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PERCEIVED BARRIERS TO CONSUMER ACCEPTANCE OF SMART HOMES IN THE FINNISH MARKET

Master's Thesis

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Abstract

The objectives of this thesis are to discover the Finnish consumers' perception of smart homes, the predictors of use intention of smart homes and the acceptance barriers of smart homes among all participants and different subgroups.

Finland was discovered to be lagging behind in smart home adoption compared to other Nordic countries, and this thesis aimed to investigate which perceptions may be holding back Finnish consumers from adopting smart homes. The objectives are reached with a factor analysis, reliability and validity analysis and regression analyses. This study is conducted as a replication study of the research by Park et al. (2018) with the same hypotheses to be tested.

There are three main findings in this thesis. First, smart homes are perceived as easy to use, enjoyable and useful, but expensive, insecure as well as moderately unreliable and incompatible with people's lifestyles. Second, use intention is strongly impacted by attitude, perceived usefulness and compatibility, of which attitude is highly motivated by perceived usefulness and ease of use while perceived usefulness is motivated mainly by compatibility and perceived system reliability. Third, acceptance barriers for all participants comprise of perceived unreliability and insecurity, while the older, female, less knowledgeable and less experienced groups introduced more barriers (incompatibility, lack of enjoyment, perceived difficulty of use, perceived high cost and perceived uselessness). The acceptance barriers are suggested as points of improvement in order to accelerate smart home adoption in the Finnish market.

Keywords Smart home, smart home acceptance, smart home adoption, perceptions of smart homes, perceived barriers of acceptance

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Tiivistelmä

Tämän pro gradu -tutkielman tavoitteena on selvittää suomalaisten kuluttajien näkemyksiä älykodeista, älykotien käyttöönoton selittäjiä sekä älykotien käyttöönoton esteitä koko vastaajaryhmälle ja sen aliryhmille.

Suomen huomattiin jääneen jälkeen älykotien käyttöönotossa muihin pohjoismaihin verrattuna, ja tämä herätti kysymyksen millaiset näkemykset saattavat estää suomalaisia ottamasta älykoteja käyttöönsä. Vastatakseen tutkielman tutkimuskysymyksiin suoritettiin faktorianalyysi, reliabiliteetti- ja validiteettianalyysi ja regressioanalyysi. Tutkimus tehtiin Park ja kollegoiden (2018) tutkimuksen replikaationa, jossa testattiin samat hypoteesit.

Tutkielmassa on kolme merkittävää löydöstä. Ensinnäkin, älykoteja koetaan helppokäyttöisinä, miellyttävinä ja hyödyllisinä, mutta kalliina, turvattomina sekä melko epäluotettavina ja yhteensopimattomina ihmisten elämäntapojen kanssa. Toisena, älykotien käyttöönottoon vaikuttaa merkittävästi asenne, koettu hyödyllisyys ja yhteensopivuus. Koettu hyödyllisyys ja koettu helppokäyttöisyys selittävät merkittävästi asenteen, kun taas yhteensopivuus ja koettu luotettavuus selittävät eniten koetun hyödyllisyyden. Kolmantena, älykotien käyttöönoton esteet kaikille vastaajille ovat koettu epäluotettavuus ja koettu turvattomuus, mutta vanhempi ikä, naissukupuoli, vähempi tietämys älykodeista ja kokemattomuus älykotien kanssa lisäävät esteiden määrää (yhteensopimattomuus, epämiellyttävyys, koettu vaikeakäyttöisyys, koettu korkea hinta and koettu hyödyttömyys). Käyttöönoton esteitä suositellaan kehitysalueiksi, jotta älykotien käyttöönottoa saataisi kiihdytettyä suomen markkinoilla.

Avainsanat Älykoti, älykotien käyttöönotto, näkemyksiä älykodeista, koettuja käyttöönoton esteitä

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1 Introduction

1.1 Background

In today's world, everything is already highly inter-connected, particularly due to the sensor networks available today. The massive market of Internet of Things, IoT, had a global value of $2.99T in 2014 and is estimated to climb to $8.9T in 2020 (Statista, 2018a). Up until now, the market for IoT has been widely used by the industrial sector (industrial IoT), including retail, automobile and mining (Pettey, 2015) for use cases such as predictive maintenance and asset tracking (Tracy, 2017). Today, however, the market of consumer IoT, which refers to the commercial IoT technologies targeted towards personal consumers, has acquired a significant role in the IoT market. In fact, in 2017 consumer IoT took up already 43 % of the global IoT market (van der Meulen, 2017).

Within the IoT sphere, there has been a shift from connected to smart, which is enabled by technological advancements (Williams et al., 2017). A connected device, as the name implies, simply means that it can be remotely controlled and monitored, whereas a smart device provides some level of automation and is able to make decisions based on its data gathered by its own and/or received from other components connected to the smart system or network. In the consumer IoT sector, this shift from connected to smart has brought an increasing interest in smart homes, to the extent that smart homes are expected to represent the leading use case within consumer IoT (Shirer and Torchia, 2017).

By 2022, the smart home market is expected to reach 1.3 billion in number of smart devices according to International Data Corporation (Shirer and Torchia, 2017). Statista (2018), on the other hand, predicts that there will be up to 286 million smart homes in the world in 2022, making the household penetration rate 19.5 % in the smart home market (countries listed in the Digital Market Outlook). This means that out of all households in the over 150 countries covered in the Digital Market Outlook, 19,5 % will be smart homes by 2022.

1.2 Research Problem

All in all, the growth of smart homes is estimated by several sources to increase significantly in the upcoming years. However, the Finnish house penetration in the smart home market is

stated to be only 15.4 %, whereas in the US it is 32 %, and even in other northern countries, such as Norway, Estonia, Denmark and Sweden, it is as high as 31.6, 26.8, 22.5 and 22.3 %, respectively (Statista, 2018b). The household penetration rate in Finland seems to be lagging behind other Nordic countries, which raise the question of what is holding the Finnish households back from integrating more smart qualities into their homes.

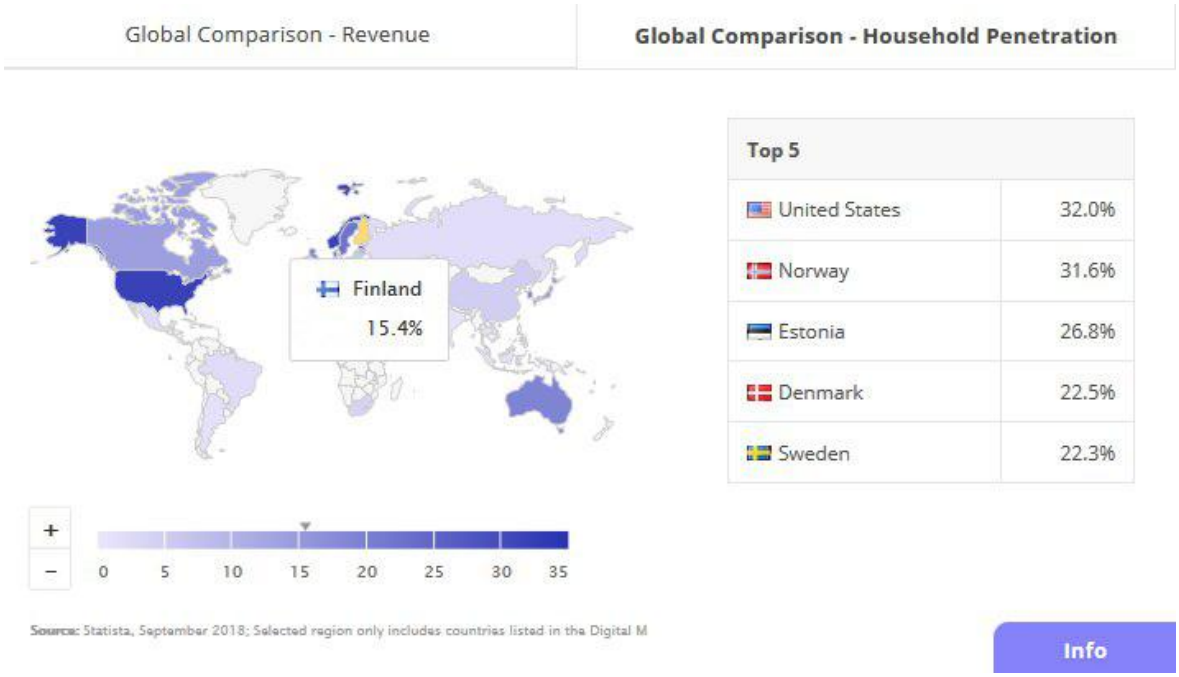

Figure 1 Household penetration of smart homes (Statista, 2018b)

1.3 Research Questions

As the Finnish market has been slower to adopt smart homes, it poses an interest of how the Finnish consumers perceive the acceptance barriers of smart homes and how it may differ from consumers in other countries. This paper will focus on the following research questions.

1. How are smart homes perceived in the Finnish market generally and among user groups with differing characteristics?
2. Which factors impact intention to use smart homes in the Finnish market and how large is the impact of each factor?
3. Which factors act as perceived barriers to consumer acceptance of smart homes in the Finnish market generally and among user groups with differing characteristics?

The goal is to find the perceived barriers to consumer acceptance of smart homes in the Finnish market and how the perceived barriers vary amongst different users (Question 3). This is achieved by detecting factors that are low in performance (Question 1) but impact usage intention greatly (Question 2)

There are several limitations related to the research of perceptional barriers, as perceptions are highly subjective and challenging to predict when selecting only a few factors. Numerous acceptance and adoption models have been created, which further poses challenges on which to build the research of smart home acceptance on. Lastly, it is essential to point out that the relationship between the factors and the users may be mediated by other factors not recognized in the research.

1.4 Objectives

When comparing the adoption rate of smart homes in Finland to other northern countries, there is a significant difference implying that the Finnish market is lagging behind. In the IEEE Communications Magazine, Hosek et al. (2017) speculate that the high price and complexity of the consumer IoT gadgets are causing the lack in adoption of smart homes. They also point out the manufacturing and retailing market of consumer IoT, in terms of the fragmentation of the market, the siloed business models and "a lack of interoperability between the existing IoT products." Although other papers have touched upon potential obstacles in a general manner, the focus of my thesis is on the consumer perspective in the Finnish market. I will focus on what is hindering the acceptance of smart homes on a perceptional level amongst Finnish consumers.

From a theoretical perspective, studying the topic of consumer acceptance to smart homes would deepen the knowledge on user attitudes, acceptance and adoption towards pervasive applications of technology in Finland. Here I refer to the pervasiveness in regard to the comprehensive involvement of technology in the users' personal lives. As the pervasive nature of some technology applications, such as smart homes, is relatively novel to today's people, this may have meaningful behavioral or societal influences that should be studied further. This thesis aims at continuing the dialogue of how pervasive technologies are perceived and accepted.

From a practical perspective, researching the barriers to consumer acceptance of smart homes in Finland would assist in growing the Finnish market of smart homes. For Finnish

consumers it means that their needs would be better understood and catered to, as the factors impacting the perceptional barriers are understood and tackled. Thus, they would be able to reap the benefits of smart homes, which is particularly essential when considering the aging population and the proportion of elderly population being high and increasing in Finland. On a company level, the research will support in understanding the Finnish smart home market and the barriers hindering the adoption of smart homes in Finland. This way service providers could understand customer needs better, improve their smart home services and provide more suitable smart home services for their customers. On a national level, the business motivation lies in Finland and Finnish corporate taxpayers being able to benefit from the forecasted growth of the global smart home market and to compete with global smart home players. Lastly, from the larger perspective of the environment and global economy, new ways to mitigate the critical state of the changing climate and dwindling resources are also called for. Smart home applications offers a means to solve those issues by sparing scarce resources and reducing your one's own carbon footprint.

In Finland the research of smart homes is still minor (Åkerblom, 2017). I will focus on the Finnish market, but I expect the research to support further research on the global smart home acceptance.

2 Literature Review and Theory

In the literature review, I will discuss the smart home concept as well as the distinction between connected home technologies, home automation technologies and smart home technologies. After defining the smart home concept, I will present the different categories of smart home applications, in order to understand the benefits and use cases. Furthermore, the concept of perceptions as drivers of technology acceptance is discussed.

2.1 Smart Home Concept

In order to explore the consumer acceptance of smart homes, it is essential to define a smart home and identify other terms closely related to smart home, such as a connected device, connected home and home automation. There exists numerous of definitions about smart homes, of which most share common traits including context-awareness, remote control and automation. To draw the definitions together, a smart home is a network of sensor-embedded

smart devices enabling interconnection and interoperability. The smart devices are applying machine learning and artificial intelligence techniques to provide user context-aware remote home control and monitoring as well as automation. In order to manage and optimize the home environment, the smart home conveys information to the users and executes user or automated commands. By allowing the smart home to learn the users' behavioral patterns and automate functions accordingly, it is able to minimize active user involvement and provide comfort without disturbing the user's daily activities. (Gartner, n.d.)(Rashidi and Cook, 2009)(Chan et al., 2008)(Wilson et al., 2015).

There are two dimensions essential to a smart home: level of network and smartness. The level of network refers to the number of items connected to the network. When there is only one item connected to the network, it is simply a device rather than a network. The smartness dimension, however, refers to the extent of intelligence behavior in the system. Connected means that the device or network can be remotely controlled and monitored, but by adding automated decision-making capabilities, the device or network turns smart. (Anesi, 2015a)(Alison Martin, 2017)

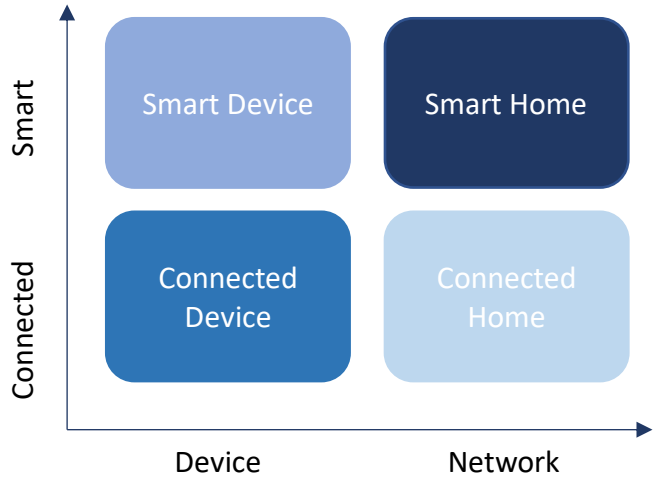

Figure 2 Visualizing the levels of smartness and networked devices

Both connected and smart devices can be connected to other similar devices, thus, creating a network, either a connected or smart network. When these networks are utilized in home environments, they become home networks, making the home either a connected or smart home. A smart home is not a set of smart devices but a connected network of smart devices in a home environment.

Giving an example of a thermostat, a connected thermostat is one that can communicate with other devices through the internet but it cannot make decisions. It only responds to user input. A smart thermostat, however, has the ability to make decisions based on data it receives (e.g. inside and outside temperature from other sensor devices) and makes adjustments in the system operation without user input to maintain the comfort of the users. (Anesi, 2015b) As the smart thermostat and other smart devices in the same connected network are utilizing each other to ensure maximum value for the home users, they begin forming a smart home.

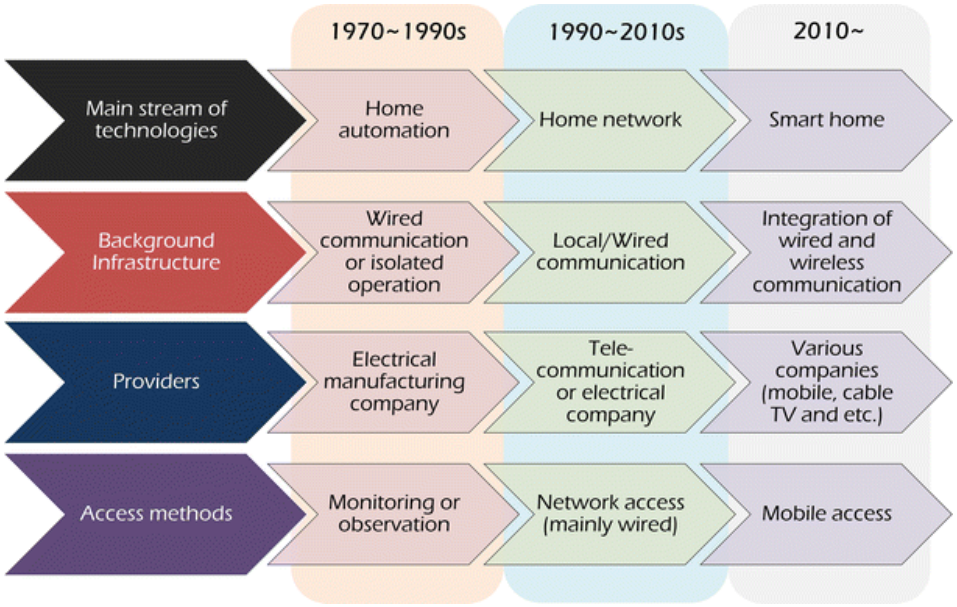

Figure 3 Transitions of smart home services (Park et al., 2018)

Smart home is often used interchangeably with other terms, such as connected home, home automation and intelligent home, however, they are not all synonyms. According to Wilson et al. (2015), synonyms to smart home are intelligent home, adaptive home, aware house and home automation. Home automation is not seen as a synonym to smart home by everyone though (Park et al., 2018). Instead home automation can be seen as the first transition in the development of the smart home concept. The infrastructure in home automation is a wired communication or isolated operation allowing on-spot monitoring and observation, whereas in a smart home it is an integration of wired and wireless communication enabling mobile access. Using this classification home automation could be described as a connected network without remote access. In order to avert confusion, in this thesis I will use the terms smart home, smart home devices and smart home services.

2.2 Smart Home Applications

As Rashidi and Cook (2009) state, smart homes aim to "aid people with cognitive and physical limitations, to provide resource conservation, and to make our lives more comfortable and productive". However, the individual device in the smart home has a goal of its own, which in turn supports the overall aim of the whole smart home system. In order to understand the applications of a smart home, it helps to view the various categorizations of smart home devices varying in viewpoint. The most common ones are based on industries, making categories such as health, safety, comfort and entertainment. Some categorizations are even more specific and contain thus more subcategories, such as energy management, wellness, communication and assisted living. (Balta-Ozkan et al., 2013)(Alam et al., 2012). When there are more categories, it resembles categorization based on service or group of products, rather than industry. Categorization can also be done based on the users' perceived values of the device (service), to which Park et al. (2018) suggests economic, hedonic, security and comfortable values. Economic values are straightforwardly cost-related and hedonic values are related to entertainment and joyfulness, whereas security refers to both security itself and healthcare, and comfortable values refers to convergence and automation. However, oftentimes these values coexist in smart devices.

Classification: level 1 (industry)	Classification: level 2 (service)	Classification: level 3 (group of products)	Products	Users' perceived values
Smart greenhouse	Energy solution	Solutions for energy conservation of home appliances	Small-sized energy storage systems (ESS), smart plug devices, blocking devices for standby electricity, smart meter devices	Economic value
	Energy conservation services	Energy conservation and management for house	House management services based on smart home systems	
Smart TV and home entertainment	Device solution	Smart TV Hardware of games	TV applications, smart controller applications, game platforms devices	Hedonic value
	Entertainment Services	Media services, TV game services, Two-way interaction services	IPTV, digital cable TV, Console game, game applications via smart TV, Two-way shopping service, 3D interaction	
Smart health care	Device solution	Healthcare applications	Smart bio-signal sensors, activity-tracking applications, smart fitness devices in house	Security value
	Healthcare Services	Health management services	Emergency correspondence, exercise monitoring, disease prevention	
Smart security	Device solution	Security storage devices		

			IP media devices, monitoring robots, CCTV systems, digital door-locking systems, devices for recognizing biosignal	Security value
	Security services	Home security services	Security control services with security business enterprises	
Smart convergence home appliances	Device solution	White goods, kitchen, lighting, cooling and heating equipment	Smart refrigerators, smart vacuum cleaners, Smart water purifiers, smart dishwashers, Functional lamps (LED, environmental friendly lighting lamps), System air-conditioners, smart heaters, house ventilation systems	Comfortable value
Home Automation	Device solution	Shared equipment for apartments and multifamily houses, In-house devices	Smart house management systems, parking control systems, remote and automatic meter reading systems, devices for shared healthcare facilities, Home gateway, in-house communication devices, in-house automatic sensing devices	Comfortable value
	Automation services	Management services for apartments and multifamily houses	Community information services, management systems for smart home services	

Figure 4 Classifications of smart home devices (Park et al., 2018)

Most use cases of smart homes and its devices are related to health and assistive services, specifically for the elderly and disabled. Smart features for health and assistive purposes include biometrics monitoring systems monitoring vital signs (e.g. pulse and respiration), lifestyle monitoring systems monitoring abnormal activity or appliance use as well as a systems to help users find objects easier. (Balta-Ozkan et al., 2013) Smart devices such as these are what make up smart home projects for the elderly and disabled, for example in the Gator Tech Smart House by University of Florida (Chan et al., 2009)(Chan et al., 2008). With assistance and assurance of smart homes the elderly and disabled are able to perform daily activities and live comfortably and securely in their own homes, instead of being institutionalized.

In the area of security, smart homes also have great potential with devices such as intruder motion detectors, digital door- and window-locking systems and devices for recognizing bio-signal (Balta-Ozkan et al., 2013)(Park et al., 2018). Smart security devices would enhanced security of the home, for example, with the help of motion detections combined with bio-identification the smart home is able to detect the activity of the home. In case suspicious activities or break-ins are detected, it can alert not only the residents but also the

security institutions. Security in smart homes do not only cover security against intruders but also against accidents such as water leakages, fires and extensive humidity, according to the Finnish smart home provider Cozify (n.d.).

Smart home features are also used for comfort purposes, some of which could also be characterized as assistive services. To mention a few comfort applications, smart home sensors enable monitoring and automatically adjust lighting and heating, open doors and turn on the vacuum (Park et al., 2018). Cozify (n.d.) could adjust the lights and music to your preference to ensure a pleasant wakening. A smart calendar ("Gate reminder") could analyze your calendar items and remind you of what you need before leaving the home, whereas the smart wardrobe would tell how to dress according to the weather outside (Park et al., 2003). In most cases, comfort is about skipping additional steps and saving time, while other times it is about simply making your daily activities more enjoyable.

For some smart home devices the main goal is entertainment. Such smart entertainment comprise of smart TVs, audio and lighting systems, voice activating control systems as well as video (motion) tracking systems, to mention a few. They are enhancing the viewing and listening experience by allowing connectivity with other smart home devices, automatically setting up the preferred atmosphere for the activity and enabling more interactivity between the digital and the physical worlds, e.g. motion tracking to allow your physical self to interact with game devices. (For The Smart Home, n.d.)(Balta-Ozkan et al., 2013)

2.3 Perceptions As Obstacles to Acceptance of Technology

In order to estimate the success of new services, it is most effective to explore the adoption patters of the services in question (Park et al., 2018). The exploration of adoption patterns essentially refers to the sense-making process of factors leading to adoption. Several models, including Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT) have attempted to explain such adoption patterns (Park et al., 2018)(Kim et al., 2007)(Davis, 1989). Such models have verified that the perceptions of the customers are at the core of how attitudes and acceptance are formed (Karjaluoto et al., 2019)(Shaw and Sergueeva, 2019). Whereas the service description and functionalities of a smart home represent the target objectives of the smart home created by the service provider, perceptions are how customers essentially feel and think about the service. It is necessary to gain an understanding of the customers in order to accelerate the acceptance of the service

(Park et al., 2018). By understanding the customers and their perceptions of the services, it enables discovery of ways to improve the services, to better meet the needs of the customers and increase acceptance of the services.

Various adaptions of the established Technology Acceptance Model (TAM) by Davis (1989) have appeared, each attempting to provide an accurate view of the factors effecting attitude (perception) and intention to use of the technology in question. The factors effecting the overall perceived value and thus the acceptance of technologies naturally vary, as different factors are valued depending on the type of technology and the user group. Nevertheless, TAM conclude that intention to adopt are heavily explained by perceptions.

The factors of the perceived value are often split into two categories, perceived benefits and perceived risks, each holding a set of more defined factors. Fanzianpour et al. (2014) define risk as the expectation of loss of an exchange, where the probability of loss occurring is unknown. As each exchange involves consequences, of which some are likely to be unpleasant, risks play a part in consumer decision making. However, consumers' perceptions of risk are constantly being influenced and may not represent the actual risk. Perceived risk is defined as the amount of risk perceived by the subjective consumer in a purchase decision making process (Khan and Chavan, 2015).

Benefits are defined as extrinsic and intrinsic factors offering functionality, utility, enjoyment and social acceptance (Yang et al., 2016). Even before witnessing any benefits themselves, customers are forming perceptions of the benefits of the exchange in question. The perceived benefits vary from consumer to consumer. Some features may even be seen as benefits to some and disadvantages to others.

Instead of researching the perceived benefits and risks separately, the aim of the paper is to discover the perceptional barriers to consumer acceptance, which I define as perceived lack of benefits and perceived risks.

Potential benefits of smart homes are already recognized, but nevertheless the adoption rate remains low (Chan et al., 2008)(Balta-Ozkan et al., 2013). While the adoption rate remains low, smart home services are still being considered one of the most promising markets. This gap between the potential and diffusion of smart home services creates a need to further examine users' perspective on the barriers hindering acceptance and adoption.

3 Theoretical Grounding and Research Model

3.1 Theory on Smart Home Acceptance

The original TAM is the most frequently used theoretical framework for researching technology adoption and it has been applied to a variety of contexts from mobile commerce to smart shared products (Lu et al., 2019). The model consists of perceived usefulness and perceived ease of use, both of which explain adoption intention through attitude development while perceived ease of use also explains perceived usefulness (Davis, 1989). While the model only names the two factors for attitude development, the aim of the model is to provide a basis for discovering underlying external variables, such as self-efficacy and cost-benefit mentioned by Davis, to explain perceptions, attitudes and intentions (Al-Momani et al., 2001). Besides TAM being widely utilized, it has also received quite much criticism, particularly for ignoring some necessary and relevant external factors (Taherdoost, 2018) (Ajibade, 2018).

Further research has revised the model in regard to technology advancements and the shift to internet-connected, IoT and smart technologies, which this has led to new factors being included in the model. Most of the TAM revisions added some of the following factors to their model: financial, privacy, security, reliability (trust), performance, enjoyment and social risk. (Park et al., 2018)(Farzianpour et al., 2014)(Yang et al., 2016)(Pantano and Di Pietro, 2012)(Al-Momani et al., 2001)(Yang et al., 2014)(Marikyan et al., 2019) However, variations of self-efficacy, perceived time-loss, perceived control, psychological risk and compatibility were also mentioned several times as factors influencing the adoption intention of such technologies (Pantano and Di Pietro, 2012)(Farzianpour et al., 2014)(Park et al., 2018)(Featherman and Pavlou, 2003)(Hargreaves et al., 2017)(Yang et al., 2014). While the new factors are covered to some extent by external variables of the two factors in the original TAM, the revised versions of TAM have put more emphasis on factors particularly relevant for the researched technology by splitting the original factors into more detailed ones. Due to the more specified factors, it is possible to define more precise factors influencing acceptance of the technology in question.

Despite the large variety of TAM revisions, for this research it seems the most appropriate to utilize a model built for smart home services specifically. Park et al. (2018) created an extensive research in South Korea on determinants for smart home adoption, which built on

TAM and added seven new determinants to the established TAM. Despite TAM being heavily used and criticized, it will nevertheless be used for the sake of carrying out a replication study. The acceptance model by Park et al. (2018) concluded the most relevant determinants to be security, cost, perceived control, enjoyment, system reliability, connectedness and compatibility. The seven additional determinants were categorized into hedonic, comfortable, security and economic values. The aim of the next section is to map these factors in addition to explaining the TAM elements, perceived usefulness, perceived ease of use, attitude, intention to use in further detail.

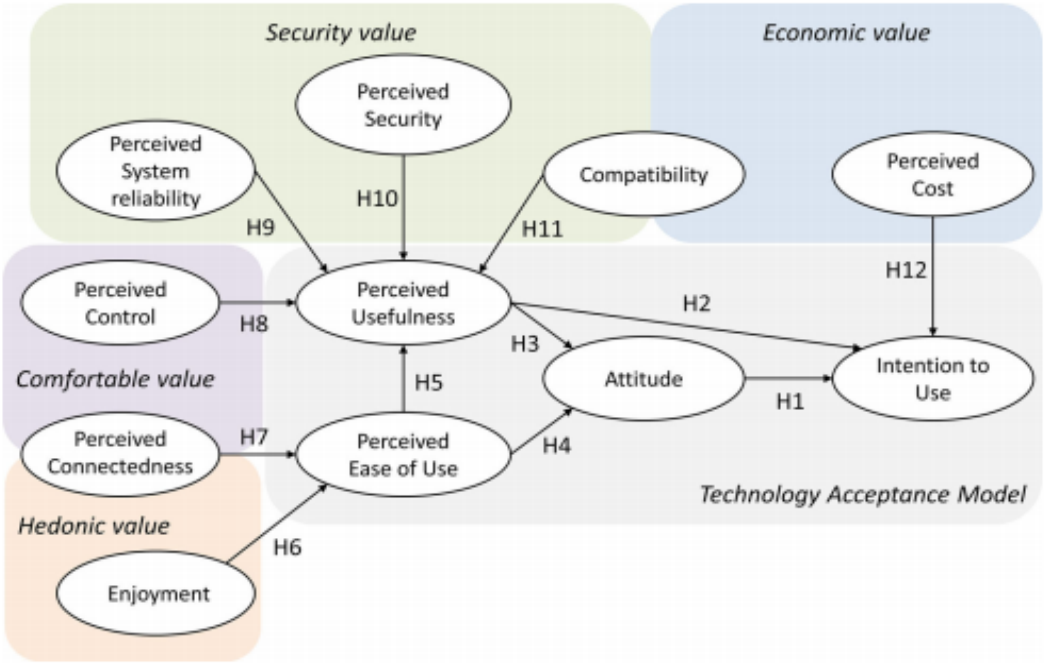

Figure 5 Determinants of The Adoption of Smart Home Services (Park et al., 2018)

3.1.1 Technology Acceptance Model

The frameworks using the original TAM construct include perceived usefulness and perceived ease of use as factors to explain attitude development and intention to use. According to the original TAM (Davis, 1989), people tend to use technology that helps them perform their tasks better. However, tendency to use is out-weighted by the difficulty and effort to use the technology. Thus, the usage of technology depends on perceived usefulness and perceived ease of use.

In TAM perceived usefulness is defined as the extent to which a person expects the use of a particular system would enhance his or her job performance (Davis, 1989). The benefits

gained from the system strengthen the perceived usefulness for the users. Perceived usefulness is linked to both attitude and intention to use. For smart home services perceived usefulness refers to the user's perception of the usefulness of smart system services in a home context. According to Al-Momani et al. (2001), perceived usefulness is one of the most important factors for adoption of IoT services in the US, which suggests importance of the factor also for smart home services.

Perceived ease of use refers to the extent to which a person perceives a system to free of difficulty and effort (Davis, 1989). Perceived ease of use is not only significant for adoption but it also impacts perceived usefulness. In China the adoption of IoT services was significantly affected by the perceived ease of use (Al-Momani et al., 2001). Smart home services still face usability issues (Marikyan et al., 2019), so thus, perceived ease of use is expected to be relevant also for smart home services.

Perceived usefulness and perceived ease of use affect the attitude, which represents the user's assessment or perception of the technology. Attitude as well as perceived usefulness in turn affect intention to use. Intention of use refers to the behavioral intent or willingness to use a particular technology, which is the ultimate element measured in this paper. (Davis, 1989)

3.1.2 Security Determinants

Perceived system reliability is defined as "users' perceived level that smart home systems can present reliable services that make the users meet their expectations toward the systems", according to Park et al. (2018). Reliability together with ease of use make up the usability barrier, which has a crucial role in acceptance of smart home services (Marikyan et al., 2019). Due to the technical complexity of smart home technology, the usability barrier has an even more significant impact compared to the acceptance of other technologies. According to Marikyan et al. (2019), people still hold a skeptical view of the reliability of smart home technology, which only emphasizes the need for tackling the reliability issues for smart home services.

Perceived Security is defined as "users' perspectives toward the protection level against the potential threats when using smart home services" (Park et al., 2018). The perceptions of the security degree is directly linked to the perceived usability of the technology (Cheng et al., 2006). Security is an increasingly important factor for information diffusing services and

online networks such as smart homes, as they collect and store large amounts of personal information. With the increasing awareness of data misuse, a hacking risk as well as personal data being the new currency for free of charge services, security is likely to become an even more significant factor for adoption of smart homes.

Compatibility is defined as "the extent to which a unique innovation is consistent with the current and traditional values and needs" (Park et al., 2018). Compatibility along with reliability and connectedness are associated with the perceived usefulness, and thus impact usage intention (Yang et al., 2016) (Park et al., 2018). As personalization has become the norm and technologies are expected to adjust to users' existing and changing lifestyles, it sets a requirement of compatibility and flexibility to smart home services (Hargreaves et al., 2017). Thus, compatibility seems like a factor worthy to take into account in smart home adoption research.

3.1.3 Comfortable Determinants

Perceived control is defined as "users' perceptions on their capability, resources, and skills for naturally performing the behavior and usage of a particular service or system" according to Park et al. (2018). This perceived lack of control is suggested to lead to a low perceived usability of a system, and thus contribute to a resistance of technology acceptance (Marikyan et al., 2019)(Al-Momani et al., 2001). In fact, ceding autonomy and independence in the home are the main perceived risks amongst UK homeowners (Wilson et al., 2017). This barrier is suggested to be tackled with features of adjustability and flexibility (Wilson et al., 2017). When it comes to users self-efficacy, perceived control is suggested to be tackled with either developing technological expertise amongst users or reducing complexity of the system (Balta-Ozkan et al., 2013). Balta-Ozkan et al. (2013) conclude that if smart homes are not able to increase users' sense of control, adoption is unlikely to happen. Due to the factor seeming critical for adoption of smart homes, it should be included in adoption research of smart homes.

3.1.4 Hedonic Determinants

Enjoyment is defined as "the extent of which the use of smart home services is perceived to be playful and enjoyable" (Park et al., 2018). Perceived enjoyment is strongly connected to perceived ease of use and usability (Park et al., 2018), and thus impacts intention to use of technologies (Al-Momani et al., 2001)(Yang et al., 2016)(Pantano and Di Pietro, 2012).

As an essential element to intrinsic motivation, enjoyment is suggested to be significant also for adoption of IoT technologies.

Perceived connectedness is defined as a sense of feeling connected to the system and ease of interacting with the components at the users' convenience (Park et al., 2018). This is suggested to be a factor tightly linked to smart homes as virtual environments. Connectedness is already an inherent characteristic of smart homes, but to effortlessly integrate the virtual environment of smart home services with the users of the physical environment, connectedness is suggested to be strengthened (Park et al., 2017). Connectedness is strongly associated with perceived usefulness of smart products (Marikyan et al., 2019)(Park et al., 2017), and thus should be considered in smart home adoption research.

3.1.5 Economic Determinants

Perceived cost is defined as "the concerns on the estimated costs in purchasing, operating, using, and repairing the components employed in smart home services" (Park et al., 2018). For information services and systems, perceived cost is suggested to be negatively associated with the adoption, and it is suggested to be one of the greatest barriers to acceptance of advanced information technologies in the construction field (Park et al., 2018). Although smart home services entail opportunities for economic advantages (Park et al., 2017), there is a higher pressure towards innovations to have significant economic benefit compared to existing established products and services according to (Mani and Chouk, 2017). Thus, perceived cost still seems to be a relevant factor in adoption of smart home services.

3.1.6 Findings of Acceptance Model by Park et al.

The acceptance model by Park et al. (2018) was tested with a survey conducted in South Korea, and the results suggested a positive correlation between perceived compatibility, connectedness, control, system reliability and enjoyment of smart home services and the intention to use smart home services. On the other hand, perceived cost had a negative correlation with usage intention but only a relatively small correlation. Out of the positively correlating factors, perceived compatibility was found to be the greatest motivation for intention and attitude, which point to "the significance of providing compatible services between the traditional user devices and components in the service for users" (Park et al., 2018, p. 184). Perceived usefulness was still the most significant predictor of use intention according to the results, but it was strongly motivated by the perceived compatibility.

Perceived control also contributed significantly to the perceived usefulness. Thus, the main finding was that smart home services need to be easily controllable and compatible to improve users' experiences of the services. The other finding showed that while impacts of perceived connectedness and perceived reliability were small compared to the impact of other factors, they were still notable motivations for TAM. The acceptance model by Park et al. (2018) provided evidence for the validity of the original TAM, while proposing the seven new factors as the main motivations for smart home acceptance.

3.2 Research Model

The aim is to integrate the acceptance model by Park et al. (2018), consisting of the variables from the original TAM and the seven additional determinants, with background and socio-demographic characteristics into a conceptual framework. The conceptual framework will be constructed in order to visually explain the individual consumer acceptance of smart homes.

The research of this paper aims to identify how the Finnish market and its different user groups perceive smart home services and the barriers to their adoption. Due to this approach, it is essential to characterize not only the adoption related factors taken into account in the research but also the factors by which the different user groups are differentiated.

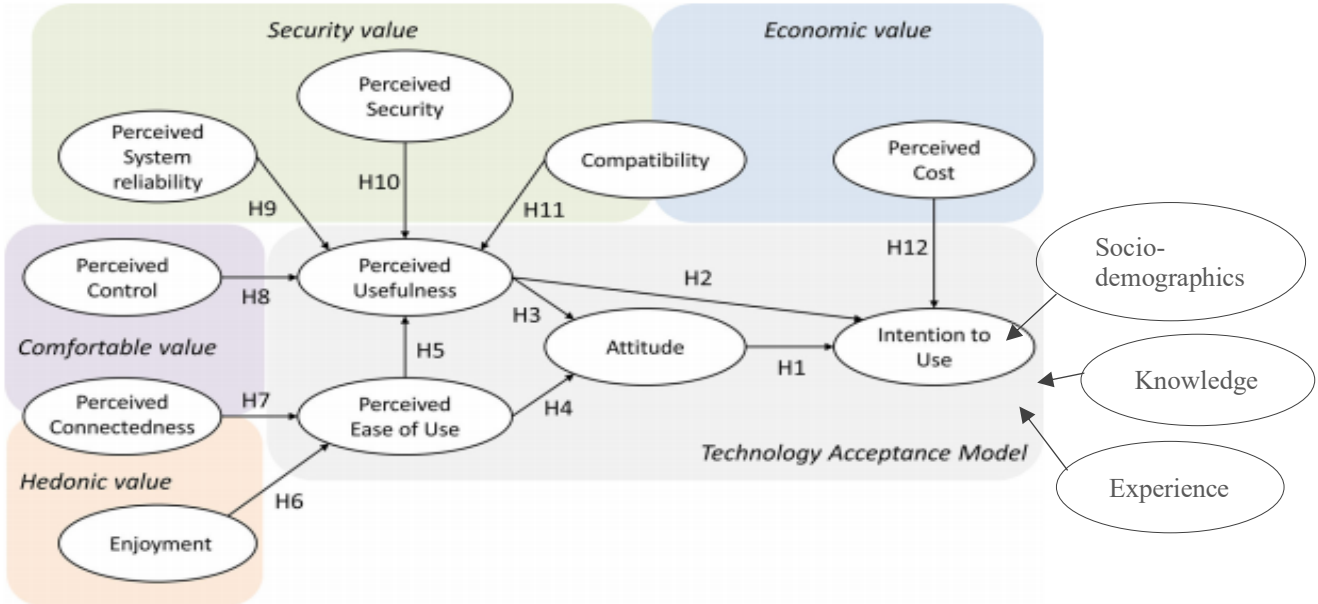

Figure 6 Conceptual framework for conducted research

The user groups are defined by socio-demographical factors, user's level of knowledge about smart homes and prior experience with smart homes. In this research socio-demographical factors include age, gender, educational level, living area, household size and monthly income. In the reference questionnaire four factors out of these were used, which were age, gender, living area and education level. The remaining factors were found in other smart home adoption surveys, such as a UK national survey by Wilson et al. (2017). Whereas in the reference questionnaire the respondents were expected to have used smart home services, this questionnaire targeted respondents with varying levels of knowledge and experience. In order to differentiate users according to level of knowledge and experience, one question for each characteristic was added to this questionnaire. The section for measuring level of knowledge was drawn from another smart home adoption survey by Wilson et al. (2017). According to another established and heavily utilized adoption theory, the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2), experience plays an important role in technology adoption (Haglund and Flydén, n.d.). In addition, experience was measured in other adoption surveys regarding smart and connected technology, such as the reference questionnaire and an IoT adoption survey by Al-Momani et al. (2001).

3.3 Hypothesis

In order to create a replication study, the reference questionnaire framework by Park et al. (2018) will be recreated. Thus, the hypotheses proposed by the reference study are suggested for this study as well. As there are no difference in the research context, the hypotheses are expected to fit Finnish consumers, too.

H1: Attitude toward smart home services has a positive effect on the intention to use the services

H2: Perceived usefulness of smart home services has a positive effect on the intention to use the services.

H3: Perceived usefulness of smart home services has a positive effect on the attitude toward the services.

H4: Perceived ease of use of smart home services has a positive effect on the attitude toward the services.

H5: Perceived ease of use of smart home services has a positive effect on the perceived usefulness of the services.

H6: The perceived enjoyment of smart home services has a positive effect on the perceived ease of use of the services.

H7: Perceived connectedness of smart home services has a positive effect on the perceived ease of use of the services.

H8: The perceived control of smart home services has a positive effect on the perceived usefulness of the services.

H9: The perceived system reliability of smart home services has a positive effect on the perceived usefulness of the services.

H10: Perceived security of smart home services has a positive effect on the perceived usefulness of services.

H11: The perceived compatibility of smart home services has a positive effect on the perceived usefulness of the services.

H12: The perceived cost of smart home services has a positive effect on the intention to use the services.

4 Empirical Research Methodology

4.1 Research Methods and Data Collection

The research consist of hypotheses drawn from the replication study and a questionnaire to test the hypotheses. From the review of previous research on smart home adoption, an established conceptual framework by Park et al. (2018) was chosen to base an replication study on. The purpose of a replication study is to validate study findings and discover whether the findings of a study can be applied to other participants by replicating the study in question on another set of participants (Allen and Preiss, 1993). The chosen framework presented the most essential factors of smart home adoption and the hypotheses to be tested on the Finnish market. While the replication study focuses on hypotheses testing, it also aims

at discovering differences in the perceptions of the participant groups in the replicated and replicating surveys as well as amongst different participant groups in this survey. The perceptions of the participant groups will be analyzed by comparing questionnaire results.

To test the hypotheses, a web-based questionnaire appeared as the most suitable empirical research instrument. A questionnaire is also deemed most suitable for researching subjective perceptions, as it allows to easily gain more perceptions. Thus, this would offer more generalizable results and better representation of the Finnish market. The research variables measured in the questionnaire to test the hypotheses constitute of independent, mediating and dependent variables. The research variables of the questionnaire are presented in Table 1 below.

Table 1 An overview of the research variables measured in the questionnaire

Independent variable	**Dependent variables**	**Mediating variables**
Perceived cost Perceived compatibility Perceived security Perceived system reliability Perceived control Perceived connectedness Perceived enjoyment	Intention to use	Perceived usefulness Perceived ease of use Attitude

The questionnaire was created with a web-based survey platform, Webropol, provided by Aalto University. A link to the questionnaire then was distributed to suitable channels. To gather primary data for the questionnaire, it was spread through various channels for reach and diversity in participator base. This way the results could appropriately represent the Finnish market. Organizations were contacted to assist in reaching participants for the survey and they were expected to contribute significantly to the data collection. The organizations that eventually reached out to their members and sent the survey link were Vuokranantajat ry, Vuokralaiset ry, Kiinteistöliitto ry and Helsingin Kaupungin Asunnot Oy (HEKA). Vuokranantajat ry sent the survey link through their email list, whereas Vuokralaiset ry, Kiinteistöliitto ry and HEKA Oy posted the link on their Facebook page. In addition to organizations, the survey was distributed to the Facebook groups Puskaradio Turku, Tampere, Vaasa, Uusikaupunki, Vantaa and Espoo as well as a Facebook group for Finnish

smart home enthusiasts, Älykoti. I also utilized my own network by posting the survey link on my personal social media (Facebook, WhatsApp and Telegram). The survey was kept open for approximately four weeks from 18th of June until 14th of July.

As a follow of the data collection channels, participants were expected to represent the Finnish market somewhat adequately, but with an anticipated emphasis on the metropolitan areas and on the younger generations. The reach of the survey was expected to be around 70-100 participants, however, the final count of participants reached up to 237.

4.2 Survey Design

The aim of the questionnaire is to test the hypotheses drawn from the acceptance model by Park et al. (2018). The questions designed to test the hypotheses followed the study as well. The questionnaire consists of four sections, which mostly follow the structure of the survey. Yet small modifications needed to be applied to suit the distinct target audience of both non-users and users as well as the focus on smart convergence home appliances instead of all smart home services. The questionnaire and its questions as well as the question modifications can be found in the appendix (Table A1 and A2).

The first section comprised of a short, general description of a smart home and smart home devices. The questionnaire's focus on smart convergence home appliances was introduced, following a set of examples explaining the functionality of smart convergence home appliances. Smart convergence home was defined as everyday and basic home appliances and home structures, such as the water, light and heat supplying devices, refrigerators, stoves, washing machines, floors, walls, doors and windows, but that offer remote control, automation and some level of self-control. The examples of such smart convergence devices were given to explain the required level of automation and self-control. The choice to focus on a subset of smart home devices was made in order to ensure a unified position when investigating perceptions about smart home services. Smart convergence home appliances was perceived as the most neutral and commonplace appliances, yet the most widespread and basic necessity in the western world. The aim was to avoid appliances with an emotional charge.

The second section focused on background information in order to categorize the respondents. The respondents were inquired about socio-demographic factors and

familiarity with smart homes. The socio-demographic factors, including age, gender, education, household size and income, will indicate whether some factors have an impact on perceptions and acceptance of smart homes. The questions on familiarity regards familiarity on both concept and experience level. This allows categorization based on level of knowledge about smart homes but also on the level of experience on using smart home devices. When considering knowledge and experience in the research, it enables exploration of whether familiarity influence perceptions and acceptance of smart homes. Familiarity is expected to influence perceptions and acceptance of smart homes positively, alike in the case of other technology, but these hypotheses need to be confirmed.

The third section examines the perceptions of using a smart home through a set of questions drawn from the study of Park et al. (2018) The questions are exploring the perceptions of smart homes in regards to security, comfort, hedonic and cost values. Respondents are asked to indicate their level of agreement to the statements through a standard five point Likert scale with strongly disagree as 1, strongly agree as 5 and do not know as 3. The sequence of all questions were randomized, except for questions regarding usage intention which were left as last. The randomization of the questions was to minimize the effect that the sequence of the questions may have on the responses.

The last section offers the respondent an option to participate in a gift card lottery. The lottery was added to the questionnaire to encourage people to respond to the questionnaire. The gift card lottery was also mentioned in the introduction of the questionnaire.

4.3 Research Limitations

The limitations of the research mostly relate to the representativeness of the Finnish market. Despite the response count being a reasonable size, the participant base were mostly residents of the larger cities, which creates an underrepresentation of the smaller cities, villages and the country side. However, the city areas are expected to be of greater interest to smart home suppliers and retailers, which assumedly makes this risk less critical. Furthermore, due to the questionnaire being shared in a group for smart home enthusiasts, there may be an overrepresentation of smart home users compared to the real level of them in the Finnish market. This risk is mitigated to some extent by grouping according to experience and analyzing the results of both experienced and non-experienced participants.

Overall, it is essential to take into account the risk of a distorted representation, since a correct representativeness of the Finnish market cannot be guaranteed.

The study focuses on smart convergence home appliances, but the results will be generalized to all smart home services. By generalizing the results of a targeted focus, there is a risk of a distorted representation of smart homes. Since smart convergence home appliances were interpreted as the most neutral type of smart home service, it is however expected to provide an average view of smart homes.

4.4 Data Screening

Data screening, which refers to the detection and deletion of missing items, unengaged responses and outliers, was conducted prior to the analysis phase. This step is important in order to detect erroneous data, skewedness and kurtosis as well as to validate the suitability of the collected data for further analysis. The data screening was conducted on Microsoft Excel. As all items of the survey were marked as mandatory, no missing values existed. In the one mandatory open answer item (Q3), two responses were either undefined or clearly humorous, and thus, they were not taken into account in further analysis. Two respondents were also deemed as unengaged, as the standard deviation of each participant's responses related to the studied factors (Q9.1-Q9.35) equaled 0. After data screening 4 responses were excluded from further analysis, thus, the total responses went from 237 to 233.

4.5 Data Analysis

The data analysis constitute of a factor analysis and regression analysis. Principal component analysis as well as a reliability and validity analysis were used to perform a factor analysis and to ensure rationality of model variables. First, regression analysis was performed for the whole participant base, to test the research model and the hypotheses, define the perception of smart homes in the Finnish market and uncover which factors impact usage intention. Lastly, regression was performed on subgroups of the participant base, to detect differences in the perceptions of smart homes between groups with different socio-demographic characteristics.

5 Research Results

5.1 Sample Characteristics

The total number of responses collected was 237, and after the data screening process 233 were left. The 233 responses were used for the data analysis, of which the sample characteristics are explained below and in table 2.

Participants from all predefined age groups were acquired, yet the most representation were found in the age groups 20-29, 30-39, 40-49 and 50-59, accounting for 32.6%, 20.6%, 22.7% and 14.6% of the total respondents respectively. Despite the youngest and oldest age groups (<20 and >59) receiving quite low levels of participants (2.6% and 6.9% respectively), the questionnaire was still able to reach participants in a large age range. As for the gender distribution, 63.1% of the participants were female and 36.5% were male.

The majority of the participant live in the capital region of Finland, constituting of Helsinki, Espoo and Vantaa with 30.5%, 18.0% and 12.4%, respectively. However, participants of other larger cities, such as Tampere and Vaasa, also composed a significant portion of the total participants, 8.2% and 6.0%, respectively. The remaining 24.9% in the category "Others" result from 32 other cities, of which most of them had only 1-2 participants each.

Regarding the education level, the majority of the participants has a lower (32.6%) or higher (29.6%) university degree, while a large portion of the participants (28.8%) was either a high school or vocational school graduates. Only 4.7% were elementary school graduates, and 4.3% had another type of education.

As for the household size of the participants, most live either in a single household (36.9%) or a household of two people (34.8%). The distribution of three remaining groups, 3-, 4- and at least 5-person-households, were fairly even with 9.0%, 11.2% and 8.2% respectively.

Table 2 Summary of Sample Characteristics

Characteristic	Item	Proportion
Age	< 20	2.6%
	20-29	32.6%
	30-39	20.6%
	40-49	22.7%
	50-59	14.6%
	> 59	6.9%
Gender	Male	36.5%
	Female	63.1%
	Other	0.4%
Residence	Helsinki	30.5%
	Espoo	18.0%
	Vantaa	12.4%
	Tampere	8.2%
	Vaasa	6.0%
	Other	24.9%
Education	Elementary school	4.7%
	High school or vocational school	28.8%
	Lower university degree	32.6%
	Higher university degree	29.6%
	Other	4.3%
Household size	1	36.9%
	2	34.8%
	3	9.0%
	4	11.2%
	5+	8.2%
Income (€/month)	0-1500	19.3%
	1500-2500	21.0%
	2500-3500	23.6%
	3500-4500	13.7%
	4500-5500	9.4%
	>5500	12.9%
Prior knowledge about smart homes	I don't know	3.0%
	Weak understanding	11.2%
	General understanding	44.2%
	Good understanding	24.0%
	I already have smart home devices	17.6%
Experience with smart homes	No experience	53.2%
	I have tried a couple of times	26.2%
	I have used more often	20.6%

As for the income distribution, the three lowest groups, 0-1500, 1500-2500 and 2500-3500, were the largest, hold 19.3%, 21.0% and 23.6% of the participants respectively. These groups are considered to represent the lower income participants, as their monthly income fall under or close to the average national monthly income, which was 3087€ in 2017 (Pehkonen, 2017). The top three income groups, 3500-4500, 4500-5500 and 5500+, comprise 13.7%, 9.4% and 12.9% of the participants, respectively.

Regarding the level of prior knowledge, most participants had either a general (44.2%) or good (24.0%) understanding of smart home devices. As large a portion of the participants as 17.6% even already has smart home devices. 11.2% had a weak understanding, and the remaining 3.0% did not know of smart home devices.

The majority of the participants (53.2%) did not have any experience of smart home devices when participating in the survey. However, 26.2% of the participants had tried smart home devices a couple of times and 20.6% had used smart home devices more often.

5.2 Exploratory Factor Analysis

An exploratory factor analysis (EFA) was conducted with SPSS Software to reveal the underlying structure of the items (Q9.1-Q9.35), discover the correlations between the items (questions) and compose factors of the items. Furthermore, the aim of the factor analysis was also to validate the factors discovered in the reference research by Park et al. (2018). The items are described in the appendix (Table A2). The principal component analysis method was used to carry out the analysis of the exploratory factors, whereas the rotation method performed is Promax with Kaiser Normalization.

The reliability and validity analysis of the collected data as well as the factor loadings are presented in Table 3. Cronbach's alfa is used as a measure of internal consistency among items and reliability of the scales. The results conclude a Cronbach's alfa over 0.6 for all ten factors and an overall Cronbach's of 0.945. Thus, the reliability test is passed. Since the reliability test is passed, it shows that the chosen independent and mediating variables support measuring the dependent variables well.

To test validity of the research model, KMO values, significance levels and factor loadings are examined (Table 3). The KMO value is over 0.7 for all factors, except for perceived control (PCON), perceived system reliability (PSR), perceived cost (PCOS) and perceived

ease of use (PEOU). Since the significance level of the Bartlett's test is below 0.05, it indicates that the factor analysis method is applicable to the questionnaire. (Park et al., 2018) After item reduction, all factor loadings are greater than 0.7 indicating a strong relationship among items. Whenever the factor loadings for an individual factor are above 0.8 and no cross loadings appear, the items are categorized as one class. Those items with more split cross loadings (CON1, PC3, PCOS3, EOU2, USE4) were excluded from the factors, thus, also from further analysis.

Table 3 Reliability and validity analysis on factors

Factor	Item	Cronbach's α	Factor loading	KMO value	Bartlett's test		
					Approx. Chi-Square	Freedom	Sig.
Enjoyment (E)	E1 E2 E3	.883	.902 .908 .890	.744	376.006	3	.000
Perceived security (PSEC)	SEC1 SEC2 SEC3 SR2	.864	.885 .827 .885 .773	.818	446.468	6	.000
Perceived control (PCON)	CON2 CON3	.800	.914 .914	.500	138.450	1	.000
Perceived system reliability (PSR)	SR1 SR2	.621	.852 .852	.500	52.200	1	.000
Compatibility (COM)	COM1 COM2 COM3 PC1 PC2	.901	.867 .824 .853 .836 .855	.889	671.791	10	.000
Perceived cost (PCOS)	COS1 COS2	.665	.869 .869	.500	69.553	1	.000
Perceived Ease of Use (PEOU)	EOU1 EOU3	.715	.883 .883	.500	86.244	1	.000
Perceived usefulness (PU)	USE1 USE2 USE3	.853	.888 .882 .867	.731	303.442	3	.000
Attitude (AT)	AT1 AT2 AT3	.888	.925 .889 .897	.735	397.879	3	.000
Intention to Use (IU)	IU1 IU2 IU3 IU4	.892	.858 .855 .889 .874	.831	530	6	.000

Cronbach's α = **.945**

Exploratory factor analysis on independent variables is shown in Table 4. The independent variables constitute of the items E1-3, SEC1-3, SR1-3, CON2-3, COM1-3, PC1-2 and COS1-2. The independent variables form six factors – enjoyment, perceived security, perceived control, perceived system reliability, compatibility and perceived cost – and the cumulative contribution rate of the six factors is 76.16%. This indicates that the content of questionnaire can be well explained by the six factors. The factor loadings of the items form the independent variables are in the appendix (Table A3). Some cross loading appeared for item SR1, but difference of the loadings (approx. 0.3) was deemed great enough. Thus, SR1 is classified together with SR3 as perceived system reliability. In addition, item PSR2 did not load well with its expected factor perceived system reliability, but instead it loaded well with perceived security. Thus, PSR2 was included in the factor perceived security. The items COM1-3 and PC1-2 loaded tightly together and were challenging to split, so they were combined and considered as one factor, perceived compatibility. However, the factor was still considered to impact both perceived ease of use and perceived usefulness in the research model, alike in the reference model. Hypothesis 7 (H7) now refers to the effect of compatibility, instead of perceived connectedness, on perceived ease of use.

Table 4 Variance of independent variables

Component	Initial Eigenvalue			Sum of squares of extracted load		
	Total	Percentage variance	Cumulative percentage	Total	Percentage variance	Cumulative percentage
1	7.041	39.118	39.118	7.041	39.118	39.118
2	2.416	13.421	52.539	2.416	13.421	52.539
3	1.747	9.705	62.244	1.747	9.705	62.244
4	1.042	5.791	68.035	1.042	5.791	68.035
5	.820	4.555	72.589	.820	4.555	72.589
6	.642	3.569	76.158	.642	3.569	76.158
7	.587	3.260	79.418			
8	.508	2.821	82.239			
9	.473	2.627	84.866			
10	.418	2.319	87.186			
11	.395	2.194	89.380			
12	.347	1.927	91.307			

13	.296	1.644	92.952
14	.292	1.625	94.576
15	.266	1.479	96.055
16	.265	1.473	97.528
17	.227	1.263	98.791
18	.218	1.209	100.000

Exploratory factor analysis on mediating variables is shown in Table 5. The mediating variables constitute of EOU1, EOU3, USE1-3 and AT1-3. They form three factors representing perceived usefulness, perceived ease of use and attitude. With three factors, 79.62% of the variance is explained, indicating that the three factors explain the content of the questionnaire well. The factor loadings of the items form the mediating variables are in the appendix (Table A4).

Table 5 Variance of the mediating variables Usefulness, Ease of Use and Attitude

Component	Initial Eigenvalue			Sum of squares of extracted load		
	Total	Percentage variance	Cumulative percentage	Total	Percentage variance	Cumulative percentage
1	4.497	56.211	56.211	4.497	56.211	56.211
2	1.174	14.671	70.882	1.174	14.671	70.882
3	.699	8.741	79.622	.699	8.741	79.622
4	.459	5.732	85.354			
5	.374	4.670	90.025			
6	.309	3.861	93.886			
7	.276	3.454	97.339			
8	.213	2.661	100.000			

Exploratory factor analysis on dependent variables is shown in Table 6. The dependent variables constitute of IU1-4, and the variance of them is explained by one factor. The cumulative contribution rate of the one factor is 75.56%, which indicates that the one factor can well explain the contents of the questionnaire. The factor loadings of the items forming the dependent variable are in the appendix (Table A5).

Table 6 Variance of the dependent variable Intention to use

Component	Initial Eigenvalue			Sum of squares of extracted load		
	Total	Percentage variance	Cumulative percentage	Total	Percentage variance	Cumulative percentage
1	3.022	75.561	75.561	3.022	75.561	75.561
2	.411	10.269	85.829			
3	.301	7.528	93.358			
4	.266	6.642	100.000			

5.3 Regression Analysis

The means of the factors (table 7) represent the mean levels for each perceived attribute in smart homes. Generally, the attitude of smart home devices is positive, as a high level of the attitude factor represents a positive attitude. Smart home devices are perceived quite easy to use, useful and enjoyable, yet they are perceived less secure and somewhat expensive. Compatibility also seemed to be perceived a bit lacking. The level of intention to use smart home devices is lower than the attitude, which could indicate existing barriers to acceptance of smart homes.

Table 7 The descriptive information of the constructs in the model

	PEOU	PU	Attitude	IU
Overall mean	3.755	3.630	3.831	3.481
Std. dev.	0.950	0.918	0.954	1.016

	E	COM	PSEC	PCON	PSR	PCOS
Overall mean	3.724	3.537	2.487	3.335	3.403	3.657
Std. dev.	0.913	0.932	0.9123	1.113	0.767	0.956

In order to discover the effect of the factors in the research model, a regression analysis was conducted. Figure 7 and Table 8 represent the results of the regression analysis. According to the results, all hypotheses except for H5 and H8 were supported. A summary of the hypotheses test results can be found in the appendix (Table A6). Users' intention to use smart home devices were determined significantly by attitude (H1, ß = 0.662, $p < 0.001$), perceived

usefulness (H2, ß = 0.219, p < 0.001) and perceived cost (H12, ß = -0.092, p < 0.05). Perceived cost was the only factor with a negative coefficient, i.e. a negative causality. Attitude was positively and significantly affected by perceived usefulness (H3, ß = 0.651, p < 0.001) and perceived ease of use (H4, ß = 0.159, p < 0.05). The factors enjoyment (H6, ß = 0.187, p < 0.05) and compatibility (H7, ß = 0.391, p < 0.001) had positively associations with perceived ease of use. Perceived usefulness were affected by perceived system reliability (H9, ß = 0.211, p < 0.001), perceived security (H10, ß = 0.108, p < 0.05) and compatibility (H11, ß = 0.619, p < 0.001). However, perceive ease of use (H5, ß = 0.015, p < 0.811) and perceived control (H8, ß = -0.1, p < 0.093) had no effect on perceived usefulness.

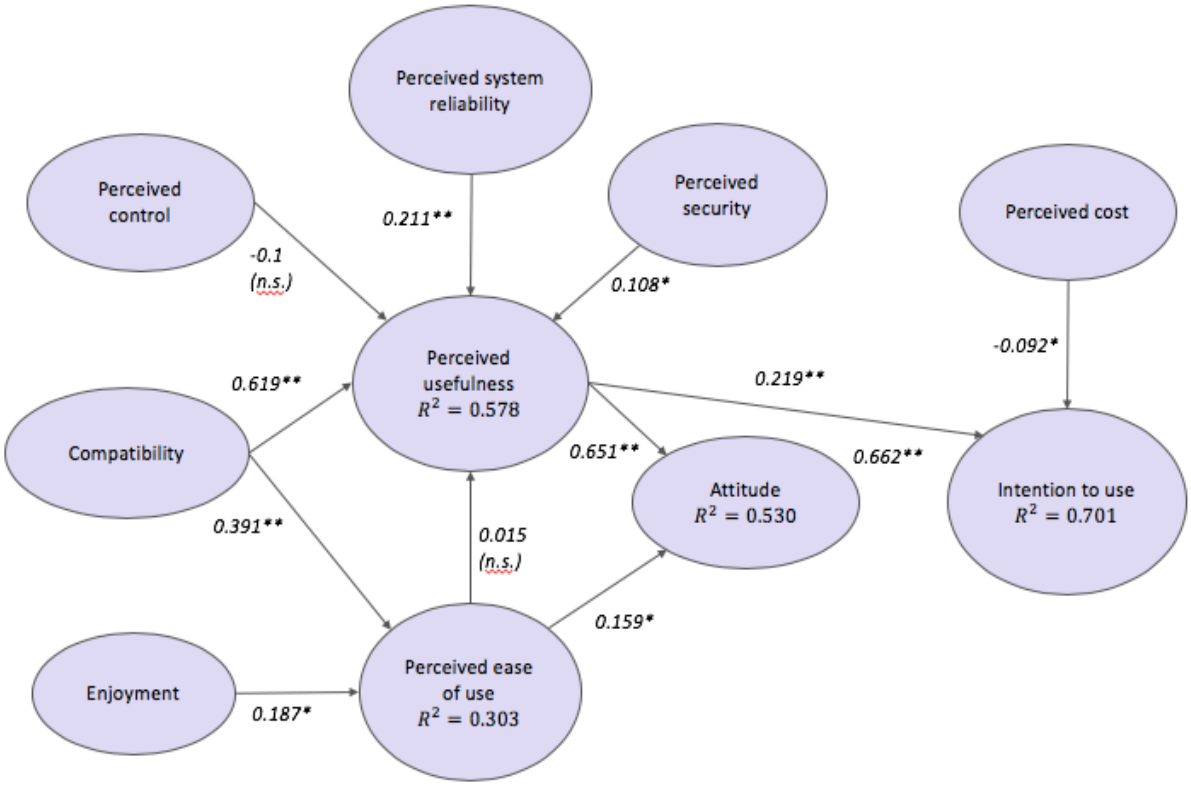

Figure 7 Summary of research model

Table 8 Results of the research model

Hypothesis		Standardized coefficient ß	t	Sig.	Std. Error	Supported
H1.	AT -> IU	0.662**	12.778	<0.001	0.055	Supported
H2.	PU -> IU	0.219**	4.225	<0.001	0.057	Supported
H3.	PU -> AT	0.651**	13.282	<0.001	0.051	Supported
H4.	PEOU -> AT	0.159*	3.245	0.001	0.049	Supported
H5.	PEOU -> PU	0.015	0.24	0.811	0.06	Not supported
H6.	E -> PEOU	0.187*	2.095	0.037	0.093	Supported
H7.	COM -> PEOU	0.391**	4.391	<0.001	0.091	Supported
H8.	PCON -> PU	-0.1	-1.687	0.093	0.049	Not supported
H9.	PSR -> PU	0.211**	4.012	<0.001	0.063	Supported
H10.	PSEC -> PU	0.108*	2.308	0.022	0.047	Supported
H11.	COM -> PU	0.619**	10.811	<0.001	0.056	Supported
H12.	PCOS -> IU	-0.092*	-2.52	0.012	0.039	Supported

* $p < 0.05$, ** $p < 0.001$

As shown in Figure 7 and Table 9, attitude, perceived usefulness and perceived cost contributed 70.1% of the variance in the intention to use smart home devices, while perceived usefulness and perceived ease of use contributed only 53.0% of the variance in attitude. 57.8% of the variance in perceived usefulness were contributed by compatibility, perceived system reliability and perceived security. However, compatibility and enjoyment only accounted for 30.3% of the variance in perceived ease of use.

Table 9 Regression analysis on dependent variable and independent variables

Dependent variable	Independent variables	R^2	Adjusted R^2
IU	AT, PU, PCOS	.701	.697
AT	PU, PEOU	.530	.526
PU	PSEC, PSR, COM	.578	.568
PEOU	E, COM	.303	.297

The standardized total effects of the factors on intention to use and attitude are presented in Figure 8 and 9. Perceived usefulness is the factor with the greatest effect (0.662) on attitude, but it was also the second most impactful factor (0.650) on intention to use. However, the attitude had the greatest effect (0.662) on intention to use. As for the external motivations,

compatibility has a significant effect on intention to use and attitude, 0.447 and 0.469, respectively. Two factors with smaller effects on intention to use and attitude were perceived ease of use and perceived system reliability. Perceived ease of use has an effect of 0.115 on intention of use and of 0.169 on attitude, whereas effect of perceived system reliability is 0.137 on both intention to use and attitude.

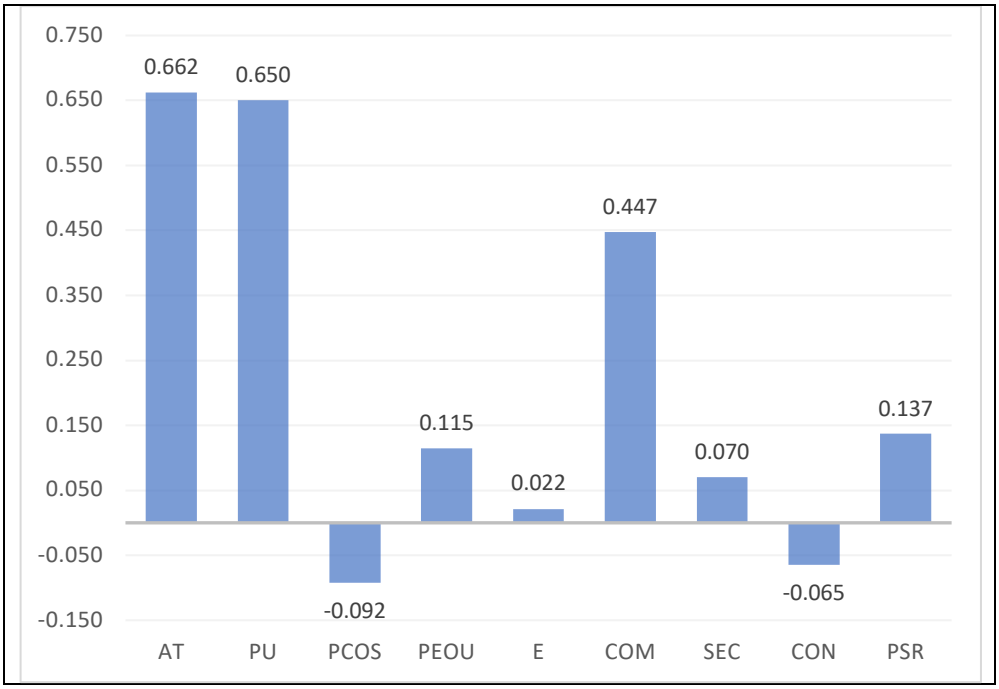

Figure 8 Total standardized effects on intention to use

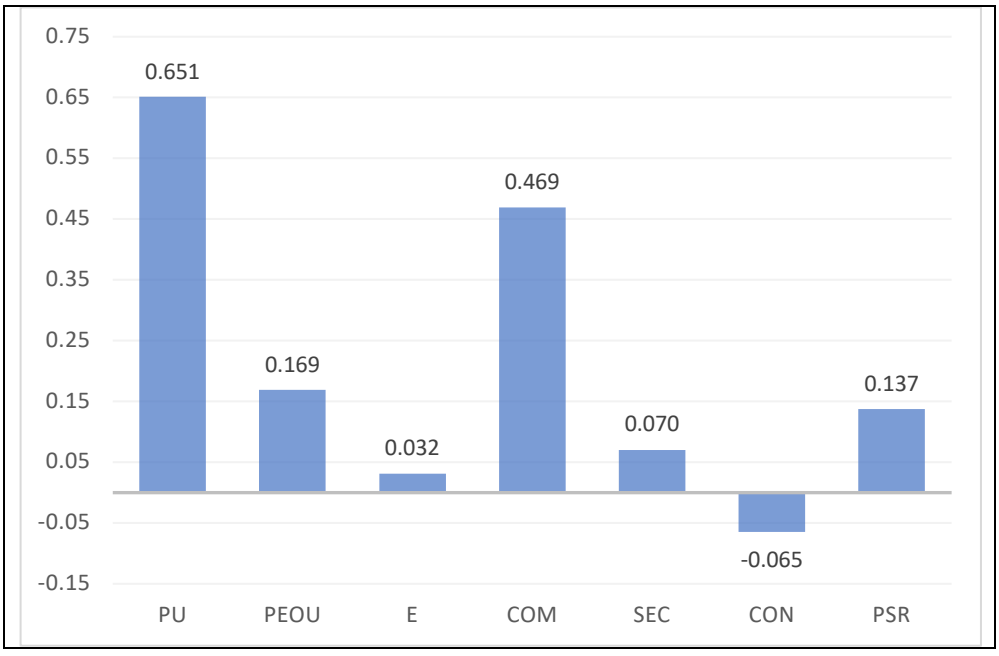

Figure 9 Total standardized effects on attitude

5.4 Control Variable Analysis

In this section the effects of the control variables on the factor means will be measured. The data will be split into two groups according to the control variables, which are gender, age, region of residence, education level, income level, household size, prior knowledge of smart home devices and experience with smart home devices. In order to ensure comparability and a significant difference among the groups, independent t-tests were conducted. If the p-value is below 0.05 for both groups, there is a significant difference in the factor means amongst the groups.

When comparing males and females, the results of the independent t-tests (appendix, Table A7) indicate that there is a significant difference in intention to use, perceived cost, perceived ease of use, enjoyment, compatibility and perceived control. Table 10 represent the group statistics for groups of males and females. By comparing the groups' means for each factor with a significant difference, differences in the groups' perceptions of smart homes can be drawn. The greatest difference can be found in the perceived ease of use with a mean of 4.041 for males and 3.599 for females. This points to males perceiving smart home devices to be easier to use than females. Furthermore, the differences in the means between the groups indicate that males perceive smart home devices to be more enjoyable, affordable, compatible with their lifestyle and easier to connect with. Males also perceive to have more control and skills to manage smart home devices than females. After these findings it hardly comes as a surprise that males also have more intention to use smart home devices.

Table 10 Group statistics of factors by gender

Factor	Group	N	Mean	Std. deviation	Std. Error Mean
IU	Male	85	3.7118	1.07287	0.11637
	Female	147	3.3486	0.96362	0.07948
AT	Male	85	3.9882	0.96561	0.10473
	Female	147	3.7392	0.94242	0.07773
PU	Male	85	3.7137	0.96931	0.10514
	Female	147	3.5805	0.89058	0.07345
PEOU	Male	85	4.0412	0.99167	0.10756
	Female	147	3.5986	0.88681	0.07314
E	Male	85	3.9765	0.90966	0.09867
	Female	147	3.5828	0.88695	0.07315
COM	Male	85	3.8047	0.96262	0.10441
	Female	147	3.3837	0.88442	0.07295
PSEC	Male	85	2.4088	0.97349	0.10559
	Female	147	2.5408	0.87294	0.07200
PSR	Male	85	3.5059	0.83272	0.09032
	Female	147	3.3469	0.72531	0.05982

PCON	Male	85	3.9059	0.90137	0.09777
	Female	147	3.0136	1.09317	0.09016
PCOS	Male	85	3.3941	0.95148	0.10320
	Female	147	3.8027	0.93001	0.07671

Next, groups of people aged below 40 and 40+ were compared. When comparing the age groups, the results of the independent t-tests (appendix, Table A8) indicate that there is a significant difference in attitude, perceived usefulness, enjoyment, compatibility and perceived cost, since the p-values for those factors were less than 0.05. Table 11 presents the group statistics for the age groups. The greatest differences in the means can be found in compatibility and enjoyment. The means for these factors indicate that below 40 year-olds perceive smart home devices as more enjoyable, more compatible with their lifestyle and that they find it easier to connect with smart home devices. Furthermore, below 40 year-olds perceive smart home devices to be more useful and they generally have a more positive attitude towards smart home devices. However, at the same time they also perceive smart home devices to be less affordable than above 40 year-olds.

Table 11 Group statistics of factors by age group

Factor	Group	N	Mean	Std. deviation	Std. Error Mean
IU	< 40	130	3.5885	0.96442	0.08458
	>= 40	103	3.3447	1.06649	0.10508
AT	< 40	130	3.9590	0.83940	0.07362
	>= 40	103	3.6699	1.06488	0.10493
PU	< 40	130	3.7667	0.85730	0.07519
	>= 40	103	3.4563	0.96676	0.09526
PEOU	< 40	130	3.8538	0.91594	0.08033
	>= 40	103	3.6311	0.98260	0.09682
E	< 40	130	3.9179	0.84252	0.07389
	>= 40	103	3.4790	0.94243	0.09286
COM	< 40	130	3.7538	0.79437	0.06967
	>= 40	103	3.2621	1.02135	0.10064
PSEC	< 40	130	2.4750	0.93066	0.08162
	>= 40	103	2.5024	0.89422	0.08811
PSR	< 40	130	3.4885	0.73259	0.06425
	>= 40	103	3.2961	0.79962	0.07879
PCON	< 40	130	3.3769	1.07303	0.09411
	>= 40	103	3.2816	1.16457	0.11475
PCOS	< 40	130	3.7962	0.94355	0.08276
	>= 40	103	3.4806	0.94693	0.09330

The participants were also divided into two groups according to their region of residence, with the first group living in the capital region (Helsinki, Espoo, Vantaa) and the second group living elsewhere. However, when comparing the two groups with different region of residence, no significant differences of the factor means between the groups were found. The p-values for all the factors were more than 0.05, and therefore no significant

comparisons could be made. The results of the independent t-test can be found in the appendix (Table A9).

Table 12 Group statistics of factors by region of residence

Factor	Group	N	Mean	Std. deviation	Std. Error Mean
IU	Capital region	142	3.4067	0.99226	0.08327
	Other	91	3.5962	1.04667	0.10972
AT	Capital region	142	3.7911	0.93155	0.07817
	Other	91	3.8938	0.99117	0.10390
PU	Capital region	142	3.6761	0.83363	0.06996
	Other	91	3.5568	1.03763	0.10877
PEOU	Capital region	142	3.7465	0.90848	0.07624
	Other	91	3.7692	1.01737	0.10665
E	Capital region	142	3.6784	0.88630	0.07438
	Other	91	3.7949	0.95293	0.09989
COM	Capital region	142	3.5310	0.88295	0.07410
	Other	91	3.5451	1.00976	0.10585
PSEC	Capital region	142	2.3979	0.87830	0.07371
	Other	91	2.6264	0.95261	0.09986
PSR	Capital region	142	3.3979	0.76617	0.06430
	Other	91	3.4121	0.77314	0.08105
PCON	Capital region	142	3.2852	1.02521	0.08603
	Other	91	3.4121	1.23961	0.12995
PCOS	Capital region	142	3.6338	0.97106	0.08149
	Other	91	3.6923	0.93621	0.09814

Next, two groups with different education levels were compared. The first group had completed either elementary, high school or vocational school, while the second group consisted of participants with either a lower or higher university degree. When comparing the two education groups, the results of the independent t-tests (appendix, Table A10) indicate that there is a significant difference in perceived cost, as the p-values for only that factor was less than 0.05. Table 13 present the group statistics for the education groups. The difference in means for perceived cost points to the lower education group perceive smart home devices as expensive and less affordable.

Table 13 Group statistics of factors by level of education

Factor	Group	N	Mean	Std. deviation	Std. Error Mean
IU	High/vocational school or lower	78	3.5353	1.13298	0.12828
	University	145	3.4448	0.95855	0.07960
AT	High/vocational school or lower	78	3.8632	1.05606	0.11957
	University	145	3.7977	0.90719	0.07534
PU	High/vocational school or lower	78	3.6368	1.01388	0.11480
	University	145	3.6161	0.86721	0.07202
PEOU	High/vocational school or lower	78	3.8462	1.01068	0.11444
	University	145	3.7000	0.93244	0.07743

E	High/vocational school or lower	78	3.7308	0.98628	0.11167
	University	145	3.7149	0.87134	0.07236
COM	High/vocational school or lower	78	3.5231	1.01992	0.11548
	University	145	3.5297	0.89645	0.07445
PSEC	High/vocational school or lower	78	2.4936	0.96444	0.10920
	University	145	2.4310	0.88068	0.07314
PSR	High/vocational school or lower	78	3.3718	0.75780	0.08580
	University	145	3.4069	0.76600	0.06361
PCON	High/vocational school or lower	78	3.2308	1.19982	0.13585
	University	145	3.4034	1.03464	0.08592
PCOS	High/vocational school or lower	78	3.9231	0.87933	0.09956
	University	145	3.5172	0.98145	0.08150

Next, two groups with different income levels were compared. The first group had a monthly income of 0-3500€, while the second group consisted of participants with a monthly income of 3500€ or more. When comparing the two income groups, the results of the independent t-tests (appendix, Table A11) indicate that there is a significant difference in perceived cost and perceived control, since the p-values for those factors were less than 0.05. Table 14 presents the group statistics for the income groups. The differences in the means for those two factors indicate that the higher income group perceive to have more control and skills to manage smart home devices and they perceive smart home devices to be more affordable.

Table 14 Group statistics of factors by income level

Factor	Group	N	Mean	Std. deviation	Std. Error Mean
IU	0-3500	149	3.4446	1.02784	0.08420
	3500+	84	3.5446	0.99710	0.10879
AT	0-3500	149	3.8166	0.98976	0.08108
	3500+	84	3.8571	0.89366	0.09751
PU	0-3500	149	3.6488	0.93945	0.07696
	3500+	84	3.5952	0.88430	0.09648
PEOU	0-3500	149	3.6846	0.94859	0.07771
	3500+	84	3.8810	0.94620	0.10324
E	0-3500	149	3.7629	0.94384	0.07732
	3500+	84	3.6548	0.85564	0.09336
COM	0-3500	149	3.5611	0.93684	0.07675
	3500+	84	3.4929	0.92850	0.10131
PSEC	0-3500	149	2.4815	0.92684	0.07593
	3500+	84	2.4970	0.89299	0.09743
PSR	0-3500	149	3.4027	0.82133	0.06729
	3500+	84	3.4048	0.66530	0.07259
PCON	0-3500	149	3.1812	1.16858	0.09573
	3500+	84	3.6071	0.95398	0.10409
PCOS	0-3500	149	3.8893	0.89828	0.07359
	3500+	84	3.2440	0.91997	0.10038

Next, two groups with different household sizes were compared. The first group consisted of single-households, while the second group consisted households with 2 or more people. When comparing the two household groups, the results of the independent t-tests (appendix, Table A12) indicate that there is a significant difference in perceived ease of use and perceived control, since the p-values for those factors were less than 0.05. Table 15 presents the group statistics for the household groups. When comparing the means for these factors between the groups, the group with larger households perceive smart home devices to be easier to use, which goes in hand with them also perceiving to have more control and skills to manage smart home devices.

Table 15 Group statistics of factors by household size

Factor	Group	N	Mean	Std. deviation	Std. Error Mean
IU	1	86	3.4942	1.07579	0.11601
	2+	147	3.4728	0.98278	0.08106
AT	1	86	3.7519	0.97577	0.10522
	2+	147	3.8776	0.94207	0.07770
PU	1	86	3.5969	0.95125	0.10258
	2+	147	3.6485	0.90136	0.07434
PEOU	1	86	3.5698	1.05486	0.11375
	2+	147	3.8639	0.86910	0.07168
E	1	86	3.6434	0.96581	0.10415
	2+	147	3.7710	0.88002	0.07258
COM	1	86	3.5233	0.97555	0.10520
	2+	147	3.5442	0.90955	0.07502
PSEC	1	86	2.4360	0.86107	0.09285
	2+	147	2.5170	0.94346	0.07782
PSR	1	86	3.3314	0.85616	0.09232
	2+	147	3.4456	0.70984	0.05855
PCON	1	86	3.0640	1.19262	0.12860
	2+	147	3.4932	1.03531	0.08539
PCOS	1	86	3.7093	0.95012	0.10245
	2+	147	3.6259	0.96131	0.07929

Next, two groups with different levels of prior knowledge about smart home devices were compared. The first group had no prior knowledge, a weak understanding or a general understanding, while the second group consisted of participants with a good or great understanding of smart home devices. When comparing the two knowledge groups, the results of the independent t-tests (appendix, Table A13) indicate that there is a significant difference in intention to use, attitude, perceived cost, perceived ease of use, enjoyment, compatibility and perceived control. According to the t-test, the p-values for those factors were less than 0.05. Table 16 present the group statistics for the knowledge groups. When comparing the groups' means of the significant factors, it suggests that the more knowledgeable group perceive smart home devices to be more affordable, more enjoyable, more compatible with their lifestyle, easier to connect with, easier to use and they perceive

to have more control and skills to manage smart home devices. Generally, they have a more positive attitude towards smart home devices, and they have more intention to use smart home devices. The greatest differences in the means are in perceived control, perceived ease of use, intention to use, perceived cost and compatibility. The greatest mean for these factors (smallest for perceived cost) is found in the group of good or great prior knowledge of smart homes.

Table 16 Group statistics of factors by prior knowledge

Factor	Group	N	Mean	Std. deviation	Std. Error Mean
IU	General or less	136	3.2243	0.91554	0.07851
	Good or great	97	3.8402	1.04469	0.10607
AT	General or less	136	3.6593	0.93533	0.08020
	Good or great	97	4.0722	0.93322	0.09475
PU	General or less	136	3.5686	0.86364	0.07406
	Good or great	97	3.7148	0.98835	0.10035
PEOU	General or less	136	3.4154	0.86400	0.07409
	Good or great	97	4.2320	0.86018	0.08734
E	General or less	136	3.5417	0.86632	0.07429
	Good or great	97	3.9794	0.91895	0.09331
COM	General or less	136	3.3044	0.86717	0.07436
	Good or great	97	3.8619	0.92752	0.09418
PSEC	General or less	136	2.4743	0.80696	0.06920
	Good or great	97	2.5052	1.04768	0.10638
PSR	General or less	136	3.3456	0.74663	0.06402
	Good or great	97	3.4845	0.79206	0.08042
PCON	General or less	136	2.7978	0.96298	0.08257
	Good or great	97	4.0876	0.84166	0.08546
PCOS	General or less	136	3.8971	0.88426	0.07582
	Good or great	97	3.3196	0.95521	0.09699

Next, two groups with different levels of experience with smart home devices were compared. The first group had no experience, while the second group consisted of participants with some or more experience with smart home devices. When comparing the two experience groups, the results of the independent t-tests (appendix, Table A14) indicate that there is a significant differences in intention to use, attitude, perceived cost, perceived usefulness, perceived ease of use, enjoyment, compatibility and perceived control. According to the t-test, the p-values for those factors are less than 0.05. Table 17 present the group statistics for the experience groups. When looking at the greatest means of these factors, they indicate that the more experienced group perceive smart home devices to be more affordable, more enjoyable, more compatible with their lifestyle, easier to connect with, easier to use, easier to control and more useful. The more experienced group also perceive to have more skills to manage smart home devices. Particularly large differences amongst the experience groups were found in perceived control, perceived ease of use, perceived cost and compatibility. However, the more experienced group has also generally

a more positive attitude towards smart home devices and has more intention to use smart home devices.

Table 17 Group statistics of factors by experience

Factor	Group	N	Mean	Std. deviation	Std. Error Mean
IU	No experience	124	3.1855	1.00450	0.09021
	Some or more experience	109	3.8165	0.92399	0.08850
AT	No experience	124	3.6263	1.00099	0.08989
	Some or more experience	109	4.0642	0.84434	0.08087
PU	No experience	124	3.5161	0.95835	0.08606
	Some or more experience	109	3.7584	0.85692	0.08208
PEOU	No experience	124	3.3669	0.92418	0.08299
	Some or more experience	109	4.1972	0.77286	0.07403
E	No experience	124	3.5323	0.92043	0.08266
	Some or more experience	109	3.9419	0.85688	0.08207
COM	No experience	124	3.2984	0.97597	0.08764
	Some or more experience	109	3.8073	0.80228	0.07684
PSEC	No experience	124	2.4415	0.85902	0.07714
	Some or more experience	109	2.5390	0.97193	0.09309
PSR	No experience	124	3.3347	0.73175	0.06571
	Some or more experience	109	3.4817	0.80198	0.07682
PCON	No experience	124	2.8548	1.04137	0.09352
	Some or more experience	109	3.8807	0.92771	0.08886
PCOS	No experience	124	3.9234	0.89951	0.08078
	Some or more experience	109	3.3532	0.93120	0.08919

6 Barriers to Acceptance of Smart Homes

The factors that were considered strong or moderate predictors of intention to use, while perceived to be at a suboptimal performance level currently, can be classified as barriers to acceptance. The classification was conducted using the regression results. The factor means were used for measuring the perception of smart homes, and standardized coefficients (betas) were used as a measure for the importance of each factor to intention to use. Generally, high factor means indicate that the factor performs well and is perceived to exist strongly in current smart homes. A high coefficient, then, indicates that the factor is important for intention to use.

The size of the barrier is determined by the factor's effect on intention to use (i.e. coefficient magnitude). Based on the regression analysis, attitude, perceived usefulness and compatibility were labeled as strong predictors of usage intention, while perceived ease of use and perceived system reliability were labeled as moderate predictors. Perceived security, perceived cost and enjoyment were considered small predictors. As the impact of perceived control on intention to use could not be confirmed in the regression analysis, perceived control was left out the analysis of the acceptance barriers. The classification of the means were conducted on a comparison basis but with a means below 3.5 being automatically considered small. In the detection of barriers for the groups, only the factors that have statistically significant differences in the means were considered. The statistical significance was tested with independent t-tests in the control variable analysis. The following figure (10) is presented to demonstrate the rationalization behind the creation of the acceptance barriers.

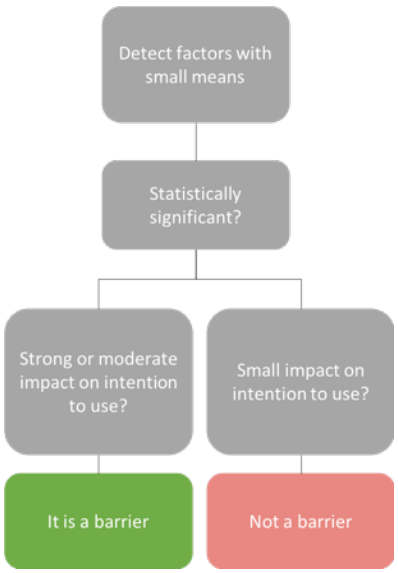

Figure 10 Process of Detecting Barriers

For the whole participant base, the greatest barriers were compatibility and perceived system reliability, as they had high or moderate coefficients but moderate or low means. In other words, they were essential for intention to use but were not perceived as being at a high level currently. Perceived security and perceived cost were classified as smaller barriers to acceptance. Since they had lower coefficients, they were not so critical to usage intention, and thus, only small barriers to acceptance. It can be drawn that, generally, the lack of compatibility, system reliability and security as well as perceived high cost are what hinders people from adopting smart homes.

By grouping participants, it was possible to distinguish different barriers for different types of people. Because perceived reliability and security exist only for the whole participant base, they are not unique to any group and they are thus barriers for all groups. On top of having shared barriers, groups also have barriers that are distinctive and unique to them. The distinctive acceptance barriers for each group are explained below.

The perceived cost seems to be the only significant barrier for younger participants. However, even that barrier is relatively weak, as perceived cost has a low effect on intention to use (i.e. small coefficient). The overall positive perception of smart homes amongst the younger participants explains well the lack of major acceptance barriers. The older group has a less positive perception of smart homes, which is visible in the lower factor means. Therefore it is sensible that the older group has more barriers to acceptance, including perceived lack of usefulness, compatibility and enjoyment. Out of these, perceived usefulness and compatibility were the greatest barriers for the older group, as these factors have higher impact on the intention to use (i.e. larger coefficients). The older group is, thus, hindered in adopting smart homes mostly by perceived uselessness and lack of compatibility but also by lack of enjoyment. As perceived cost acted as a barrier to acceptance only for the younger group, age can be said to play a role in whether perceived cost is likely to hinder adoption. Particularly, a younger age can hinder adoption through a perceived high cost.

While the male group turned out to have no significant barriers to acceptance, the female group has three barriers, of which the greatest were perceived ease of use and compatibility. Enjoyment and perceived cost have a very small effect on intention to use, thus, they are only very small barriers. Females can therefore be said to be mostly hindered by perceived difficulty of use and lack of compatibility, but also slightly by perceived high cost and lack of enjoyment.

The group more knowledgeable of smart homes has only one significant barrier, which is perceived cost. Yet, the barrier is quite weak, as the factor has only a small effect on intention to use (i.e. small coefficient). On the other hand, the group with less prior knowledge of smart homes has four barriers to acceptance. The greatest barriers are perceived ease of use and compatibility, and the smaller ones are perceived cost and enjoyment. Thus, people with less prior knowledge about smart homes can be said to be hindered to adopt particularly by perceived difficulty of use and lack of compatibility, but also by perceived high cost and lack of enjoyment.

The barriers of the groups with different levels of prior knowledge of smart homes are quite similar to the barriers of the groups with different levels of experience with smart homes. The more experienced group is only hindered by the perceived cost, alike the more knowledgeable group. At the same time, the less experienced group has more barriers, alike the less knowledgeable group. The less experienced group has all the same barriers as the less knowledgeable group, with an additional strong barrier of perceived usefulness. The similar barriers consisted of perceived cost, perceived ease of use, enjoyment and compatibility.

When comparing the means of perceived cost of the more knowledgeable and more experienced groups to that of their counter-groups, the means are quite low. However, when comparing the more knowledgeable and more experienced groups' means for perceived cost to their means of other factors, perceived cost is actually quite high. The relative highness of the mean of perceived cost, thus, points to perceived cost being an acceptance barrier also to the more knowledgeable and more experience groups. As perceived cost is a barrier for all knowledge and experience groups, it points to perceived cost being a barrier to smart home adoption regardless of the level of prior knowledge and experience of smart homes. Thus, the only barrier of more knowledgeable and experienced groups, which is perceived cost, is not distinctive to those groups when compared to their counter-parts, less knowledgeable and less experienced groups.

Compatibility, enjoyment and perceived ease of use, however, acted as barriers only in the less knowledgeable and less experienced groups, which indicates that lack of compatibility, lack of enjoyment and perceived difficulty of use hinder smart home adoption for people with less knowledge about and/or less experience with smart homes. For the less experienced people, also perceived lack of usefulness (i.e. perceived uselessness) hinders adoption.

Figure 11 is presented to support the rationalization behind the creation of the acceptance barriers, whereas figure 12 is summing up the acceptance barriers for the total participant base and each group.

Means = perceived level of factor in smart homes	Group	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
	Experience	3.62	4.06	3.51	3.75	3.29	3.80	3.36	4.19	3.33	3.48	2.44	2.53	3.92	3.35	3.53	3.94	2.85	3.88
	Knowledge	3.65	4.07	3.56	3.71	3.30	3.86	3.41	4.23	3.34	3.48	2.47	2.50	3.89	3.31	3.54	3.97	2.79	4.08
	Gender	3.98	3.73	3.71	3.58	3.80	3.38	4.04	3.59	3.50	3.34	2.40	2.54	3.39	3.80	3.97	3.58	3.90	3.01
	Age	3.95	3.66	3.76	3.45	3.75	3.26	3.85	3.63	3.48	3.29	2.47	2.50	3.79	3.48	3.91	3.47	3.37	3.28
	All	3.831		3.630		3.537		3.755		3.403		2.487		3.657		3.724		3.335	

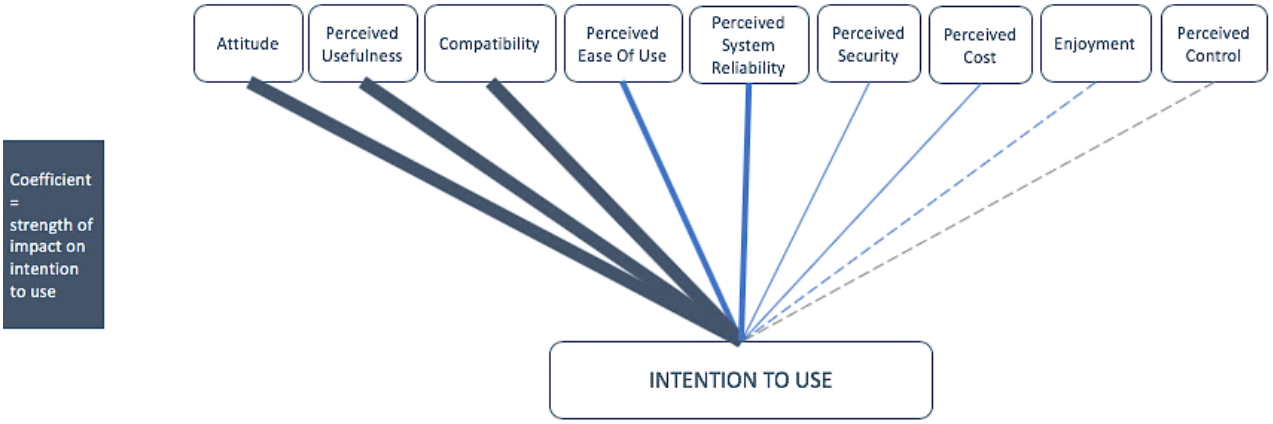

Figure 11 Decision Support for Detection of Barriers

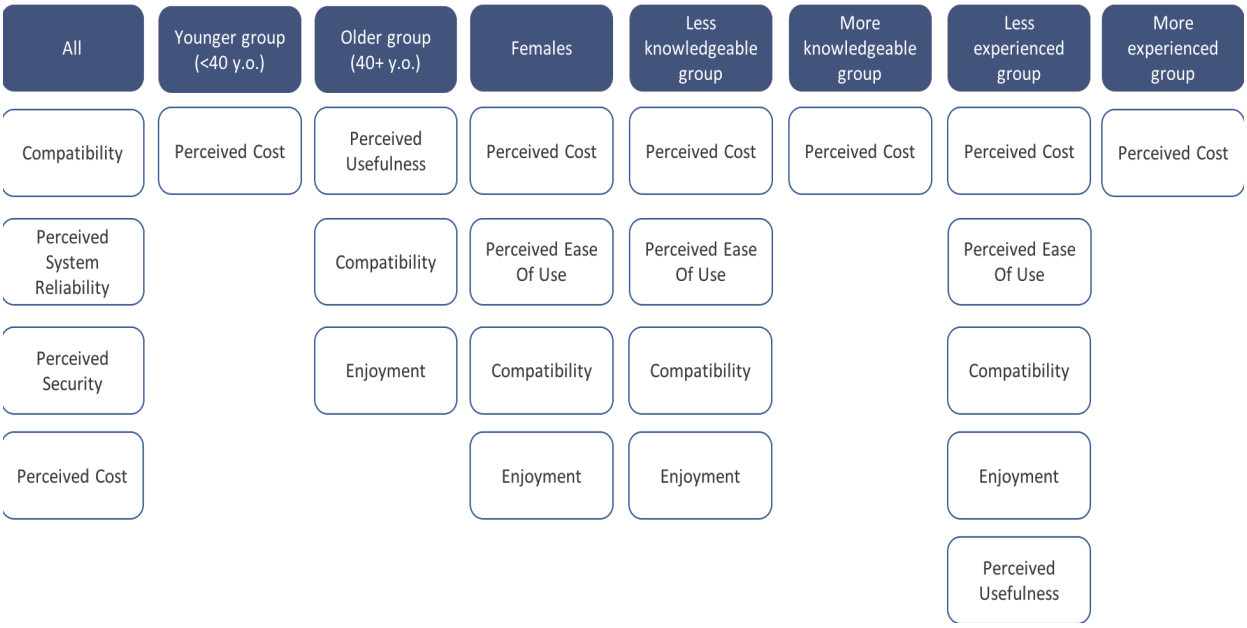

Figure 12 Acceptance Barriers to Smart Homes by Groups

7 Discussion and Conclusions

7.1 Discussion of Results

This study revealed that currently in Finland people have a positive attitude towards smart homes and smart homes are perceived as easy to use, enjoyable and useful. However, Finnish consumers also perceive smart homes as being expensive, insecure as well as moderately unreliable and incompatible with their lifestyles. When comparing these results with results of the study by Park et al. (2018), it shows that Finnish and South Korean consumers share only the perception of enjoyability, usefulness and unreliability as features of smart homes. The perceptions differ most greatly in compatibility, ease of use, security, control and cost. Whereas South Koreans perceive smart homes as being very compatible, secure, easy to control, fairly affordable but difficult to use, Finns perceive them more or less the opposite. Furthermore, the comparison shows that while South Koreans have a relatively high use intention, their attitude was less positive, but Finns had the opposite situation. Finns had a very positive attitude, yet only a moderate use intention. The South Koreans' situation can be explained by attitude being a smaller factor impacting use intention, as discussed in the next chapter. However, the situation of the Finns are quite peculiar, as for the Finns attitude has a strong impact on use intention. There clearly is a blockage for the positive attitude to generate use intention, which could be explained by the negative perception in attributes such as compatibility.

The research model of the study was able to predict use intention very well ($R^2 = 0.701$). All hypothesized effects (paths) were supported, except for the effect of perceived control on perceived usefulness and perceived ease of use on perceived usefulness which were not statistically significant. As for the factors' effect on intention to use, this study found eight factors with a positive effects, of which the strongest are attitude, perceived usefulness and compatibility. Attitude is greatly motivated by perceived usefulness and ease of use, while perceived usefulness is greatly motivated by compatibility and perceived system reliability. Perceived cost is the only factor with a negative effect on intention to use. The study by Park et al. (2018) concluded mostly the same results. The effects of all factors (hypotheses) were supported, also perceived control, but excluding perceived security, which did not have statistical significance. Both Finns and South Koreans were strongly effected to adopt by perceived usefulness, compatibility and moderately by perceived ease of use, but barely by

perceived cost nor enjoyment. Previous research on IoT and smart technology adoption supports perceived usefulness and ease of use as strong predictors of use intention (AlHogail, 2018), however, enjoyment is considered a more prominent predictor (Gao and Bai, 2014), contrary to these results. Finns were also strongly affected by attitude and moderately by perceived system reliability, but for South Koreans attitude was only a moderate influence and reliability a small one. South Koreans were however also moderately affected by perceived control.

The acceptance barriers were covered in this replication study, despite being excluded in the replicated study by Park et al. (2018) Most of the discovered acceptance barriers were quite intuitive and expected, but the interpretations of the barriers should still be discussed. Among the whole participant base and the socio-demographic groups, the most common acceptance barriers were perceived high cost, lack of enjoyment and compatibility, perceived difficulty of use and perceived uselessness, but only the three last are of moderate or great impact. The total participant base, however, carries the barriers lack of compatibility, system reliability and security as well as perceived high cost. Because lack of system reliability and security only exist for the total participant base, they are not unique to any group and are thus barriers for all groups, on top of the barriers that are distinctive to the groups. According to the results, Finnish consumers are hindered to adopt smart homes by their perceived lack of compatibility, system reliability and security as well as perceived high cost. These are attributes that smart home providers are suggested to make improvements to. While in the South Korean market smart home services need to be easily controllable and compatible to drive use intention, smart home providers in the Finnish market need to offer more compatible, reliable, secure and affordable smart homes to increase adoption.

The more intuitive results are found in the group-based acceptance barriers. For the younger group, the only barrier seems to be the perceived high cost, which is intuitive because younger people tend to have a lower income and thus they would find the price as a barrier. The older group, however, has less of an issue with the price, but they perceive smart homes to be useless, incompatible with their lifestyles and unenjoyable. This also fits intuition, as older people tend to be less open to change and to adopt new technologies. While males have no acceptance barriers, females are hindered to adopt by a perceived high cost, difficulty of use, incompatibility with their lifestyles and lack of enjoyment. Unfortunately, there is still

a wage gap between males and females, and thus, this could explain the cost barrier for females. The technology field in both educational and recreational terms is also underrepresented by females, which could explain the otherwise more negative perception of smart homes among females. When it comes to prior knowledge about smart homes and experience with smart homes, it is quite sensible that the barriers of less and more knowledgeable or experienced groups go hand in hand. The people with less prior knowledge and/or no experience are hindered to adopt by perceptions of high cost, difficulty of use, incompatibility and lack of enjoyment. People with more knowledge and experience only share perceived cost as a small barrier. Intuitively, people who have gathered knowledge about and experience with a new technology tend to view the technology more positively. It is neither a surprise that people with less knowledge and/or experience tend to view their ability to use the technology as low. What is, however, a noteworthy result, is that there is no significant difference in how any of groups, not even between the less knowledgeable/experienced and the more knowledgeable/experienced, perceived the level of security. Perceived security is a acceptance barrier to all, also regardless of the level of knowledge or experience. As Gao and Bai (2014) suggest, this may be due to consumers being more aware of security threats and their needs in pervasive services, and this raises a need for improved safety features in smart homes and perhaps institutional safety structures.

7.2 Conclusions

The main objectives of the research were to discover how Finnish people perceive smart homes based on the chosen factors (attributes) overall and how it differs based on sociodemographic factors, such as age and experience with smart homes. Furthermore, the research investigated which factors predict the intention to use smart homes amongst Finnish consumers and how much each factor contribute to the usage intention. Barriers to acceptance were also revealed by discovering factors that are important for usage intention but that are not perceived as being at an optimal level currently. The research results are drawn from regression analyses of the collected questionnaire data.

The research showed that usage intention can be conceptualized with a set of independent factors with different levels of perceived realization. The first research question regards the perception of smart homes. For the whole participant base, smart homes were perceived as

easy to use, enjoyable, useful but also expensive and insecure. Generally, people had a positive attitude towards smart homes and a moderate intention to use.

When it comes to perceptions of smaller groups, some distinctions were visible, but most of them are quite intuitive. The most significant distinctions were in the comparisons between groups of different age, gender, prior knowledge and experience. The perceptions of the groups can roughly be divided into four groups by general perception and perceived cost. A positive perception is held by the younger group, males, more knowledgeable and more experienced groups. While males perceive smart homes as affordable, more knowledgeable and experienced people perceive them as slightly pricy and younger people as expensive. A more negative perception was held by older people, females, less knowledgeable people and people with no experience with smart homes. Out of these, older people perceived smart homes as affordable, while females, less knowledgeable people and people with no experience perceived them as expensive.

The second research question regards the factors impacting intention to use smart homes. The factors with the greatest importance to usage intention are attitude, perceived usefulness and compatibility. Attitude is highly motivated by perceived usefulness and ease of use, while perceived usefulness is motivated mostly by compatibility and perceived system reliability. Enjoyment, perceived security and perceived cost have only little importance to usage intention. Perceived control is deemed as not significant in the regression analysis, and thus, it was excluded from further analysis. Thus, all hypotheses, excluding H5 (perceived ease of use on perceived usefulness) and H8 (perceived control on perceived usefulness), are supported.

The third research question regards the acceptance barriers of smart homes. The factors that were rated as currently contributing to a negative perception of smart homes while being considered a strong predictor of intention to use, were classified as barriers to acceptance. For the whole participant base, the greatest barriers are compatibility and perceived system reliability, while perceived security and perceived cost are classified as smaller barriers to acceptance.

When grouping participants by age, gender, knowledge and experience, differences in barriers to acceptance were discovered. Perceived cost arose as the only and small barrier to the younger group, the group with more prior knowledge of smart homes as well as the group

with more experience with smart homes. Because perceived cost is also a small barrier for the groups with *more* knowledge and *more* experience with smart homes, perceived cost is, in fact, a barrier regardless of the level of prior knowledge and experience. However, as perceived cost is a barrier only for the younger group, not the older group, it can be drawn that younger people are more likely to be hindered by perceived high cost than older people.

Compatibility and enjoyment were shared barriers for the older group, the female group, the less knowledgeable group and the less experienced group. Because the barriers do not exist in the counter-parts of these groups, it can be said that age, gender as well as level of knowledge and experience impact whether perceived lack of enjoyment and compatibility hinder adoption of smart homes.

The perceived difficulty of use hinders females, less knowledgeable and less experienced people in adopting smart homes. Older people, however, are not hindered by perceived difficulty of use but rather by the perceived lack of usefulness. For people with less experience with smart homes, the hindering factors are both perceived difficulty of use and perceived lack of usefulness.

The grouping variables that induce most barriers were age, gender, level of prior knowledge of smart homes and level of experience with smart homes. Particularly an older age (40+ years old), a female gender, a lower level of prior knowledge about smart homes and/or a lack of experience with smart homes introduce more barriers to acceptance. For these groups, some common barriers were lack of compatibility, lack of enjoyment, perceived difficulty of use, perceived high cost and perceived uselessness. These barriers are also the ones occurring mostly when considering all groups. All groups also carry the barriers of perceived system reliability and perceived cost (on top of their distinctive barriers) as those two are barriers of the total participant base but are not unique to any group. This means that the perceived system reliability and cost are, surprisingly, perceived as a barrier regardless of age, gender, prior knowledge and experience.

7.3 Implications, Limitations & Future Work

The theoretical significance lies in demonstrating the generalizability of the acceptance model by Park et al. (2018) in other countries and cultures. Most of the results remained the same as for the replicated study, but some differences occur in the perceptions of smart

homes and attributes important to adoption amongst Finns and South Koreans. While there are similarities between their perceptions and motivations, Finns do have a distinct perception of smart homes and are motivated to adopt smart homes by different factors. Thus, this study continues the dialogue on how pervasive technologies, such as smart homes, are perceived and accepted. Neither this nor the replicated study take into account cultural factors to smart home acceptance. As cultural factors may have held a role in the differences in the results of the two studies, studying this topic further in future work is suggested.

From the practical perspective, the study offers insight on which aspects of smart homes should be improved, in order to increase the perceived value and accelerate the acceptance of smart homes. The study focused on smart convergence appliances, yet the results are generalized to cover all smart home services. These findings can likely also be generalized to suit other pervasive technologies beside smart homes, as they are expected to share a number of attributes. It lies in future research to investigate whether the generalizability of smart convergence home appliances to smart home services and other pervasive technologies is a correct assumption. The implications of the findings for the Finnish smart home market are that smart home providers ought to improve the compatibility, system reliability and security of smart homes and offer less expensive options of smart home devices. When targeting specific user groups, however, they are to make improvements in the factors that arise as acceptance barriers for the specific group in question. Some acceptance barriers are shared by all or many groups, whereas some are unique to specific user groups. It is suggested that future research investigate the means to overcome the biggest barriers discovered, as it is not covered in this paper and could provide great practical value for smart home providers. In this research, the Finnish market is grouped by certain characteristics, yet, it would be of interest to provide a more thorough segmentation of potential users of smart homes in order to discover underutilized segments.

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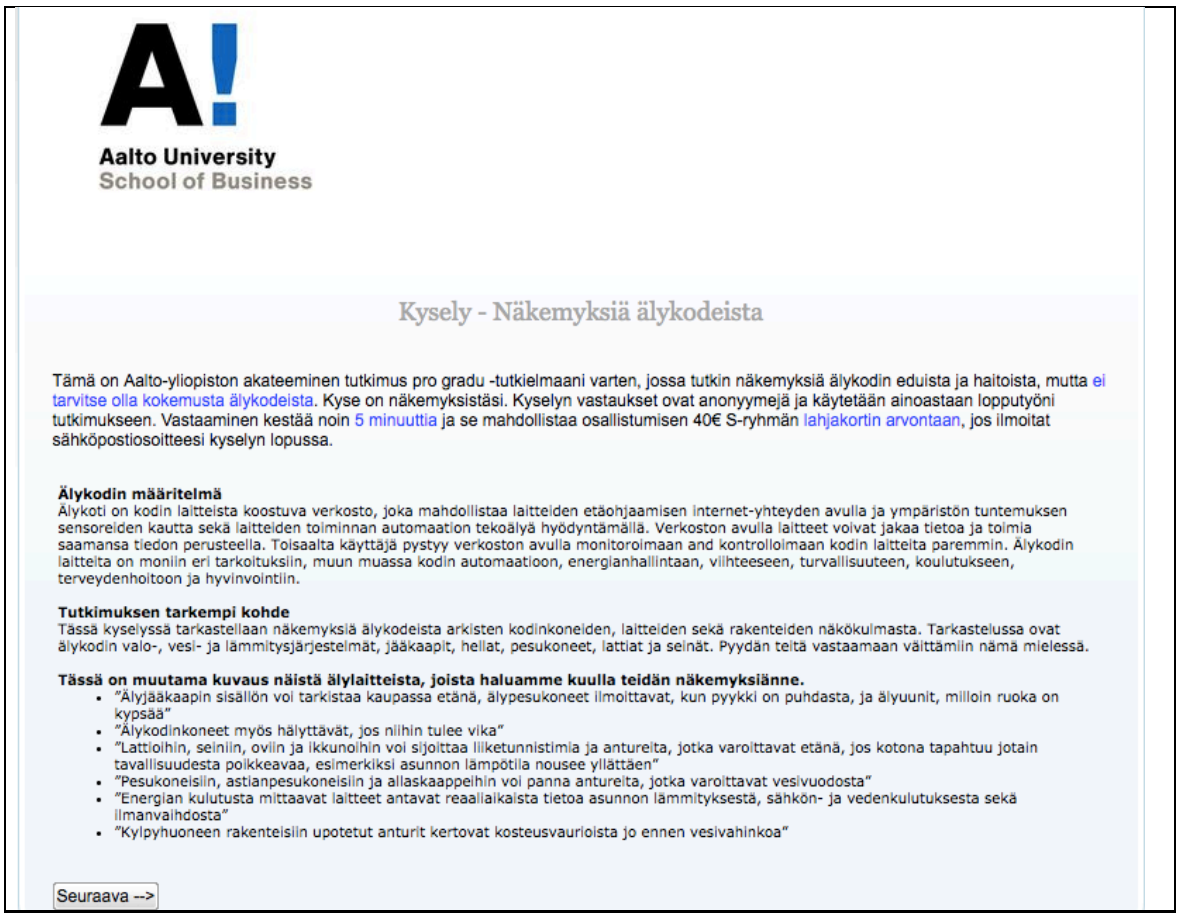
8 Appendix

Table A 1 Questionnaire questions



Aalto University
School of Business

Kysely - Näkemyksiä älykodeista

Tämä on Aalto-yliopiston akateeminen tutkimus pro gradu -tutkielmaani varten, jossa tutkin näkemyksiä älykodin eduista ja haitoista, mutta ei tarvitse olla kokemusta älykodeista. Kyse on näkemyksistäsi. Kyselyn vastaukset ovat anonyymejä ja käytetään ainoastaan lopputyöni tutkimukseen. Vastaaminen kestää noin 5 minuuttia ja se mahdollistaa osallistumisen 40€ S-ryhmän lahjakortin arvontaan, jos ilmoitat sähköpostiosoitteesi kyselyn lopussa.

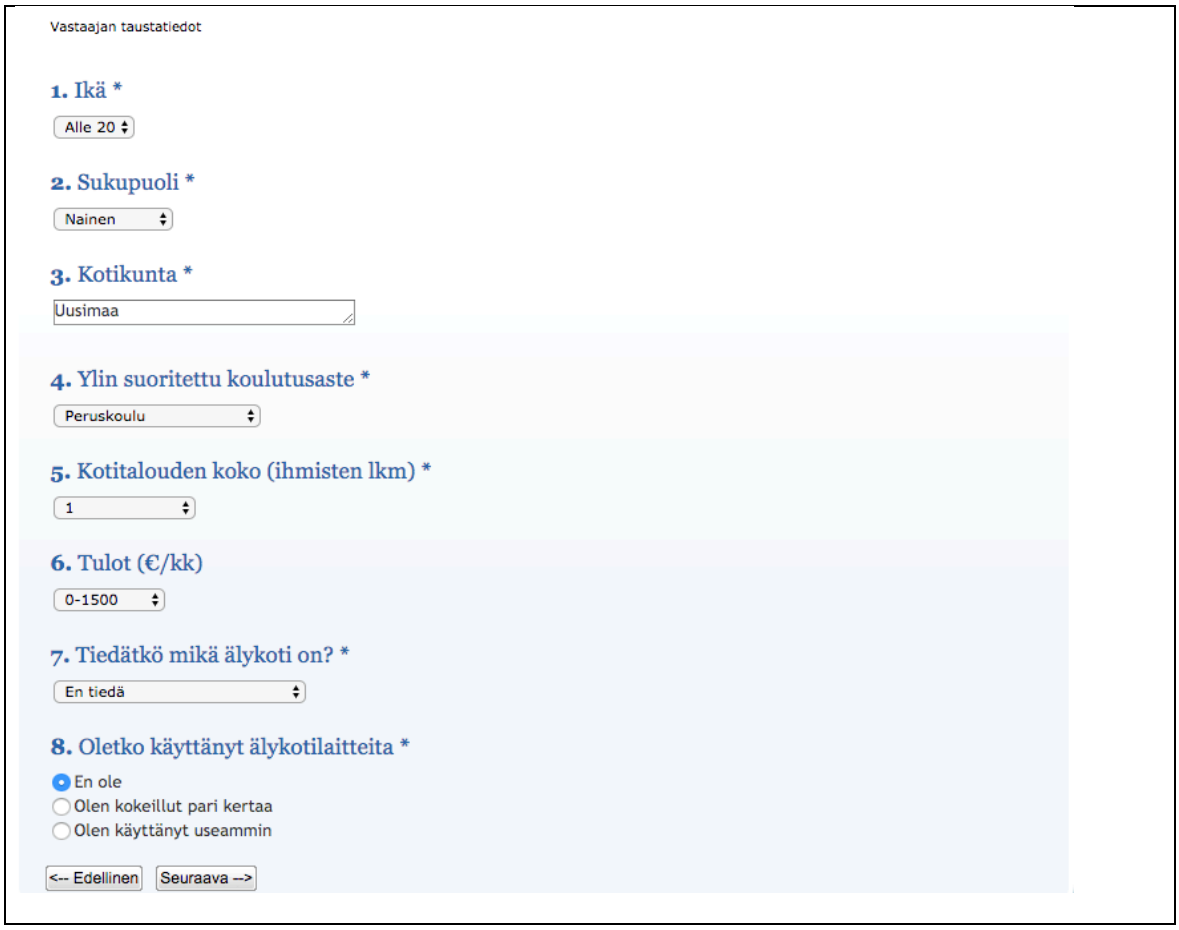
Älykodin määritelmä
Älykoti on kodin laitteista koostuva verkosto, joka mahdollistaa laitteiden etäohjaamisen internet-yhteyden avulla ja ympäristön tuntemuksen sensoreiden kautta sekä laitteiden toiminnan automaation tekoälyä hyödyntämällä. Verkoston avulla laitteet voivat jakaa tietoa ja toimia saamansa tiedon perusteella. Toisaalta käyttäjä pystyy verkoston avulla monitoroimaan and kontrolloimaan kodin laitteita paremmin. Älykodin laitteita on moniin eri tarkoituksiin, muun muassa kodin automaatioon, energianhallintaan, viihteeseen, turvallisuuteen, koulutukseen, terveydenhoitoon ja hyvinvointiin.

Tutkimuksen tarkempi kohde
Tässä kyselyssä tarkastellaan näkemyksiä älykodeista arkisten kodinkoneiden, laitteiden sekä rakenteiden näkökulmasta. Tarkastelussa ovat älykodin valo-, vesi- ja lämmitysjärjestelmät, jääkaapit, hellat, pesukoneet, lattiat ja seinät. Pyydän teitä vastaamaan väittämiin nämä mielessä.

Tässä on muutama kuvaus näistä älylaitteista, joista haluamme kuulla teidän näkemyksiänne.

- ”Älyjääkaapin sisällön voi tarkistaa kaupassa etänä, älypesukoneet ilmoittavat, kun pyykki on puhdasta, ja älyuunit, milloin ruoka on kypsää”
- ”Älykodinkoneet myös hälyttävät, jos niihin tulee vika”
- ”Lattioihin, seiniin, ovilin ja ikkunoihin voi sijoittaa liiketunnistimia ja antureita, jotka varoittavat etänä, jos kotona tapahtuu jotain tavallisuudesta poikkeavaa, esimerkiksi asunnon lämpötila nousee yllättäen”
- ”Pesukoneisiin, astianpesukoneisiin ja allaskaappeihin voi panna antureita, jotka varoittavat vesivuodosta”
- ”Energian kulutusta mittaavat laitteet antavat reaaliaikaista tietoa asunnon lämmityksestä, sähkön- ja vedenkulutuksesta sekä ilmanvaihdosta”
- ”Kylpyhuoneen rakenteisiin upotetut anturit kertovat kosteusvaurioista jo ennen vesivahinkoa”

Seuraava -->



Vastaajan taustatiedot

1. Ikä *

Alle 20

2. Sukupuoli *

Nainen

3. Kotikunta *

Uusimaa

4. Ylin suoritettu koulutusaste *

Peruskoulu

5. Kotitalouden koko (ihmisten lkm) *

1

6. Tulot (€/kk)

0-1500

7. Tiedätkö mikä älykoti on? *

En tiedä

8. Oletko käyttänyt älykotilaitteita *

- En ole
- Olen kokeillut pari kertaa
- Olen käyttänyt useammin

<-- Edellinen Seuraava -->

9. Vastaa väittämiin omien näkemystesi mukaan. *

Sinulla ei tarvitse olla kokemusta älykotilaitteista. Kyse on näkemyksistäsi.

Nämä ovat kyselyn viimeiset pakolliset kysymykset!

	Täysin eri mieltä	Osittain eri mieltä	Ei eri eikä samaa mieltä	Osittain samaa mieltä	Täysin samaa mieltä
Älykodin laitteet ovat kalliita.	○	○	○	○	○
Vuorovaikutus älykodin laitteiden kanssa ei vaadi minulta henkistä ponnistelua.	○	○	○	○	○
Minulla ei ole helposti varaa älykodin laitteisiin	○	○	○	○	○
Pidän interaktiosta älykodin laitteiden kanssa, koska saan niistä tietoa.	○	○	○	○	○
Älykodin laitteiden ostaminen ja käyttö on taakka minulle.	○	○	○	○	○
Älykodin laitteiden käyttö on täysin minun kontrollissa.	○	○	○	○	○
Älykodin laitteiden käyttö sopii hyvin yhteen tapaan, jolla haluan hoitaa kotiani.	○	○	○	○	○
Osaan taidokkaasti käyttää älykodin laitteita.	○	○	○	○	○
Minulla on tarpeeksi tietämystä ja osaamista älykodin laitteiden käyttöön.	○	○	○	○	○
Älykodin laitteiden käyttö parantaa työtehokkuutta.	○	○	○	○	○
Uskon että älykodin laitteiden käyttö on hyödyllistä kotitöiden kannalta.	○	○	○	○	○
Älykotilaitteiden käyttö on hyvä idea.	○	○	○	○	○
Älykodin laitteiden käyttö sopii hyvin yhteen tapaan, jolla haluan olla vuorovaikutuksessa kotini osien kanssa.	○	○	○	○	○
Älykodin laitteita on jännittävää ja miellyttävää käyttää.	○	○	○	○	○
Uskon että älykodin laitteiden käyttö on hyödyllistä kotien kannalta.	○	○	○	○	○
Älykodin laitteet toimivat nopeasti.	○	○	○	○	○
Älykodin laitteeet ovat luotettavia ja virheettömiä.	○	○	○	○	○
Älykodin laitteiden käyttö ei ole minulle vaikeaa.	○	○	○	○	○

Henkilökohtaiset tietoni ovat turvassa älykodin laitteissa.	○	○	○	○	○
Älykodin laitteiden käyttö auttaa minua suorittamaan tehtäväni nopeammin.	○	○	○	○	○
On fiksu idea käyttää älykotilaitteita.	○	○	○	○	○
Uskon ettei kukaan pääse näkemään ja käyttämään tietojani, jotka ovat tallennettu älykodin laitteisiin.	○	○	○	○	○
Vuorovaikutukseni älykodin laitteiden kanssa on ymmärrettävää ja selkeää.	○	○	○	○	○
On mielenkiintoista käyttää älykodin laitteita.	○	○	○	○	○
On luontevaa, että voin käyttää älykotipalveluita laitteideni avulla.	○	○	○	○	○
Nautin siitä, että voin käyttää älykodin laitteita milloin tahansa.	○	○	○	○	○
Älykodin laitteet ovat yhteensopivia elämäni kanssa.	○	○	○	○	○
Älykodin laitteet reagoivat välittömästi pyyntöihini.	○	○	○	○	○
Uskon ettei tietojani älykodin laitteissa käytetä väärin.	○	○	○	○	○
Suhtaudun positiivisesti älykotilaitteisiin yleisesti.	○	○	○	○	○
Älykodin laitteita on hauska käyttää.	○	○	○	○	○
Olen halukas kokeilemaan älykotilaitteita omassa omassa kodissani.	○	○	○	○	○
Kannustan muita käyttämään älykotilaitteita kodeissaan.	○	○	○	○	○
Aion todennäköisesti ottaa älykotilaitteita pysyvään käyttöön omaan kotiini jossain vaiheessa.	○	○	○	○	○
Haluan käyttää älykotilaitteita niin paljon kuin mahdollista.	○	○	○	○	○

10. Mahdollisuutesi osallistua lahjakortin arvontaan!

Kiitokseksi kyselyyn vastaamiseen tarjoan mahdollisuuden osallistua lahjakortin arvontaan. Jos haluat osallistua, ilmoita sähköpostiosoitteesi alla olevaan kenttään. Sähköpostiosoitettasi ei yhdistetä antamiisi vastauksiin.

Muista vielä painaa 'lähetä' ennen kuin suljet ikkunan.

Sähköposti

<-- Edellinen Lähetä

Table A 2 Factors and items of replication study by Park et al. (2018)

Factors	Items	Explanations
Enjoyment	E1	Using smart home services is fun.
	E2	It is so interesting to use smart home services.
	E3	Using smart home services is exciting and pleasant.
Perceived connectedness	PC1	I feel good because I can access smart home services anytime.
	PC2	I feel like being connected to the smart home services because I can take any information on the services' components that I want.
	PC3	I feel comforted because I can interact with the components in my house via smart home services.
Compatibility	COM1	Using smart home services in compatible with my life.
	COM2	Using smart home services fits well with the way I like to manage my house.
	COM3	Using smart home services fits well with the way I want to interact with the components in my house.
Perceived security	SEC1	Smart home services are safe for my personal information.
	SEC2	I think my information in smart home services will not be manipulated.
	SEC3	I think that nobody can see and use my information stored in smart home services.
Perceived system reliability	SR1	Smart home services perform their functions rapidly.
	SR2	Smart home services are reliable without errors.
	SR3	Smart home services are being immediately responsive to my request.
Perceived control	CON1	In my life, using smart home services in entirely my control.
	CON2	I have enough knowledge and ability to use smart home services.
	CON3	I can skillfully use smart home services.
Perceived cost	COS1	Smart home services are expensive.
	COS2	I am not able to easily afford smart home services.
	COS3	COS3. Buying and operating smart home services are a burden to me.
Perceived ease of use	EOU1	Using smart home services is not difficult for me.
	EOU2	My interaction with smart home services is understandable and clear.
	EOU3	Interacting with smart home services does not require my mental effort.
Perceived usefulness	USE1	Using smart home services improves my job effectiveness.
	USE2	Using smart home services makes me accomplish my tasks more rapidly.
	USE3	I think that smart home services are beneficial in my job.
	USE4	Smart home services are a useful service for houses.
Attitude	AT1	Using smart home services in a good idea.
	AT2	I have positive feelings toward smart home services in general.
	AT3	It is a wise idea to use smart home services.
Intention to use	IU1	I want to try smart home devices in my own home. (addition)
	IU2	I recommend others to use smart home services for their houses.
	IU3	I am likely to take smart home devices into permanent use at some point in my life. (modified from: I am likely to continually use smart home services in my life)
	IU4	I intend to use smart home services as much as possible.

Table A 3 Pattern Matrix for Items Forming The Independent Variables

Pattern Matrix[a]

	Component					
	1	2	3	4	5	6
COM3	,982					
COM2	,881					
COM1	,803					
PC2	,644					
PC1	,569					
SEC3		,923				
SEC1		,876				
SEC2		,833				
SR2		,691				
E1			,761			
E3			,742			
E2			,723			
CON2				,918		
CON3				,900		
COS2					,881	
COS1					,846	
SR3						,861
SR1			,410			,776

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Table A 4 Pattern Matrix for Items Forming The Mediating Variables

Pattern Matrix[a]

	Component	
	1	2
USE1	,890	
USE3	,882	
USE2	,862	
EOU1		,945
EOU3		,807

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Component Matrix[a]

	Component
	1
AT1	,925
AT3	,897
AT2	,889

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table A 5 Pattern Matrix for Items Forming The Dependent Variables

Component Matrix[a]

	Component 1
IU3	,889
IU4	,874
IU1	,858
IU2	,855

Extraction Method: Principal Component Analysis.

a. 1 components extracted.

Table A 6 Summary of Hypotheses Validation

Number	Hypothesis	Validation result
H1	Attitude toward smart home services has a positive effect on the intention to use the services.	Supported
H2	Perceived usefulness of smart home services has a positive effect on the intention to use the services.	Supported
H3	Perceived usefulness of smart home services has a positive effect on the attitude toward the services.	Supported
H4	Perceived ease of use of smart home services has a positive effect on the attitude toward the services.	Supported
H5	Perceived ease of use of smart home services has a positive effect on the perceived usefulness of the services.	Not supported
H6	The perceived enjoyment of smart home services has a positive effect on the perceived ease of use of the services.	Supported
H7	Perceived connectedness of smart home services has a positive effect on the perceived ease of use of the services.	Supported
H8	The perceived control of smart home services has a positive effect on the perceived usefulness of the services.	Not supported
H9	The perceived system reliability of smart home services has a positive effect on the perceived usefulness of the services.	Supported
H10	Perceived security of smart home services has a positive effect on the perceived usefulness of the services.	Supported
H11	The perceived compatibility of smart home services has a positive effect on the perceived usefulness of the services.	Supported

Table A 7 The independent t-test for the differences in the mean levels of factors between groups of males and females

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
fEnjoyment	Equal variances assumed	0.139	0.710	3.227	0.001	0.39370	0.12200
	Equal variances not assumed			3.205	0.002	0.39370	0.12283
fSecurity	Equal variances assumed	0.929	0.336	-1.063	0.289	-0.13199	0.12413
	Equal variances not assumed			-1.033	0.303	-0.13199	0.12780
fCost	Equal variances assumed	0.003	0.959	-3.197	0.002	-0.40860	0.12780
	Equal variances not assumed			-3.178	0.002	-0.40860	0.12859
fReliability	Equal variances assumed	1.803	0.181	1.522	0.129	0.15894	0.10442
	Equal variances not assumed			1.467	0.144	0.15894	0.10834
fControl	Equal variances assumed	5.712	0.018	6.374	0.000	0.89228	0.13998
	Equal variances not assumed			6.709	0.000	0.89228	0.13300
fCompatibility	Equal variances assumed	0.204	0.652	3.381	0.001	0.42103	0.12451
	Equal variances not assumed			3.306	0.001	0.42103	0.12737
fEOU	Equal variances assumed	1.230	0.269	3.505	0.001	0.44254	0.12624

	Equal variances not assumed			3.402	0.001	0.44254	0.13007
fUsefulness	Equal variances assumed	0.603	0.438	1.063	0.289	0.13323	0.12538
	Equal variances not assumed			1.039	0.300	0.13323	0.12825
fAttitude	Equal variances assumed	0.046	0.831	1.922	0.056	0.24901	0.12958
	Equal variances not assumed			1.909	0.058	0.24901	0.13043
fIntentionOfUse	Equal variances assumed	0.694	0.406	2.652	0.009	0.36313	0.13693
	Equal variances not assumed			2.577	0.011	0.36313	0.14092

Table A 8 The independent t-test for the differences in the mean levels of factors between groups below and above 40 years

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
fEnjoyment	Equal variances assumed	2.874	0.091	3.747	0.000	0.43898	0.11714
	Equal variances not assumed			3.699	0.000	0.43898	0.11867
fSecurity	Equal variances assumed	0.093	0.760	-0.227	0.820	-0.02743	0.12067
	Equal variances not assumed			-0.228	0.820	-0.02743	0.12011
fCost	Equal variances assumed	0.015	0.902	2.531	0.012	0.31557	0.12466

	Equal variances not assumed			2.530	0.012	0.31557	0.12472
fReliability	Equal variances assumed	2.102	0.148	1.911	0.057	0.19235	0.10064
	Equal variances not assumed			1.892	0.060	0.19235	0.10167
fControl	Equal variances assumed	3.457	0.064	0.649	0.517	0.09537	0.14700
	Equal variances not assumed			0.643	0.521	0.09537	0.14841
fCompatibility	Equal variances assumed	6.892	0.009	4.134	0.000	0.49171	0.11894
	Equal variances not assumed			4.017	0.000	0.49171	0.12240
fEOU	Equal variances assumed	0.559	0.455	1.785	0.076	0.22278	0.12478
	Equal variances not assumed			1.771	0.078	0.22278	0.12581
fUsefulness	Equal variances assumed	1.245	0.266	2.593	0.010	0.31036	0.11968
	Equal variances not assumed			2.557	0.011	0.31036	0.12136
fAttitude	Equal variances assumed	8.485	0.004	2.317	0.021	0.28907	0.12474
	Equal variances not assumed			2.255	0.025	0.28907	0.12818
fIntentionOfUse	Equal variances assumed	1.212	0.272	1.829	0.069	0.24380	0.13333
	Equal variances not assumed			1.807	0.072	0.24380	0.13490

Table A 9 The independent t-test for the differences in the mean levels of factors between groups living in the capital region and elsewhere

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
fEnjoyment	Equal variances assumed	0.008	0.929	-0.950	0.343	-0.11647	0.12258
	Equal variances not assumed			-0.935	0.351	-0.11647	0.12454
fSecurity	Equal variances assumed	1.274	0.260	-1.874	0.062	-0.22849	0.12192
	Equal variances not assumed			-1.841	0.067	-0.22849	0.12412
fCost	Equal variances assumed	0.208	0.649	-0.455	0.650	-0.05850	0.12859
	Equal variances not assumed			-0.459	0.647	-0.05850	0.12756
fReliability	Equal variances assumed	0.011	0.917	-0.138	0.891	-0.01420	0.10325
	Equal variances not assumed			-0.137	0.891	-0.01420	0.10345
fControl	Equal variances assumed	7.479	0.007	-0.848	0.397	-0.12688	0.14954
	Equal variances not assumed			-0.814	0.417	-0.12688	0.15585
fCompatibility	Equal variances assumed	0.797	0.373	-0.112	0.911	-0.01407	0.12547
	Equal variances not assumed			-0.109	0.913	-0.01407	0.12921
fEOU	Equal variances assumed	1.859	0.174	-0.178	0.859	-0.02275	0.12789

	Equal variances not assumed			-0.174	0.862	-0.02275	0.13110
fUsefulness	Equal variances assumed	3.244	0.073	0.967	0.335	0.11928	0.12334
	Equal variances not assumed			0.922	0.358	0.11928	0.12933
fAttitude	Equal variances assumed	0.011	0.915	-0.801	0.424	-0.10269	0.12827
	Equal variances not assumed			-0.790	0.431	-0.10269	0.13003
fIntentionOfUse	Equal variances assumed	0.438	0.509	-1.392	0.165	-0.18946	0.13613
	Equal variances not assumed			-1.376	0.171	-0.18946	0.13774

Table A 10 The independent t-test for the differences in the mean levels of factors between groups with a university degree and lower degrees

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
fEnjoyment	Equal variances assumed	3.011	0.084	0.123	0.902	0.01583	0.12821
	Equal variances not assumed			0.119	0.905	0.01583	0.13307
fSecurity	Equal variances assumed	0.364	0.547	0.489	0.625	0.06256	0.12788
	Equal variances not assumed			0.476	0.635	0.06256	0.13143
fCost	Equal variances assumed	1.360	0.245	3.052	0.003	0.40584	0.13299

	Equal variances not assumed			3.154	0.002	0.40584	0.12867
fReliability	Equal variances assumed	0.070	0.792	-0.328	0.744	-0.03510	0.10716
	Equal variances not assumed			-0.329	0.743	-0.03510	0.10681
fControl	Equal variances assumed	5.783	0.017	-1.123	0.263	-0.17268	0.15376
	Equal variances not assumed			-1.074	0.285	-0.17268	0.16074
fCompatibility	Equal variances assumed	1.971	0.162	-0.050	0.960	-0.00658	0.13218
	Equal variances not assumed			-0.048	0.962	-0.00658	0.13740
fEOU	Equal variances assumed	0.689	0.407	1.084	0.280	0.14615	0.13486
	Equal variances not assumed			1.058	0.292	0.14615	0.13817
fUsefulness	Equal variances assumed	1.835	0.177	0.160	0.873	0.02066	0.12932
	Equal variances not assumed			0.152	0.879	0.02066	0.13552
fAttitude	Equal variances assumed	1.548	0.215	0.485	0.628	0.06555	0.13504
	Equal variances not assumed			0.464	0.644	0.06555	0.14133
fIntentionOfUse	Equal variances assumed	2.448	0.119	0.630	0.530	0.09043	0.14361
	Equal variances not assumed			0.599	0.550	0.09043	0.15098

Table A 11 The independent t-test for the differences in the mean levels of factors between groups with income below and above 3500€/month

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
fEnjoyment	Equal variances assumed	0.857	0.356	0.868	0.386	0.10810	0.12459
	Equal variances not assumed			0.892	0.374	0.10810	0.12122
fSecurity	Equal variances assumed	0.233	0.630	-0.124	0.901	-0.01548	0.12482
	Equal variances not assumed			-0.125	0.900	-0.01548	0.12353
fCost	Equal variances assumed	0.407	0.524	5.219	0.000	0.64521	0.12363
	Equal variances not assumed			5.184	0.000	0.64521	0.12446
fReliability	Equal variances assumed	2.179	0.141	-0.020	0.984	-0.00208	0.10491
	Equal variances not assumed			-0.021	0.983	-0.00208	0.09898
fControl	Equal variances assumed	6.469	0.012	-2.847	0.005	-0.42593	0.14958
	Equal variances not assumed			-3.012	0.003	-0.42593	0.14142
fCompatibility	Equal variances assumed	0.201	0.654	0.535	0.593	0.06822	0.12742
	Equal variances not assumed			0.537	0.592	0.06822	0.12710
fEOU	Equal variances assumed	0.210	0.647	-1.519	0.130	-0.19639	0.12931

	Equal variances not assumed			-1.520	0.130	-0.19639	0.12922
fUsefulness	Equal variances assumed	0.148	0.701	0.426	0.670	0.05353	0.12553
	Equal variances not assumed			0.434	0.665	0.05353	0.12342
fAttitude	Equal variances assumed	0.527	0.469	-0.311	0.756	-0.04059	0.13048
	Equal variances not assumed			-0.320	0.749	-0.04059	0.12682
fIntentionOfUse	Equal variances assumed	0.003	0.953	-0.721	0.472	-0.10001	0.13875
	Equal variances not assumed			-0.727	0.468	-0.10001	0.13757

Table A 12 The independent t-test for the differences in the mean levels of factors between groups with a household size of 1 and 2+ persons

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
fEnjoyment	Equal variances assumed	0.878	0.350	-1.030	0.304	-0.12756	0.12388
	Equal variances not assumed			-1.005	0.316	-0.12756	0.12694
fSecurity	Equal variances assumed	0.912	0.341	-0.652	0.515	-0.08096	0.12409
	Equal variances not assumed			-0.668	0.505	-0.08096	0.12115
fCost	Equal variances assumed	0.009	0.926	0.642	0.521	0.08345	0.12995

	Equal variances not assumed			0.644	0.520	0.08345	0.12955
fReliability	Equal variances assumed	1.983	0.160	-1.097	0.274	-0.11418	0.10412
	Equal variances not assumed			-1.044	0.298	-0.11418	0.10932
fControl	Equal variances assumed	3.710	0.055	-2.885	0.004	-0.42924	0.14877
	Equal variances not assumed			-2.781	0.006	-0.42924	0.15437
fCompatibility	Equal variances assumed	0.081	0.776	-0.165	0.869	-0.02096	0.12685
	Equal variances not assumed			-0.162	0.871	-0.02096	0.12920
fEOU	Equal variances assumed	3.071	0.081	-2.301	0.022	-0.29418	0.12785
	Equal variances not assumed			-2.188	0.030	-0.29418	0.13445
fUsefulness	Equal variances assumed	0.476	0.491	-0.413	0.680	-0.05163	0.12490
	Equal variances not assumed			-0.408	0.684	-0.05163	0.12668
fAttitude	Equal variances assumed	0.541	0.463	-0.969	0.333	-0.12561	0.12960
	Equal variances not assumed			-0.960	0.338	-0.12561	0.13080
fIntentionOfUse	Equal variances assumed	1.090	0.298	0.155	0.877	0.02140	0.13820
	Equal variances not assumed			0.151	0.880	0.02140	0.14152

Table A 13 The independent t-test for the differences in the mean levels of factors between groups with prior knowledge and no prior knowledge

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
fEnjoyment	Equal variances assumed	0.003	0.955	-3.707	0.000	-0.43771	0.11809
	Equal variances not assumed			-3.670	0.000	-0.43771	0.11927
fSecurity	Equal variances assumed	8.468	0.004	-0.254	0.800	-0.03089	0.12157
	Equal variances not assumed			-0.243	0.808	-0.03089	0.12690
fCost	Equal variances assumed	0.913	0.340	4.752	0.000	0.57747	0.12153
	Equal variances not assumed			4.691	0.000	0.57747	0.12311
fReliability	Equal variances assumed	0.001	0.980	-1.365	0.174	-0.13895	0.10178
	Equal variances not assumed			-1.352	0.178	-0.13895	0.10279
fControl	Equal variances assumed	6.376	0.012	-10.613	0.000	-1.28983	0.12154
	Equal variances not assumed			-10.854	0.000	-1.28983	0.11883
fCompatibility	Equal variances assumed	0.147	0.702	-4.698	0.000	-0.55744	0.11865
	Equal variances not assumed			-4.646	0.000	-0.55744	0.11999
fEOU	Equal variances assumed	0.099	0.753	-7.124	0.000	-0.81652	0.11461

	Equal variances not assumed			-7.129	0.000	-0.81652	0.11453
fUsefulness	Equal variances assumed	1.056	0.305	-1.199	0.232	-0.14615	0.12194
	Equal variances not assumed			-1.172	0.243	-0.14615	0.12472
fAttitude	Equal variances assumed	0.090	0.764	-3.324	0.001	-0.41285	0.12419
	Equal variances not assumed			-3.326	0.001	-0.41285	0.12414
fIntentionOfUse	Equal variances assumed	1.259	0.263	-4.772	0.000	-0.61594	0.12909
	Equal variances not assumed			-4.667	0.000	-0.61594	0.13197

Table A 14 The independent t-test for the differences in the mean levels of factors between groups with experience and no experience

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means			
		F	Sig.	t	Sig. (2-tailed)	Mean Difference	Std. Error Difference
fEnjoyment	Equal variances assumed	1.403	0.237	-3.501	0.001	-0.40964	0.11702
	Equal variances not assumed			-3.517	0.001	-0.40964	0.11648
fSecurity	Equal variances assumed	1.032	0.311	-0.813	0.417	-0.09746	0.11995
	Equal variances not assumed			-0.806	0.421	-0.09746	0.12090
fCost	Equal variances assumed	0.299	0.585	4.749	0.000	0.57018	0.12007

	Equal variances not assumed			4.738	0.000	0.57018	0.12034
fReliability	Equal variances assumed	0.308	0.580	-1.463	0.145	-0.14697	0.10049
	Equal variances not assumed			-1.454	0.147	-0.14697	0.10109
fControl	Equal variances assumed	2.778	0.097	-7.894	0.000	-1.02590	0.12996
	Equal variances not assumed			-7.953	0.000	-1.02590	0.12900
fCompatibility	Equal variances assumed	4.661	0.032	-4.312	0.000	-0.50895	0.11803
	Equal variances not assumed			-4.366	0.000	-0.50895	0.11656
fEOU	Equal variances assumed	2.743	0.099	-7.381	0.000	-0.83031	0.11249
	Equal variances not assumed			-7.466	0.000	-0.83031	0.11121
fUsefulness	Equal variances assumed	2.038	0.155	-2.023	0.044	-0.24228	0.11979
	Equal variances not assumed			-2.037	0.043	-0.24228	0.11893
fAttitude	Equal variances assumed	3.367	0.068	-3.582	0.000	-0.43788	0.12224
	Equal variances not assumed			-3.621	0.000	-0.43788	0.12092
fIntentionOfUse	Equal variances assumed	0.641	0.424	-4.967	0.000	-0.63103	0.12705
	Equal variances not assumed			-4.993	0.000	-0.63103	0.12637