrastructure and support system. Researchers, such as [29], have stressed the importance of information exchange between SHT vendors and consumers as a key aspect of the infrastructure related to SHT implementation and use. Kim et al. [33] found that the facilitating conditions of technical and vendor support also play a crucial role in SHT adoption. In addition, Aldossari and Sidorova [8] noted that a lack of experience with SHT can lead consumers to overlook the importance of supporting resources for adoption. Moreover, Sovacool et al. [23] revealed that lower-income individuals may perceive SHT as non-essential, which might increase reliance on external experts.

The compatibility of technologies is also a critical aspect of SHT adoption [18,34] . Interconnectivity between different SHT technologies, software, and hardware is an important factor in motivating consumers to adopt SHT, as demonstrated by [35,36]. In addition, the level of compatibility of SHT has been found to affect the consumers' perception of ease of use and the technology's usefulness [34]. On the other hand, the lack of interoperability may cause significant difficulties and inconvenience for consumers [14,29]. Incompatibility may also increase stress and frustration, especially for those with low technical understanding, and negatively impact perceived usefulness and adoption intention [37]. Additionally, individuals with limited technological literacy and difficulty adapting to new technologies may experience an increased dependency on others for using SHT [23].

2.6. Hedonic motivation and enjoyment of use

Existing quantitative studies have indicated that the adoption of SHT is influenced by the perceived usefulness of these solutions (e.g., [21,38,39]). One of the key drivers for the adoption of SHT is the consumers' enjoyment of using these technologies. This factor has been referred to in the literature as perceived enjoyment of use, technological enthusiasm, or hedonic motivation [19]. This hedonic motivation refers to the perceived fun and enjoyment of using SHT beyond its mere convenience. Additionally, technological enthusiasm and enjoyment of SHT have been shown to have a positive impact on the perceived ease of use and the consumer's technological literacy [24,40]. These factors also play a role in determining the perceived value of SHT and the intention to adopt it. The more enjoyable the consumer experience with the technology, the higher the perceived usefulness of the SHT [40], as the results suggest that the users' inclination to utilize SHT was significantly influenced by perceived usefulness ($\beta = 0.658$, CR $= 17.363$, $p < 0.001$). Aldossari and Sidorova [8] emphasized the importance of considering the user experience when designing smart home solutions, as the consumer's hedonic motivation is a crucial aspect of SHT adoption. Previous studies have also concluded that technological enthusiasm for new technologies has a positive impact on the motivation to adopt SHT in general (e.g., [41,10,18]). Moreover, literature has suggested that income and personal economy could be potential determinants of technological enthusiasm [24].

2.7. Price value

Costs associated with SHT have been a subject of nuanced and divergent discussions in existing scholarly literature. Some research (e.g., [40,41]) suggests that cost is a key factor in determining whether consumers will adopt SHT, with uncertainty and unfamiliarity potentially leading to cost-related concerns. On the other hand, the perceived value of SHT investments can also be a driving factor for adoption [32]. The monetary costs of SHT can be seen as a barrier to adoption, but it can also be a motivator if the perceived benefits of the technology outweigh the cost. The tradeoff between monetary cost and perceived benefits is referred to as price value. For example, a study found that the respondents considered the benefits of SHT more important than the price [8], where the results indicate that perceived value (PV) has a significant impact on behavioral intention (PV = > BI, $p < 0.001$). In addition, another study by Paetz et al. [41] showed that monetary savings were the most important benefit to focus group participants. The price value had a positive effect on the participants' intention to adopt SHT when the payback time was short, and the benefits of the investment were high. The same findings were suggested by [40], where their results show that one of the factors that significantly affect SHT adoption and use was influenced by the perceived cost ($\beta = -0.091$, CR $= -4.566$, $p < 0.001$).

2.8. Security and privacy risk

SHT adoption is hindered by security, privacy, and trust issues [11]. The deficiency in user technical knowledge also may make smart homes an appealing target for cybercriminals [42]. Consumers' top concerns may include fears of surveillance capitalism, privacy invasion, data protection, and hacking vulnerability [24]. Some other studies have also disclosed a divide in people's views on security, privacy, and safety related to SHT [23]. Although security concerns and privacy risks can act as barriers to SHT adoption, they can also provide a sense of increased safety and security, as literature has highlighted how SHT can improve home safety, security, and health [23].

Since smart homes collect significant data from residents, security, privacy, and trust in smart home vendors are then critical topics [43]. Geeng and Roesner [44] found that privacy concerns focus more on the risk of companies collecting and using data than on interpersonal privacy. Barbosa et al. [36] found that only 11 % of respondents viewed security and privacy as motivating factors for SHT adoption, yet 50 % believed that security and privacy concerns could prevent adoption. Yang et al. [35] stressed the importance of security and privacy among consumers, who are sensitive and protective in their safe spaces at home. Another study [42], presented a versatile framework that utilizes adaptable components designed to identify abnormalities in both network traffic and application-layer data transmitted by IoT devices within smart home environments. By employing this framework, the authors devised a specific intrusion detection system (IDS) for a case analysis, leveraging a publicly available dataset containing the energy consumption information of 21 household devices recorded over a span of one year [42].

Consumers may not desire automated control and management of security systems in their homes, as having control themselves would increase trust and a sense of control [35]. Shuhaiber et al. [11] and Barbosa et al. [43] found that perceived risk related to security and privacy concerns negatively affects trust in SHT and intentions to use it. For example, the findings on SHT adoption the United Arab Emirates (UAE) suggest that the most substantial influence on trust in smart homes was attributed to perceived security risks ($\beta = -0.565$, T-Statistic = 6.651, P-value = 0.00). Hence, these security risks are perceived as a significant adverse element that can diminish consumer trust in smart homes [11]. Bhati et al. [45] also found security and privacy risks to be a central concern among their study's respondents, due to the sensitivity of data and stability of SHT solutions such as smart healthcare.

2.9. Social influence

The effect of social influence on the adoption of smart home technologies has been widely discussed in the literature. Social influence refers to the impact that significant others, such as family and friends, peers, social networks, or mass media, have on an individual's perceptions and decisions related to SHT [8]. Positive social influence, such as shared positive experiences with SHT, has been shown to have a positive impact on attitudes and intentions to use SHT [11]. Social influence is particularly relevant in the early stages of the decision-making process when the consumer lacks experience and familiarity with the technology [9]. The influence of gender on social influence has also been noted, with women found to be more susceptible to social influence than men [46]. However, negative social influence can also impact the adoption of SHT, as it can shape a consumer's judgments of emerging innovations and products [9]. The impact of negative social influence is heightened when the consumer's access to experience the technology is limited due to a lack of adopters within their social network [47]. For instance, within the context of smart homes in the UAE, the influence of social factors assumes a pronounced role in nurturing trust. This influence operates through diverse mediums, encompassing word of mouth, online reviews, and the circulation of social media content, orchestrated by notable figures like family members, friends, colleagues, and relatives [11]. This collaborative dissemination of information pertinent to smart homes within the UAE domain substantially reverberates through individuals' cognitive landscapes [11]. For example, [11] found that 'social influences' is evidently found to exert a significant influence on all categories of perceived risks and, importantly, to directly impact trust in the domain of smart homes in the UAE. Social influences emerge as a pivotal driving force for fostering trust in smart homes, wielding their influence on the perception of security, privacy, and financial risks. This influence is wielded through various channels, including word of mouth, online reviews, and the dissemination of social media content, all orchestrated by significant individuals in an individual's life, such as family members, friends, colleagues, and relatives. As demonstrated in the findings of [11], the most significant influence on trust within the context of smart homes and social influence was found to be perceived security risks ($\beta = -0.565$, T-Statistic = 6.651, P-value = 0.00). Thus, these security risks are regarded as a significant negative determinant that has the potential to undermine consumer trust in the realm of smart homes. While several studies are focusing on social issues in adoption, however, the field of social influence on the adoption of SHT requires further research, as the technology advances rapidly [11].

3. Theoretical background and research methodology

The use of a theoretical framework facilitates the examination of user perspectives and attitudes toward the adoption of SHT. Technology acceptance research in the past had a strong focus on user acceptance in the corporate environment context, and models like the technology acceptance model (TAM) [48], or the original UTAUT [49], which do not consider factors such as hedonic motivation, making them inappropriate for applications within the consumer context. The revised version UTAUT2 however, addresses these issues and is considered as a holistic and consolidated tool that is suitable for exploring consumers' adoption behavior [10].

TAM, UTAUT/2, and PLS-SEM have been widely used in studies focusing on technology adoption and use. For example, a recent study [50] employed PLS-SEM for hypotheses testing exploring the intentions of university students in Malaysia to use online recruiting platforms by employing a conceptual framework that integrates TAM and the theory of planned behavior (TPB). Within the SHT adoption and use context, another longitudinal study [21] focusing on SHT adoption, employed a modified UTAUT combined with PLS-SEM for hypotheses testing within Australian senior citizens' context. Another study [22] conducted in Malaysia developed an integrated framework with added constructs from previous literature to the TPB, TAM, and UTAUT2 to investigate SHT adoption motivations. The authors argue that the majority of acceptance studies concerning the adoption of SHT have predominantly concentrated on the perspectives of elderly or senior citizens [22]. This emphasis can be attributed to the growing life expectancy, which subsequently leads to increased public pension expenditure and puts a significant burden on available care facilities and resources [22]. However, there is a notable lack of research focusing on other segments of the population, particularly working-class citizens, which indicates the need for studies that explore the adoption of SHT among diverse demographic groups, allowing for a more comprehensive understanding of the factors influencing adoption behaviors and preferences [22]. By broadening the scope of research beyond elderly populations, we can gain valuable insights that can inform the development of inclusive and tailored strategies for promoting SHT adoption among different segments of the population. Especially that the literature findings highlight the ongoing and increasing enthusiasm among millennials for adopting and using SHT [22]. This growing interest also emphasizes the need for additional research to explore SHT adoption patterns among demographics beyond the elderly population. In addition, the findings also suggest that the integration of various constructs from literature in the integrated framework, such as automation, mobility, perceived security, and hedonic motivation, enhances the theoretical foundation of technology adoption by incorporating the role of technical systems in SHT adoption [22]. Hence, due to its suitability and wide application in extant literature, this study adopts the UTAUT2 with modifications and additions to the constructs from literature, which deemed relevant to the consumer adoption within the scope of this research. The UTAUT2 combines elements from prior adoption models in information systems and includes factors such as *"Performance Expectancy", "Effort Expectancy", "Social Influence"*, and *"Facilitating Conditions"*. The UTAUT2 was also chosen due to its relevance to the critical topics and constructs found in previous literature on SHT. Based on our review of the literature, *"Habit"* was excluded, and *"Security/Privacy"* and *"Energy Management"* were added to the UTAUT2 model (see Fig. 1) in this study. The *"Behavioral Intention"* construct was used to measure the user's intention to adopt or continue to use SHT.

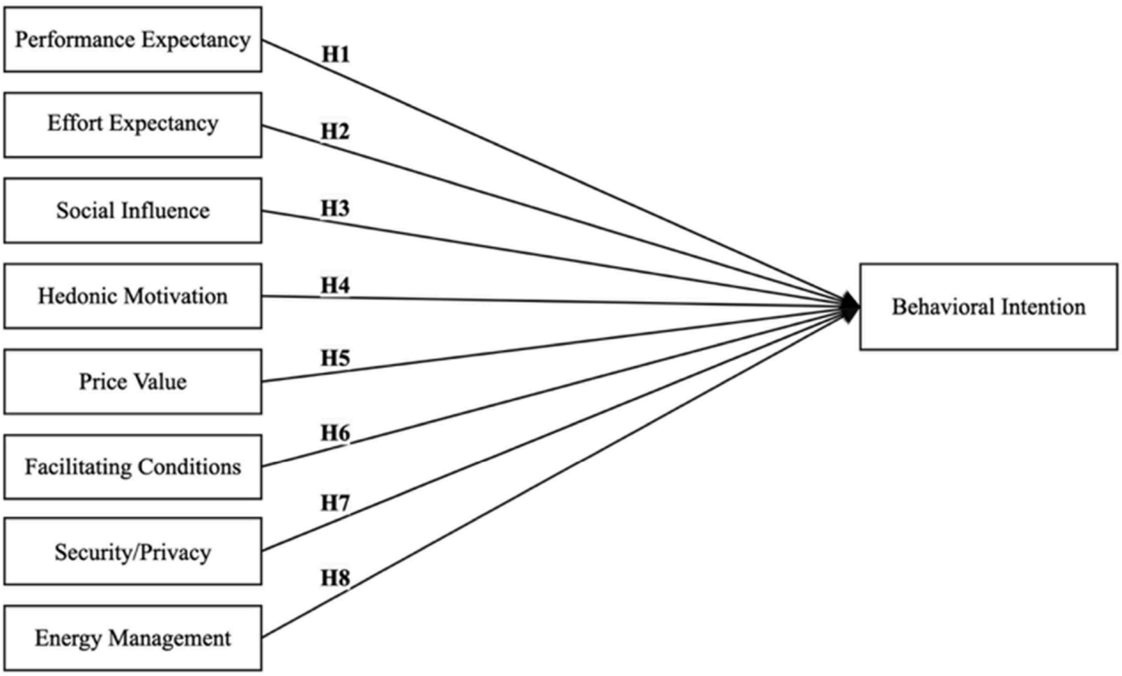

Fig. 1. Research model: adapted version of the UTAUT2 [10].

As described by Venkatesh et al. [10], the *performance expectancy* (PE) construct probes how useful and helpful the consumer considers smart home technology to be, and whether it is beneficial for solving certain tasks. *Effort expectancy* (EE) investigates the consumer's use of smart home technology, and to which extent the consumer experiences ease of use or difficulties related to the use of smart home technology. The *social influence* (SI) construct explores the influence others have on the consumer's intention and use of smart home technologies. This entails influence by family or friends, or by other peers. *Hedonic motivation* (HM) scrutinizes the perceived enjoyment of using smart home technology. This construct has been shown to influence the acceptance and use of technologies. The *price value* (PV) construct refers to the cognitive tradeoff that consumers face between the advantages and the monetary cost of acquiring and using smart home technologies. *Facilitating conditions* (FC) construct represents the consumer's perception of the availability of support and resources related to smart home technology. The *security/privacy* (SP) construct investigates the security and privacy issues that were deemed relevant for the context of this study. Based on our review of the literature focusing on the use and adoption of smart home technology, privacy, and security have been argued to be important factors that may affect consumers' attitudes and intentions of using technology [24]. And finally, the *energy management* (EM) construct is another additional variable that has been added to the model, as it is a highly central part of smart technology in general and was argued to be a fundamental part of smart homes in extant literature . Based on the literature review, the research model, and previous studies using the UTAUT2, these hypotheses were formulated:

H1: Performance Expectancy significantly affects behavioral intention toward smart home technology adoption.
H2: Effort Expectancy significantly affects behavioral intention toward smart home technology adoption.
H3: Social Influence significantly affects behavioral intention toward smart home technology adoption.
H4: Hedonic Motivation significantly affects behavioral intention toward smart home technology adoption.
H5: Price Value significantly affects behavioral intention toward smart home technology adoption.
H6: Facilitating Conditions significantly affect behavioral intention toward smart home technology adoption.
H7: Security and Privacy significantly affect behavioral intention toward smart home technology adoption.
H8: Energy Management significantly affects behavioral intention toward smart home technology adoption.

3.1. Research design and approach

This study employed a sequential quantitative-qualitative mixed-method research design [51], to gather comprehensive data from both consumers and industry professionals. This design allows for a deeper understanding of attitudes, perspectives, and behaviors in the market by combining quantitative and qualitative data collection methods [10]. The methods used in this study were complementary, providing different channels for insights into the research topic and enhancing the validity of the research through method triangulation [52].

This study sought to obtain an inclusive understanding of the market's attitudes, intentions, and behaviors by dividing the units of analysis into two distinct groups: consumers and experts. The first group, consumers, was comprised of a diverse sample population, including individuals of varying ages, occupations, locations, and income rates. The data collected from this group was obtained through a survey, which served as a reliable and effective means of acquiring data on their perceptions and behaviors. The second unit of analysis was industry experts from SHT-related industries, who provided valuable insights into the market outlooks, observations, and experiences from the vendors' perspectives. The inclusion of experts in the study allowed for a deeper understanding of the industry's inner workings, providing a valuable context for interpreting the data collected from the consumer group. The validity of the study's quantitative and qualitative methods is discussed in subsequent sections, highlighting the thoroughness and rigor with which the data was collected and analyzed. By employing a multi-pronged approach to data collection and analysis, this study offers a broader and nuanced understanding of the market's attitudes, intentions, and behaviors, providing valuable insights to both industry professionals and academics alike.

3.1.1. Quantitative method and quantitative data collection

The purpose of using a quantitative survey in this study was to elucidate knowledge and information from the participants and develop an understanding of consumer perceptions, perspectives, and usage of smart technologies in Norway. This aimed to identify the main barriers and drivers of SHT adoption in the market. Quantitative research methods can discover patterns, trends, and generalizable insights into a population based on a representative sample. This is achieved through standardized and systematic data collection from a representative number of respondents [51], who in this case were Norwegian citizens with varied demographics such as occupation, age, income level, and location.

The questionnaire employed in this study was developed based on the main topics identified in existing relevant literature on SHT adoption (e.g., [4,53]) and consisted of closed-ended questions with a 5-point Likert scale, multiple-choice questions, and a rank-order question to assess various constructs [51]. The survey was designed to generate pre-coded data for easy analysis through closed-ended questions and was presented in a structured and logical manner for the respondents [34]. Questions on demographics were also included to provide insight into the general demographical backgrounds of the respondents and the representativeness of the sample. Demographical questions were multiple-choice with brief response options that grouped respondents into pre-determined demographic clusters. This enabled the analysis of descriptive statistics on the survey respondents and any disproportionate representation of certain demographic groups. Research model questions were presented as statements with a 5-point Likert scale, providing numerical values for analysis. A rank-order question on the importance of SHT attributes was included at the end of the survey to provide further insights into the respondents' priorities, with alternatives identified from the literature. The survey was created on Qualtrics, which did not collect personal information or any data that could identify respondents. Responses were anonymized in Qualtrics to comply with the general data protection regulation (GDPR) and ensure complete anonymity of the respondents. The survey was mainly distributed via social media platforms and email during March and April of 2022. The survey was also published on Amazon's MTurk limited to Norway but did not yield any new responses. The sample size of the survey reached 104 respondents, with 100 respondents remaining after data cleaning (52 men and 48 women). The number of respondents is deemed viable to provide insights into the population, though a larger sample size would be ideal for better generalizability.

The internal validity of the survey was established through following content and construct validity guidelines [51]. Content validity was considered by including questions on all important aspects of the research model and other relevant topics, while construct validity was achieved by having three questions for each construct from the research model. To enhance external validity, a preliminary pilot study was meticulously carried out, involving 35 respondents whose data were carefully analyzed. Additionally, the survey instrument underwent an initial review by both a seasoned researcher and a subject-matter expert in the field, thereby ensuring the robustness of the survey design as well as the construct validity of the study [51]. Hence, changes were made based on the feedback received before distributing the survey.

3.1.2. Quantitative data analysis

The data collected from the survey was imported into the Statistical Package for the Social Sciences (SPSS) and checked for completeness and validity. Descriptive statistics were used to obtain insights about the respondents, and SPSS was used to test for Common Method Bias. The cleaned dataset was then exported as a .csv file and was analyzed using PLS-SEM in SmartPLS. Since this study aimed at examining the use and adoption of SHT in Norway through an extended and modified version of the UTAUT2, PLS-SEM was regarded as an appropriate approach, as it is effective for theory building or development and prediction of the constructs [54]. The analysis was done in two stages, the first to assess the measurement model's reliability and validity, and the second to assess the structural model's relationships, explanatory power, and predictive power.

3.2. Qualitative method and data collection

Qualitative research often involves collecting non-numeric data through methods like case studies, in-depth interviews, focus groups, document analysis, and experiments. These methods allow researchers to gain deeper insights and understand participants' thoughts, behaviors, attitudes, and challenges related to the research topic. They can also identify themes, phenomena, or categories in the data [52]. Thus, this study used in-depth interviews as a qualitative method to supplement the survey and gain a deeper understanding of topics not revealed through the survey and to elaborate on key sub-topics not covered or not provided in detail in the survey. Ten semi-structured interviews [55] were conducted in Norwegian language with five experts and five consumers from over a period of seven months between November 2021 and May 2022. The experts were from the smart home, IoT, and Smart City-related industries in Norway and provided insights into the suppliers' side of the SHT market and consumer trends.

The consumers were interviewed to understand their attitudes, behaviors, and intentions toward SHT. Both groups were selected using a combination of snowball sampling for the experts and stratified sampling for the consumers [51]. The interviews were recorded and transcribed, with quotes checked and verified with the participants. The data was analyzed by the researchers to reveal variations in perspectives between consumers and vendors and provide critical insights into the research topic. The participants were anonymized, and all were provided with a consent form prior to the interview. Due to COVID-19, the interviews were conducted via Microsoft Teams or Zoom and lasted between 30 and 60 min. All participants (see Table 1) were provided with a consent form prior to the interviews that they signed, with information regarding the research project, the data handling, the research project process, and their rights. The interviews were transcribed in Norwegian and then translated to English for further data analysis. To preserve their anonymity, the participants will be referred to as "EXP1, EXP2, …" for the Experts, and "CON1, CON2, …" for the Consumers instead of their personal name or company name (Table 1). The quotes that were deemed relevant to include in the study were then checked with the participants in an "interpretation" check, to ensure that the researchers have an aligned and correct understanding and categorization of the data and discussed topics [55].

Table 1
Overview of participants.

Nr.	Role	Industry sector/Expertise	Type	Code
1	CEO	Smart home technology	Vendor	EXP1
2	Head of Smart Cities	Smart technology for smart cities	Vendor	EXP2
3	Head of Sales	Smart home technology	Vendor	EXP3
4	Head of Business Development	Smart home technology	Vendor	EXP4
5	Product Manager	Smart home technology	Vendor	EXP5
6	SHT User	Extensive experience with SHT and home automation solutions	Consumer	CONS1
7	SHT adopter	Good experience with SHT	Consumer	CONS2
8	SHT adopter	Some experience with SHT	Consumer	CONS3
9	SHT non-adopter	Limited knowledge about SHT	Consumer	CONS4
10	SHT User	Some experience with SHT	Consumer	CONS5

3.2.1. Qualitative data analysis

To identify patterns and themes in the qualitative data, a thematic analysis method was used [56]. This method aids in pinpointing differences, similarities, and variations in participants' perspectives on topics. The analysis employed a deductive approach and focused on discovering themes beyond the pre-defined questions in the interview guide [52]. The six steps of a thematic analysis, as per [56], are: getting familiar with the interviews, coding the data, searching for themes, reviewing themes, defining themes, and reporting.

The raw data collected from the semi-structured interviews were coded and tagged by the identified themes and topics discussed. This helped in organizing the unstructured data and adding context to it. The themes were then reviewed and defined to discover any additional sub-topics. However, with a deductive approach, there is a risk of missing themesthat requires the researchers to exercise extra caution during the data interpretation and thematic analysis . The *validity* of the interviews also can be challenging due to subjectivity and lack of consistency [51]. However, elements like participants' relevance and experience with the research topic, the context of the interviews, and the information provided to participants can be evaluated to ensure that they are appropriate for the research. Although, these evaluations still rely on the researchers' interpretation [51]. To reduce subjectivity, the interview guide was designed to match the study's objectives with clearly defined questions and was reviewed by peers before employing it.

In general, there is no consensus regarding the appropriate number of informants participating in interviews, and determining the appropriate number of participants is a delicate balance between ensuring both representativeness and quality of responses to obtain comprehensive and insightful information [57]. Thus, by carefully considering both the representativeness of participants and the quality of their responses, the researchers can ensure that the gathered information is both exhaustive and reliable, thereby enhancing the validity and robustness of the study findings [57]. It is also important to note that data saturation [58] was achieved after approximately the 3rd interview in both groups, the vendors and users. Thus, recruiting more interview participants was deemed unnecessary.

4. Study findings

In this section, the quantitative and qualitative findings are presented consecutively. The quantitative findings are demonstrated in sub-Section 4.1, while qualitative findings are illustrated in sub-Section 4.2.

Table 2
Overview of respondents' demographics.

Demographics		n	%
Age	18–25	22	22 %
	26–35	19	19 %
	36–45	11	11 %
	46–55	26	26 %
	56–65	20	20 %
	66 or older	2	2 %
Gender	Male	52	52 %
	Female	48	48 %
Income	IOO.OOONOK or less	9	9 %
	101.000–300.000NOK	15	15 %
	301.000–500.000NOK	16	16 %
	501.000–700-OOONOK	22	22 %
	701.OOONOK or more	38	38 %
Occupation	Student	21	21 %
	Working	75	75 %
	Retired	4	4 %
Education	Upper secondary school	26	26 %
	Bachelor's degree	49	49 %
	Master's degree	15	15 %
	PhD	2	2 %
	Other	8	8 %
Ownership	Owner	71	71 %
	Tenant	25	25 %
	Live at the residence for free	4	4 %
Residential type	House	56	56 %
	Apartment	41	41 %
	Other	3	3 %
Location	Eastern Norway	65	65 %
	Western Norway	10	10 %
	Southern Norway	14	14 %
	Northern Norway	1	1 %
	Central Norway	10	10 %
Use	Yes	79	79 %
	No	21	21 %

4.1. Quantitative findings

The demographical factors of the 100 respondents shown in Table 2,provide an overview of the distribution of the respondents' age, gender, location (part of Norway), highest completed education, occupation, income (before taxes), homeownership, and residence type. The overview shows that some demographical factors contained a disproportionate distribution. Resultingly, respondents of 66 years of age or older (2 %) and people who are retired (4 %) were not highly represented. Furthermore, people living in Northern Norway (1 %) were also underrepresented.

4.1.1. Respondents' behaviors

The respondents were asked whether they currently use SHT and which functionalities and technologies they utilize. Out of the total 100 respondents, 79 respondents answered that they used SHT, while 21 did not use any. Through a frequency calculation in descriptive statistics, the findings showed that smart entertainment/multimedia was clearly the most commonly used by 71 % of the respondents, followed by smart security systems (38 %) and connected cars (36 %). The least common smart home technologies used by the respondents were smart healthcare technologies, integrated smart home systems, and other types of SHT that were not listed in the question. Furthermore, only 17 % answered that they used smart energy management (Table 3).

4.1.2. Model assessment PLS-SEM

To conduct the necessary tests for assessing the model, SmartPLS and SPSS were used. To assess the study's model, two stages were conducted: the assessment of the measurement model involving testing the reliability and validity, and the assessment of the structural model, testing the hypotheses. These two stages help the researcher check that the data is reliable and valid before making interpretations and conclusions about the constructs in the research model [59]. PLS-SEM is a popular method within information systems research as it can handle complexity, is suitable for small sample sizes, and does not assume a normal distribution of data [60]. The minimum sample size of PLS-SEM should be at least ten times the number of independent variables in the model, which in this study involved eight independent variables hence a minimum sample size of eighty respondents [61]. The dataset used in SmartPLS for this study had a sample size of 100 respondents, which fulfilled this rule.

Measurements for Skewness and Kurtosis were also conducted to check the univariate and multivariate normality of the data. The latent variables were exported into an Excel sheet and put into webpower.psychstat.org, which then processed and calculated the measures for skewness and kurtosis. Most latent variables had an acceptable degree of normality with skewness and kurtosis within the interval of $-1 - +1$, except PE, which had kurtosis at 1.460 [54]. This signified that PE had a peaked distribution. However, in this case, this was not a critical issue, and SmartPLS is effective in handling nonnormal data.

4.1.3. Assessment of measurement model

To assess the validity and reliability of the model, indicator reliability, internal consistency, convergent validity, and discriminant validity were checked [54]. Indicator reliability measures how accurately the items measure the latent construct and can be assessed by factor loadings for each of the items. The loadings should be at least 0.5 [59], but preferably above 0.7 for the items to be good measures for the latent constructs [54]. By running the PLS algorithm, findings showed that most loadings satisfied the criteria and could be kept for further tests. However, SP2 had a loading of 0.617 and did not satisfy the criteria of 0.7 (Table 4). Since FC3 had a loading of 0.699, it was then decided that FC was to be included in the analysis, while SP was excluded before proceeding further (Fig. 2).

The internal consistency was tested with composite reliability (CR), entailing how well the items measured the latent construct they were meant to measure through values between 0 and 1 [54]. The CR should be above 0.7, and the findings showed acceptable CR values (Table 4) . Another measure for assessing internal consistency is the rho_A or Cronbach's alpha. [54] suggested that Cronbach's Alpha might be too conservative; hence rho_A provided an acceptable intermediary measure for internal consistency. Since both rho_A and Cronbach's alpha were also measured above 0.7 , the values were considered as satisfactory and suggested that the items were positively related. Convergent validity explains the convergence of the constructs for explaining the variance of their items. To

Table 3
Use of smart home technologies among respondents.

Smart home technology	% of respondents
Smart entertainment/multimedia	71 %
Smart security system	38 %
Connected car	36 %
Smart lights	29 %
Smart heating, ventilation, or air conditioning (HVAC)	29 %
Smart speaker	24 %
Home robots	21 %
Smart energy management	17 %
Integrated smart home system	11 %
Smart healthcare technology	7 %
Other	5 %
None of the above	14 %

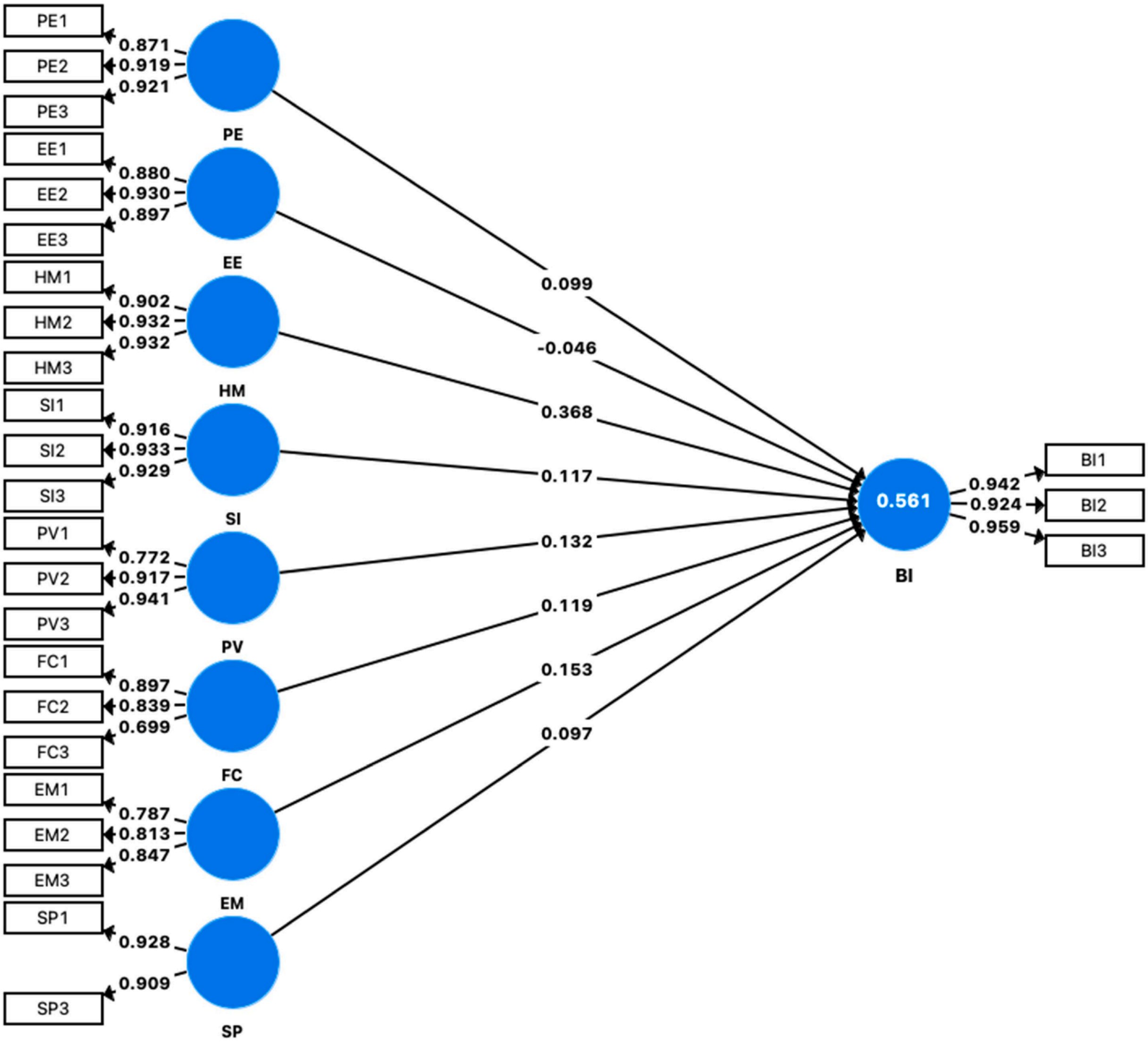

Fig. 2. Outer loadings and path coefficient.

measure convergent validity for the constructs, Average Variance Extracted (AVE) for each item should be above 0.5. The findings showed that AVE for all items was above 0.5, implying that 50 % or more of the items' variance was explained by the constructs [54].

Discriminant validity was assessed to check the subjective independence of the items on their latent construct. The discriminant validity can be measured through Cross Loadings, Fornell-Larcker, and Hetero-Monotrait (HTMT). Cross-loadings were checked to ensure that the items only loaded at 0.7 or above under one single construct (Table 5) [61]. In addition, Fornell-Larcker was assessed by checking that the constructs shared the highest variance with its items (Table 6). HTMT has often been argued by researchers to be a better measurement for discriminant validity [54]. HTMT is the mean of the item correlations for the constructs, whereas high HTMT values might indicate problematic discriminant validity [62]. The findings showed that the HTMT values were satisfactory as they were below the threshold of 0.85 and hence had discriminant validity (Table 7) [54]. Based on these assessments, the findings suggested that the questions measured the latent constructs they were indented to measure.

4.1.4. Assessment of the structural model

In order to evaluate the structural model, several important factors were considered using SmartPLS [54]. These factors included collinearity issues, the significance and relevance of relationships, as well as the explanatory and predictive power of the model. For assessing collinearity, the variance inflation factor (VIF) values were examined, with values above 5 indicating potential collinearity issues where the construct is highly correlated with other variables [62]. The results of the analysis indicated that all inner VIF values for the constructs were below 2.5, suggesting the absence of significant collinearity concerns (Table 8). These findings provide assurance that the model's variables are sufficiently distinct and independent from one another, enhancing the reliability of the

Table 4
Reliability and validity: loadings, AVE, CR, rho_A, Cronbach's alpha.

Construct	Items	Loadings	AVE	CR	Rho_A	Cronbach's alpha
Performance Expectancy	PE1	0.871	0.818	0.931	0.896	0.888
	PE2	0.919				
	PE3	0.921				
Effort Expectancy	EE1	0.880	0.814	0.929	0.913	0.887
	EE2	0.930				
	EE3	0.897				
Social Influence	SI1	0.916	0.858	0.948	0.929	0.917
	SI2	0.933				
	S13	0.929				
Hedonic Motivation	HM1	0.902	0.850	0.945	0.929	0.913
	HM2	0.932				
	HM3	0.932				
Price Value	PV1	0.772	0.774	0.911	0.969	0.862
	PV2	0.917				
	PV3	0.941				
Facilitating Conditions	FC1	0.897	0.666	0.856	0.831	0.756
	FC2	0.839				
	FC3	0.699				
Security and Privacy	SP1	0.908	0.675	0.858	0.878	0.769
	SP2	0.617				
	SP3	0.905				
Energy Management	EM1	0.787	0.666	0.856	0.759	0.750
	EM2	0.813				
	EM3	0.847				
Behavioral Intention	BI1	0.942	0.887	0.959	0.943	0.936
	BI2	0.924				
	BI3	0.959				

* AVE ≥ 0.5.
* CR, rho_A. Cronbach's alpha ≥ 0.7.

Table 5
Discriminant validity: cross loadings.

	PE	EE	EM	SI	HM	PV	FC	SP	BI
Bl1	**0.942**	0.356	0.432	0.375	0.594	0.498	0.476	0.386	0.266
BI2	**0.924**	0.241	0.480	0.326	0.559	0.575	0.461	0.426	0.356
B13	**0.959**	0.347	0.581	0.401	0.651	0.608	0.535	0.456	0.310
EE1	0.234	**0.880**	0.233	0.443	0.458	0.400	0.232	0.101	0.078
EE2	0.339	**0.930**	0.355	0.427	0.450	0.434	0.231	0.058	0.003
EE3	0.316	**0.897**	0.364	0.481	0.415	0.382	0.204	0.041	−0.003
EM1	0.431	0.245	**0.787**	0.253	0.470	0.458	0.314	0.326	0.113
EM2	0.373	0.317	**0.813**	0.414	0.291	0.434	0.191	0.207	0.005
EM3	0.486	0.322	**0.847**	0.494	0.342	0.556	0.405	0.428	0.228
FC1	0.399	0.349	0.526	**0.897**	0.282	0.372	0.373	0.163	0.026
FC2	0.316	0.535	0.268	**0.839**	0.317	0.233	0.326	0.078	0.003
FC3	0.195	0.358	0.349	**0.699**	0.130	0.286	0.081	0.152	0.154
HM1	0.506	0.438	0.361	0.282	**0.902**	0.591	0.355	0.193	0.121
HM2	0.666	0.429	0.497	0.318	**0.932**	0.698	0.495	0.314	0.237
HM3	0.582	0.482	0.378	0.263	**0.932**	0.586	0.456	0.351	0.209
PE1	0.513	0.355	0.571	0.314	0.559	**0.871**	0.333	0.283	0.216
PE2	0.507	0.465	0.514	0.420	0.631	**0.919**	0.449	0.428	0.283
PE3	0.593	0.401	0.536	0.269	0.655	**0.921**	0.431	0.371	0.256
PV1	0.226	0.137	0.174	0.177	0.239	0.224	**0.772**	0.362	0.335
PV2	0.471	0.249	0.382	0.380	0.429	0.437	**0.917**	0.385	0.302
PV3	0.570	0.232	0.382	0.323	0.510	0.448	**0.941**	0.372	0.287
SI1	0.374	0.132	0.34	0.152	0.346	0.389	0.391	**0.916**	0.449
S12	0.466	0.011	0.391	0.111	0.228	0.344	0.400	**0.933**	0.426
S13	0.402	0.065	0.388	0.179	0.318	0.381	0.364	**0.929**	0.431
SP1	0.319	0.038	0.140	0.085	0.227	0.239	0.330	0.494	**0.928**
SP2	0.286	0.001	0.142	0.011	0.156	0.275	0.282	0.360	**0.909**

analysis and the validity of the results.

For testing the research hypotheses, bootstrapping was conducted. Bootstrapping is a method to evaluate the direct effects of the relationships that are hypothesized in the research model [63]. The significance level was set to 0.1 for a two-tailed test type; hence the

Table 6
Discriminant validity: Fornell-Larcker.

	BI	EE	EM	FC	HM	PE	PV	SI	SP
BI	0.942								
EE	0.335	0.902							
EM	0.532	0.361	0.816						
FC	0.391	0.498	0.478	0.816					
HM	0.641	0.486	0.453	0.313	0.922				
PE	0.597	0.449	0.597	0.366	0.682	0.904			
PV	0.523	0.245	0.383	0.352	0.479	0.448	0.880		
SI	0.450	0.070	0.404	0.157	0.316	0.399	0.416	0.926	
SP	0.330	0.023	0.153	0.055	0.211	0.278	0.334	0.469	0.918

Table 7
Discriminant validity: HTMT.

	BI	EE	EM	FC	HM	PE	PV	SI	SP
BI									
EE	0.359								
EM	0.624	0.430							
FC	0.439	0.617	0.612						
HM	0.683	0.545	0.537	0.354					
PE	0.650	0.506	0.725	0.448	0.750				
PV	0.529	0.268	0.425	0.382	0.493	0.476			
SI	0.480	0.091	0.471	0.194	0.345	0.444	0.474		
SP	0.376	0.045	0.203	0.112	0.235	0.328	0.414	0.538	

Table 8
Inner VIF values.

Inner VIF values	
	BI
EE	1.663
EM	1.897
FC	1.614
HM	2.188
PE	2.479
PV	1.586
SI	1.612
SP	1.360

t-value should be above 1.645 for the path coefficients to be statistically significant [54]. The t-values showed that only two of the relationships had significance while the others did not. This resulted in only H4, H5, and H6 being supported (Table 9). The path coefficients are often referred to as standardized beta coefficients in the structural model, which is labeled as "Std. Beta", as seen in Table 9 [54]. Findings from the bootstrapping also produced measures for the coefficient of determination (r^2) and effect size (f^2). The r^2 measured the predictive accuracy of the model and the explanatory power of the endogenous constructs, which here was BI. The r^2

Table 9
Direct relationships for hypothesis testing.

Hypothesis	Relationship	Std beta	Stdev	T statistics	Decision	f^2	95 %CI LL	95 %CI UL
H1	PE -> BI	0.099	0.119	0.829	Not supported	0.009	−0.077	0.306
H2	EE -> BI	−0.046	0.114	0.401	Not supported	0.003	−0.210	0.170
H3	SI -> BI	0.117	0.069	1.689*	Supported	0.019	0.007	0.230
H4	HM -> BI	0.368	0.111	3.317**	Supported	0.141	0.166	0.530
H5	PV -> BI	0.132	0.076	1.746*	Supported	0.025	0.023	0.267
H6	FC -> BI	0.119	0.114	1.041	Not supported	0.020	−0.093	0.292
H7	SP -> BI	0.097	0.072	1.349	Not supported	0.016	−0.013	0.216
H8	EM -> BI	0.153	0.107	1.431	Not supported	0.028	−0.026	0.324

CI = confidence interval. LL = lower limit. UL = upper limit.
*$p < 0.1$. **$p < 0.01$.
Effect size: 0.02 small. 0.15 medium. 0.35 large.
r^2 BI = 0.561.
q^2 BI = 0.460.

ranges between 0 and 1, whereas a higher value would imply higher explanatory power or the predictive power of the construct. The bootstrapping resulted in an r^2 of 0.561 and an r^2 adjusted of 0.523, which was considered a moderate explanatory power [54]. To assess how big an effect each construct or path had on the endogenous construct, the f^2 was measured. [62]. An f^2 value of 0.02 is considered a small effect size, 0.15 as a moderate effect size, and 0.35 as a large effect size. The findings suggested that EM, SI, HM, PV, and FC had f^2 of 0.02 or above, implying a small effect size, while PE, EE, and SP had f^2 below 0.02, implying no effect. Additionally, a blindfolding procedure was conducted to calculate and assess the predictive relevance (q^2) of the path model, also known as cross-validated redundancy. A smaller difference between the original values and the estimated values gives a higher q^2 indicating a greater predictive accuracy [54]. The omission distance (D) for the blindfolding procedure was set to the default of 7 [54]. The findings from the blindfolding showed a q^2 of 0.460, which was an acceptable value for proving predictive relevance [54].

To avoid biased interpretations of the data , common method bias (CMB) was checked using SPSS. A lack of consideration of potential common method effects in the data may cause biased estimations of the reliability and validity of the data analyses and might ultimately affect the findings of the analyses [64]. Consequently, Harman's single factor test was conducted to see if there was common method bias in the data. By doing a Dimension Reduction for Factors in SPSS with a principal axis factoring, no rotation, and a fixed number of factors 1, the single factor that was extracted from the analysis was 34.29 %. It was thus concluded that there was no sign of common method bias in the data as this measure was considerably lower than 50 [64].

Scholars have argued that a general measurement of model fit is not applicable for PLS-SEM as it often proves to be unsuccessful or insufficient [54]. However, there are still some measures of model fit that can be assessed in PLS-SEM, such as SRMR, yet it is important to note this is often considered to be somewhat ineffective [54]. SRMR values below 0.08 are considered a good fit [65], which the findings fulfilled with an SRMR of 0.072 (Table 10).

4.2. Qualitative findings

In the analysis of the qualitative data collected from the interviews, some key topics were emerging, emphasized, and reoccurring throughout the interviews. Accordingly, these themes and sub-themes were identified and extracted through a thematic analysis to put the qualitative data into context, and to aid in elucidating and explicating the research questions. In the following sub-sections, insights and findings from the interviews are presented by the key themes that were identified in the analysis and discussed during the interviews. Onwards, the experts interviewed are referred to as "EXP" (singular) or "Experts" (plural), while the consumers interviewed are referred to as "CON" (singular) or "Consumers" (plural).

4.2.1. Usefulness

When asked about their perception of the usefulness of SHT, most Consumers (4/5) asserted that the usefulness of SHT was important for them to buy it. However, the Consumers, except CON1, did only have knowledge and familiarity with a few types of SHT and were not aware of the variety of SHT. There was a clear consensus among the participants that it is important to clearly communicate and show what benefits and convenience the SHT can add to consumers' everyday lives. EXP5 stated that one of their methods for communicating the applicability of SHT was through articles that address certain problems or challenges and how SHT can help in solving these challenges, rather than writing merely about their products.

4.2.2. Ease of use

The Consumers were asked to what extent they perceived the ease of use of the SHT that they were familiar with. The answers suggested that the perspectives related to ease of use were somewhat divided. While most of the consumers that were interviewed in this study stated that they were relatively confident that they would master the implementation and use of basic SHT, CON5 was not equally confident that they would master the implementation and use of basic solutions without help from others. However, CON5 explained that this did not hinder their own adoption of SHT, due to the availability of assistance from their spouse.

4.2.3. Social influence

There was a general consistency among the Experts' answers that social influence is an important part of SHT adoption. All the Experts agreed that social influence from friends and family, demonstrations, and showcasing of the technology are important in spreading awareness, knowledge, and attention among consumers.

Initially, CON1 and CON2 put more emphasis on the functionalities and benefits of SHT in influencing their choices of adoption. However, they also admitted that social influence will always have some impact. CON3 and CON5 stated that social influence was a large part of their decision-making process for buying new technological products and valued the opinions and experiences shared by trusted people. CON4 explained that social influence would probably somewhat influence decision-making and awareness of SHT yet did not think this standalone would lead to investing in and adopting SHT. CON5 expressed social influence as one of the most important drivers for adoption, whereas this was especially central for adopting new SHT beyond what they already used. Moreover,

Table 10
SRMR.

SRMR	Original sample	Sample mean	95 %CI LL	95 %CI UL
Saturated Model	0.072	0.05	0.059	0.062
Estimated Model	0.072	0.05	0.061	0.067

mass media and social media were brought up as influencing factors for use and adoption, especially among the younger Consumers.

4.2.4. Enjoyment and enthusiasm

As indicated by experts EXP2 and EXP3, a prevalent characteristic among Norwegians is their affinity for cutting-edge gadgets; the majority own a smartphone, and many also have the latest and fanciest smartphones. CON1, CON2, and CON3 stated that they enjoy gadgets and like to test out new products and stay informed. Generally, curiosity was explained as a central source of motivation and interest in SHT. When asked about what they enjoyed with SHT, CON3, and CON5 expressed that the opportunities to choose and switch the color of the lights remotely in a seamless way were among the main reasons. Additionally, controlling everything through one's smartphone was highlighted by three of four Consumers who used SHT, while CON1 preferred everything to be automated.

Two of the Experts mentioned that some of the consumers who are very enthusiastic about SHT also program solutions themselves, which they post on social media for others to use. This was supported by CON1, who had respectively created such solutions and made them available to others. Further, CON1 also suggested comfort and luxury as important drivers for SHT interest. EXP1 pointed out comfiness and coziness as central characteristics of the Norwegian market, whereas Norwegians, in general, will not compromise on coziness at home. Relatedly, CON2 and CON5 both expressed that they have timed outdoor lights and leave some lights on in the house at night and when they are away because it looks cozier to the neighbors and that the technology enables them to control it remotely.

4.2.5. Costs and cost-savings

Regarding the prices and costs related to SHT, the participants were somewhat split in their perspectives. Most experts (4/5) argued that many smart home technologies being offered today have reduced their price levels, as more solutions are based on "do-it-yourself" solutions that do not require costly implementation by electricians or installers. However, for most Consumers, the implementation price was not a big issue regarding investing in SHT, since they did not use complex interconnected SHTs that required large investments and implementations. Still, CON2 emphasized that in the end, the spreadsheet will have the final word in any decision-making process; hence it all comes down to costs and savings. Other Consumers (3/5) considered the functionality of the SHT to be more important than the price in the decision-making process, up to a certain cost level. Additionally, the opportunity to save costs, for example, by energy management, was emphasized by the majority of the Consumers (4/5) as a motivator for using SHT. CON3 and CON4 stated that they would prefer to achieve a return on investment within a year of purchase, while CON2 and CON5 were willing to wait up to 3 years. CON1, however, stated that they would never be able to save on the costs used on creating a fully automated home.

Homeownership was also identified as a factor influencing the decision-making regarding SHT. When asked about willingness to invest in SHT, CON3, and CON4 declared that as long as they do not own the residence, the willingness to invest in SHT was low. This factor was also mentioned by EXP5 as an influencing determinant for adoption.

4.2.6. Facilitating conditions

When asked about the facilitation of SHT today, a commonly mentioned topic by the Experts was the need for a general standard on which to build all SHT solutions. Arguably, this will enable a much higher level of interoperability and compatibility between vendors and technologies and increase the overall functionality of a smart home. As EXP2 pointed out, there have been several attempts to create other standards previously, yet no one has succeeded in creating one universal standard that everyone will use. Another challenge pointed out by the Experts was the limited training and knowledge of the salespersons at the distributors' stores, causing them not being able to provide the knowledge and guidance necessary for the customers to match the right products to their needs can become a barrier for some consumers in using SHT.

The Experts agreed that having properly functioning customer support is a critical element as there will always be some consumers who will never be able to implement the solutions themselves. The Consumers also considered customer support as an important factor, and that they expect the vendor to assist them if problems should occur, yet they had a more nuanced perspective. Three of the Consumers stated that they would rather ask friends or family for support or assistance regarding SHT. This was explained that they knew one or more persons who could usually provide them with an immediate necessary help .

4.2.7. Security and privacy of smart home technology

Regarding the security and privacy of SHT, the Consumers were also somewhat divided in their views. **CON4** stated that this factor was the main reason they did not use any SHT today and especially pointed out that smart speakers were problematic due to the possibility of them listening to personal conversations and accessing sensitive information. It was stipulated as a matter of what technology the consumer was comfortable with having at home. On the other hand, the other Consumers did not have any severe security or privacy concerns regarding the use of SHT and trusted the vendors and their software and hardware. EXP1 pointed out that the SHT for home security is getting mature and have already been used for quite a while by alarm companies. Furthermore, EXP5 emphasized that privacy and security-related concerns should, by principle, mainly apply to the vendors and not so much to the consumer, as the vendors should ensure to follow the highest possible security and privacy measures in their technologies.

4.2.8. Home energy management

All the Experts had a consensus that energy management is a critical factor in the adoption of smart homes today due to rising energy prices. However, there were some divided opinions on the importance of energy management regarding SHT among Consumers. The Consumers that owned their residences cared more about energy management and getting a better overview and control of electricity consumption and costs. In contrast, the Consumers who were tenants or who had the energy costs included in their rent did not acknowledge energy management as a particular focus or motivation for adopting SHT. Moreover, some Consumers were not aware of the possibilities of energy and cost-saving enabled by SHT.

5. Discussion

The research model for examining the use and adoption of SHT in Norway in this study extends the UTAUT2 by including energy management and security and privacy as suggested by the literature. The quantitative findings showed that hedonic motivation had the strongest effect on behavioral intention toward using and adopting SHT, followed by social influence and price value. Surprisingly, these three constructs were the only ones that were significantly different from 0 and thus had a considerable effect on BI. Therefore, H3, H4, and H5 were supported, while H1, H2, H6, H7, and H8 were not supported (Table 11). The rest of the discussion is divided into sub-sections based on the main constructs used in the hypotheses.

5.1. Performance expectancy

PE has often been discussed as a strong driver for SHT adoption, involving the perceived usefulness and benefits of the SHT [40]. Nonetheless, the quantitative findings showed that PE did not have a significant effect on BI in this study. A possible explanation for the insignificant relationship between PE and BI might be that the potential usefulness of SHT is not perceived or realized by the respondents. As Becks et al. [29] and our informants suggested, clear communication and demonstration of SHT are crucial for educating consumers about the functionalities and features that SHT can bring to simplify daily life. In addition, the interview data also suggest that the awareness of SHT applicability was relatively low among most of the Consumers. The lack of awareness, familiarity, or experience with SHT might strongly affect consumers' capability to perceive the usefulness of SHT, which corresponds to existing research [34]. Further, as the literature argued, consumer needs should be in focus when developing and selling SHT for the consumers to see the usefulness of the solutions [66]. Two Experts and a Consumer pointed out a related issue, whereas the distributors who sell SHT often do not have sufficient competence about the products to provide expertise to find and cover the consumers' needs or preferences. This might also contribute to explaining the lack of perceived usefulness in the Norwegian market. In essence, PE appears to be a central aspect of SHT adoption, yet not a guaranteed or exclusive driver for consumers in Norway to adopt SHT.

5.2. Effort expectancy

A somewhat counterintuitive finding in the quantitative findings was the slightly negative relationship between EE and BI. The findings suggested that effort expectancy or ease of use had a negative effect on adoption, differently from the findings of some similar studies [67]. EE relates to the user-friendliness of SHT and to what degree consumers perceive the technology as easy or difficult to use. Like literature emphasized the importance of creating seamless and user-friendly solutions to avoid complexity becoming a barrier to adoption [29], the Experts in this study also pointed out that more smart home vendors are now starting to offer technology that is more user-friendly that consumers can adopt without assistance from electricians or installers. Hence, EE might be less prone to be a potential barrier in the process of acquiring, implementing, and using the SHT. Yet, the slightly negative value was an unexpected result. This might be explained by that even though the respondents who answered that they do not use and do not intend to start using SHT, they still considered themselves equipped to handle SHT relatively easily. As descriptive statistics showed, the mean for EE for those who did not use any SHT was relatively high, even though the mean for their behavioral intentions was low (Table 8). Additionally, the rank-order findings also suggested that a lack of technical skills was not considered a barrier by the non-users themselves (Table 9). Furthermore, for the Consumer-interviews, the perceptions of ease of use did not seem to be a barrier to the Consumers, regardless of use or intentions to use SHT or not. As literature has suggested, perceived difficulty of use being a barrier to adoption applies particularly to people with less technical literacy and the elderly [9], which might suggest that the respondents have a relatively high technological literacy, despite whether they are using SHT or not.

5.3. Social influence

Consistent with the reviewed literature regarding the effect of social influence on SHT adoption, the quantitative findings showed that SI had a significantly positive effect on behavioral intention to use and adopt SHT among the respondents, confirming the findings by Chen et al. [68], and Shuhaiber et al. [11], among others. As the qualitative and quantitative findings also showed, influence from

Table 11
Hypotheses-testing results.

	Hypothesis	Decision
H1	Performance Expectancy significantly affects behavioral intention toward smart home technology adoption.	Not supported
H2	Effort Expectancy significantly affects behavioral intention toward smart home technology adoption.	Not supported
H3	Social Influence significantly affects behavioral intention toward smart home technology adoption.	Supported
H4	Hedonic Motivation significantly affects behavioral intention toward smart home technology adoption.	Supported
H5	Price Value significantly affects behavioral intention toward smart home technology adoption.	Supported
H6	Facilitating Conditions significantly affect behavioral intention toward smart home technology adoption.	Not supported
H7	Security and Privacy significantly affect behavioral intention toward smart home technology adoption.	Not supported
H8	Energy Management significantly affects behavioral intention toward smart home technology adoption.	Not supported

friends, family, mass media, and social media was generally considered as an important source of information for the decision to use and adopt SHT by the majority of the participants in [11] and [68]. For example, social influences emerge as a prominent catalyst for fostering trust in the context of smart homes in UAE, exerting their impact through channels like word of mouth, online reviews, and social media content disseminated by influential individuals such as family members, friends, colleagues, and relatives [11]. This sharing of information pertaining to smart homes within the UAE context can substantially affect individuals' attitudes, behaviors, and underlying intrinsic values, thereby significantly shaping the levels of trust they place in these technological environments [11]. As literature has also previously suggested (e.g., [9]), this study's findings suggest that social influence is a central part of consumers' decision-making process for SHT adoption, whereas influence from people close to them or from people with integrity was highlighted. As a non-user, CON4's statement that they would not adopt SHT based on the influence of others, and the low mean for SI among the respondents could be explained by Vrain and Wilsońs [47] argument concerning that a limited number of adopters in the non-users social network might restrain them from exposure to and experiences with the respective technologies.

5.4. Hedonic motivation

Another construct that showed a significant positive effect on BI in the quantitative data analysis was the HM. The relationship between HM and BI was the strongest relationship out of all the constructs, which might suggest that HM was the strongest driver for SHT adoption among the respondents. As suggested by Venkatesh et al. [10], hedonic motivation had a stronger effect than performance expectancy on the consumers' intentions to use smart home technology. As literature also suggested, the more enjoyable, entertaining, or fun experiences with SHT are, the more consumers' perceptions of usefulness and relevance will increase and affect intentions to use and adopt the technology [11,40]. As expressed by CON4 and CON5, the enthusiasm regarding adopting new SHT can be strengthened by having had positive experiences with SHT. This might imply that hedonic motivation works as an accelerator for adoption for those who already are familiar with and have earlier positive experience with SHT. The Consumers interviewed in this study who expressed the most enthusiasm and enjoyment regarding SHT, were homeowners, and were also those with a higher and more stable income. Moreover, the descriptive statistics showed that the income distribution among the respondents descended from "701.000NOK or more", suggesting that the respondents have a generally good purchasing power. These observations corresponded to the literature's suggestion that income and personal economy might have an impact on the level of HM [24]. Furthermore, as more smart home technologies are becoming increasingly user-friendly and require less prior knowledge about the solutions, a more widespread interest and curiosity about SHT might be demonstrated. This view was pointed out by Experts and corresponds to the literature discussing technological literacy as a relevant aspect relating to technological enthusiasm [24].

5.5. Price value

There was consistency between the majority of literature underlining the positive effect of investments in SHT [8], and also the quantitative findings of this research suggested a significant positive effect of price value on behavioral intention. Additionally, the qualitative findings also demonstrated that cost-savings and the perceived value of using SHT can have a motivating effect on intentions to adopt SHT, as suggested earlier by [36]. As the price value involves the consumers' perceived tradeoff between the price and benefits of the SHT [10], the qualitative interviews however revealed that for most Consumers price might only become a barrier for large investments. Aligning with findings by [24], which show that homeownership was found to have an impact on the consumer's motivation for investing in SHT, whereas homeowners had a higher willingness than tenants. Due to rising energy prices in Norway, smart home vendors have noticed an escalation in consumer interest in SHT to manage the costs of their energy consumption. Resultingly, the cost-saving aspect of smart homes was perceived as a driving factor for adopting SHT, whereas consumers can save energy and costs as well as possibly have a return on investment over time [41]. On the contrary, and despite the expectation of high costs associated with SHT, a quantitative study [39] conducted on German consumers indicated that costs do not have a significant impact on the adoption decision of SHT. This result challenges the commonly held assumption that higher costs act as a deterrent to the adoption of SHT, as well as contradicts with our quantitative findings, however, partially corresponds with our qualitative results. This absence of a significant impact suggests that other factors, such as perceived value, convenience, or functionality, may outweigh the influence of costs in shaping consumers' adoption decisions within the German context [39]. These contrasting findings highlight the need for a deeper understanding of the complex interplay between different factors influencing the adoption of SHT and underscore the importance of considering a more nuanced perspective when examining the role of costs in technology adoption contexts and cultures.

5.6. Facilitating conditions

The facilitating conditions of SHT entail the surrounding infrastructures that enable the SHT to function as intended, whether it be interoperability between different solutions, available customer support, and/or the consumer's ability to acquire the necessary knowledge and skills to utilize the SHT [10,33]. The qualitative findings suggested that both the Experts and the Consumers considered FC as important in SHT adoption. Due to convenience and access, almost half of the interviewed Consumers would ask friends and family for assistance rather than contacting customer support. Hence, support from friends and family appeared to be important in facilitating SHT adoption besides support from the vendor [35]. However, the quantitative findings showed that FC had a slightly positive relationship with BI, yet there was no significant effect. This might be explained by a relatively limited experience with SHT among the respondents, leading to an underestimation of the importance or value of the facilitating conditions [8].

5.7. Security and privacy

In the literature, concerns regarding security and privacy risks have often been discussed as a central barrier to SHT adoption [24]. However, as the qualitative findings revealed, the Consumers' attitudes toward security and privacy varied, which contradicts with recent research on SHT adoption. For example, a qualitative study by Georgiev and Schlögl [69] suggests that privacy and security remain the primary obstacles for SHT adoption [69]. On the other hand, our findings suggest that those who used some SHT solutions did not have particular security and privacy concerns, and some also felt that SHT enabled better home security [23]. In contrast, the Consumer who did not use SHT and the Consumer who used the most complex SHT did, however, have some security and privacy concerns. These diverging attitudes might explain the insignificant slightly positive relationship between SP and BI in the quantitative findings. However, this relationship was not significant. Another explanation might be, as suggested by EXP5, that SP concerns mainly apply to the vendors and should therefore not be a concern to the consumers. This explanation requires that the consumers have trust in the smart home vendor [68]. Either way, SP did not appear to be a critical factor in the adoption of SHT among the respondents.

5.8. Energy management

Consistent with the extant literature [9], the Experts participants emphasized how SHT has the potential to help consumers obtain an overview of their energy consumption at home and can help reduce overall consumption. Literature has suggested the motivational effect of energy-saving to be a driver for SHT adoption, provided it does not compromise comfort and convenience [45]. However, as EXP2 pointed out, awareness of household energy consumption has been a central challenge to SHT adoption. The findings from the rank-order question also suggested that energy management was not prioritized as an important attribute for investing in SHT among the users. Moreover, the descriptive statistics also showed that the respondents were not aware of having a smart meter or advanced metering system (AMS) even though this was installed in most residences in Norway by 2019 [4]. This might stipulate an example of a relatively low awareness regarding smart home energy management solutions, which was also supported by EXP2′s statement about Norwegians' unconsciousness regarding energy consumption and the importance of comfort. This, in turn, corresponded with the literature's findings regarding the tradeoff between comfort and energy-saving [17]. The quantitative findings of this study did not indicate a significant relationship between EM and BI. Despite this, both Expert- and Consumer interviews proposed EM as a critical aspect of sparking interest in SHT among consumers in Norway, now more than ever before. The Experts interviews suggested that due to the increase and instability in the energy prices in Norway over the past year, consumers have shown more interest in SHT for obtaining an overview of their residential energy consumption and costs. The somewhat diverging findings might be explained by factors such as unawareness, energy costs being included in the rent, or perceived difficulty [24]. As also reported in the findings, most of the Consumers were not aware of the different ways SHT can help manage and save energy and costs.

6. Study implications

Overall, the implications of this study offer valuable insights and recommendations for researchers, policymakers, and industry professionals. By considering and applying these implications, stakeholders can enhance their understanding, strategies, and practices related to smart home technology adoption, fostering its widespread acceptance and usage. A discussion of the research's implications for the body of knowledge and practice is presented below.

6.1. Implications for research

Despite much research on SHT adoption existing in general, there is to the knowledge of the researchers limited new research on SHT adoption in Norway. Hence, this study contributes to the research field by providing an overview and insights into the SHT market in Norway from both a consumer and a vendor perspectives. This study provides empirical support for the importance of hedonic motivation, the perceived price value, and the social influence regarding the use and adoption of SHT in Norway.

Most of the reviewed research on SHT adoption has addressed central topics concerning the benefits and usefulness of SHT, ease and difficulty of use, dependence on help and support, opportunities for energy-saving and energy management, and costs and cost-saving. Through a mixed-methods research design, the findings of this study suggested that HM, PV, and SI were the strongest drivers of SHT adoption among the respondents. However, other factors, like PE and EE, that were often identified as the drivers in literature [11,67], did not prove to have a significant effect on behavioral intention in this study. Even though the quantitative findings did not fully align with the expected outcomes of the proposed research model, the findings provide insights into Norwegian respondents' perceptions, attitudes, and intentions toward the use and adoption of SHT. Minding that Norway is a wealthy country with a functioning welfare system, these identified drivers suggested that mere usefulness, energy-saving, or ease of use of SHT are not sufficient motivators for adoption. The strong impact of HM on intentions to use and adopt SHT and the high income of the respondents support a generalized understanding that Norwegians have good purchasing power and often have an interest in gadgets. Interestingly, the study's quantitative findings might imply that the respondents did not perceive SHT as particularly useful in improving or assisting current daily life tasks, but rather perceived SHT as an enjoyable and fun attribute to their daily lives. This finding highlights the potential hedonic motivation that drives the adoption of SHT among consumers. However, further research is warranted to gain a more comprehensive understanding of smart home technology adoption in Norway. By delving deeper into the factors influencing adoption decisions and investigating additional contexts, future studies can provide a more nuanced perspective on the drivers and barriers of SHT adoption.

6.2. Implications for practice

Through the analysis of quantitative and qualitative findings, the main identified barriers to SHT adoption in Norway involved the lack of awareness and familiarity with SHT and its applicability to daily life tasks, especially among the non-users. Hence, to increase the diffusion of SHT adoption in Norway, the awareness of the variety of SHT solutions needs to increase in the mass market. Additionally, improving consumers' awareness regarding energy consumption and home energy management might lead to an increased interest in SHT, which can contribute to the national energy consumption management towards enhanced sustainability. In addition, as social influence was also identified as a driver of adoption, positive word-of-mouth and focus on mass- and social media might contribute to a higher awareness regarding SHT and possibly generate increased SHT adoption. Since non-users did not consider SI to impact their intentions to use SHT to a large degree, achieving increased exposure to SHT within their social network might contribute to making them more familiar with the concept [47].

The practical implications of the study also suggest that smart home vendors in Norway might want to focus on persistent and clear market communication regarding the benefits and convenience that SHT can add to consumers' lives, beyond mere entertainment. For instance, raising awareness of the household's energy consumption through real-time monitoring based on gamification principles might appeal to consumers' hedonic motivation to adopt SHT for energy management. Government agencies as well as product managers and designers of SHT products and services have to ensure that the features are attractive, easy, and fun to use to motivate and accelerate public adoption. By raising awareness and consumers' familiarity with SHT, the perceived usefulness might also improve [53]. Furthermore, increasing Norwegian consumers' awareness of their own energy consumption and the opportunities for energy management and potential energy and cost-savings might also increase the initiative among consumers to adopt SHT. As the participating Experts in this research expressed, they had already experienced an increased initiative from consumers due to rising energy prices in the past months. Such incentives for home energy management can have a considerable impact on total energy consumption in a national context if a widespread diffusion of smart home technology adoption is achieved.

7. Conclusion, limitations, and future research

Through a mixed-methods research design, this study examined perceptions, attitudes, intentions, and use of SHT in Norway from both a smart home vendor's perspective and a consumer's perspective to answer the respective research questions.

The findings from the structural model showed that hedonic motivation, price value, and social influence had significant effects on behavioral intention among the survey respondents, whereas hedonic motivation and enthusiasm regarding SHT were identified as the strongest driver of adoption. In addition, descriptive statistics and the analysis of the consumer qualitative interviews revealed that the awareness and knowledge of SHT's applicability to daily life tasks were relatively low beyond the technologies the participants currently used. Consequently, a lack of awareness and familiarity with SHT and its usefulness was identified as the main potential barrier to adoption.

To increase the diffusion of SHT adoption in Norway, the awareness of the variety of SHT solutions needs to increase in the mass market along with the benefits and usefulness of the respective technologies. Hence, a suggestion was to ensure clear and broad communication of SHT's applicability and advantages to the consumers. Also, the consumers need to be better educated by vendors and other stakeholders about how SHT might be useful in reducing or monitoring their energy consumption and how it can potentially improve daily life convenience and comfort. Additionally, increased awareness of energy consumption might generate an initiative from consumers to adopt SHT in combination with the rising energy prices. Nonetheless, the SHT market in Norway remains interesting for future studies, as this study contributes to providing insights that future researchers may use to compare findings for gaining a detailed overview of the Norwegian SHT market.

There are some relevant limitations that should be pointed out to ensure a proper and transparent interpretation of this study. Limitations related to the subjectiveness of participants can make it hard to achieve consistency in the qualitative data generated by the interviews. For example, the descriptive statistics showed that the elderly (66 years old or older), and consumers living in Northern Norway were underrepresented in the samples. Hence, the external validity and the generalizability of the quantitative analysis might be reduced. On the other hand, existing research argues that the majority of SHT adoption studies focus more on the elderly population, and that millennials exhibit a persistent and growing enthusiasm for SHT adoption and use, which calls for more research into other age segments beside the elderly. Moreover, although PLS-SEM works well with small sample sizes, yet a larger sample size might have generated a more precise quantitative analysis with possibly larger effect sizes and possibly a more generalizable representation of the population. Due to insufficiencies in the first survey that was distributed, a new one had to be tested and distributed. This might explain a lower response rate for the latter survey. Nonetheless, the sample size of 100 respondents was deemed acceptable.

Future research in the domain of SHT adoption offers a plethora of avenues that remain unexplored. For example, future research has the potential to expand on the findings of this study by conducting additional interviews and surveys with a broader demographic spectrum of Norwegian participants, including both experts and consumers. This approach would provide a deeper perception of the market and offer a more comprehensive understanding of the different demographic groups. Future studies may also inquire the role of socio-economic status in the adoption and utilization of smart home technologies, examining whether these technologies are widening or narrowing social inequalities. Further, the impact of cultural factors on the adoption of smart home technologies across different countries or regions also warrants scholarly attention. Finally, it would be worthwhile for researchers to explore the role of SHT within a wider national context, specifically by studying its use in Norwegian households from a sustainability perspective. Such research could shed light on the potential impact of SHT on sustainability in Norwegian communities, cities, and the country as a whole. By pursuing these directions, future scholarly efforts have the potential to significantly deepen our comprehension of market dynamics, consumer perceptions, and the multifaceted impact of SHT adoption on both individual consumers and the broader environmental landscape. These future investigations will not only enrich the academic discourse, but could also offer actionable insights that may have practical implications for both policymakers and industry stakeholders, which can transform industry practices and contribute meaningfully to the achievement of the sustainable development goals.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data that has been used is confidential.

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