



## Safe delivery of goods and services with smart door locks: Unlocking potential use

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### ABSTRACT

The purpose of this paper is to identify the potential of using smart door locks in unattended home delivery of goods, and at home services (unattended and attended) by producing new knowledge on Potential adopters and Non-adopters. Survey data on Potential adopters and Non-adopters were statistically analysed to identify their 1) characteristics (sociodemographic, interpersonal trust and technological literacy), 2) stated demand for unattended home delivery of goods and 3) attitudes regarding in-home services using smart door-locks. Results suggest that potential users are resourceful and more sociable than non-adopters. Furthermore, they have a higher problem perception. Potential adopters are more positive to let in cleaners, craftsmen, healthcare personnel, service personnel, in-fridge delivery services and pet sitters into their home unattended using smart door locks. Regarding goods, they are more positive towards delivery of sports equipment and furniture and appliances. Due to the differentiated needs of Potential adopters and Non-adopters, we propose a typology based on three dimensions (*Technological trust*, *Social trust* and *Life management needs*). Increased understanding of potential users' delivery preferences can be used in the smart door lock market development. The proposed typology can e.g. be used in the upscaling of smart door locks for home delivery of goods and services by diversifying strategies to meet varying adopter needs. A successful unattended delivery system behind closed door can reduce the number of failed deliveries, porch piracy, and unnecessary trips to let in service providers, and might enhance perceived flexibility and convenience of consumers.

### 1. Introduction

E-commerce is an increasingly prominent feature of modern societies, and for more than a decade, scholars have delved into the promises and challenges of e-commerce. Research has pointed to the many upsides and downsides that e-commerce represents to the transport sector (Allen et al., 2018; Le et al., 2022; Siegfried et al., 2021), and there is an abundance of research on the different delivery options that are available for e-commerce deliveries (Mangiaracina et al., 2019). The growth in B2C e-commerce, especially during and following the pandemic years (Guthrie et al., 2021) has produced innovative services that interact directly with end-consumers. Innovative delivery options, especially smart parcel lockers (e.g., Leung et al. (2023), Sawik (2024)), are becoming increasingly dominant and a real competitor to what has been considered the preferred delivery option; home delivery.

Home deliveries have faced challenges related to failed and missed deliveries, producing "house arrest", in that the customers are placed under house arrest because they need to wait to their delivery within a

specific time window (e.g. Singh and Söderlund (2022)). To respond to such challenges, perceived as big inconveniences by the customer, delivery windows have become increasingly narrow and expectations to delivery speed have increased (Köhler et al., 2024; Strauss et al., 2021). Another remedy against house arrest are unattended home deliveries, suggesting that the end-receiver need no longer wait at home to receive their delivery. However, this merits yet other challenges, particularly related to porch piracy (Stickle et al., 2020), product damages (Periyasamy et al., 2023) and the liability of drivers and transport service providers.

In parallel with the growth of e-commerce, we are also seeing rapid development within smart home technology (SHT). Smart door locks are features of safety and security segments in SHT but could also be considered to enable innovative delivery options in last mile transport of e-commerce. Although smart locks are also integrated features of parcel lockers, locker stations etc., they are yet not fully recognised by research as options for both attended and unattended home delivery. In their study on smart door locks Buldeo Rai et al. (2021) point to an obvious

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lack of research on “promising but challenging home delivery innovations”. This paper tends to this need for research by turning to the potential of smart door locks that allow the unlocking of private doors with a unique digital key (Reyes et al., 2017).

Thus, this paper aims to explore the potential of smart door locks to facilitate home delivery of goods and services to individual consumers. Specifically, we ask;

- What characterise potential users of smart door locks?
- What is their expected use of smart door locks?
- What are barriers and drivers for upscaling of smart door locks for unattended delivery?

These questions are answered by investing a survey among 496 Norwegians conducted in 2023/2024, allowing this study to make three contributions to existing research. For one, as called for by Buldeo Rai et al. (2021) this study builds on their qualitative, exploratory research to identify profiles of the most likely adopters of smart door locks. As such it contributes to research by adding to research on smart door locks as components in the delivery of goods and services. Second, this paper enhances the knowledge of potential uses of smart locks beyond the delivery of goods. Research has pointed to convenience and service innovation as valuable features of (un)attended home delivery (Buldeo Rai et al., 2021; Olsson et al., 2022), but has not systematically explored what services customers are interested in receiving in their home. With growing rates of in-home service consumption (Tsiotsou and Boukis, 2022), this research therefore provides insight into a topic that is likely to gain increasing interest. Furthermore, this research contributes directly to operators involved in transport, storage and distribution of goods by providing them with knowledge that allows them to assess what last-mile delivery solutions to invest in, and ways in which they can enhance security concerns within their daily operations. Finally, this study contributes to research by examining the profile of likely and unlikely smart door lock adopters alike. Ratchford et al. (2023) have called for more evidence about consumer reactions to innovations in retail delivery and a greater recognition of different consumer segments when it comes to e-commerce delivery innovations. Thus, this study also discusses the need for differentiated upscaling strategies aimed at different user groups.

The next section of this paper turns to existing research on innovative home delivery options in general and smart home technology and smart door locks in particular, to extract knowledge relevant to the use and uses of smart door locks in delivery of goods and services. The following sections turn the methods, data and results of this study, before we in Section 5 discuss potential upscaling strategies for different groups of Potential adopters.

## 2. Existing literature on smart door locks and last mile delivery options

Much research on e-commerce has focused on the implications that e-commerce might have on freight transport (Gatta et al., 2023), or ways in which e-commerce might shape the travel behaviour of individual consumers (Le et al., 2022). Within both strands of research, impacts, practices and behaviour are largely shaped by available delivery options. Delivery options can shape freight transport practices by inviting more heavy duty transport into residential areas (Maat and Konings, 2018), impact the levels of returns and failed deliveries (Morganti et al., 2014; Visser et al., 2014), inviting increasingly narrow time windows (Allen et al., 2018; Manerba et al., 2018) and needs for cooperation and consolidation (Zissis et al 2018), modified supply and value chains (Goodchild et al., 2018). Furthermore, delivery options might impact travel behaviour of consumers travel (Bjerkan et al., 2020) and determine their assessment of e-commerce services. Yousefi et al. (2023) studied consumer preferences and the relationship between transport demand and e-commerce. They found that sociodemographic traits

affect online purchasing behaviour, and that less car-centric people are more interested in online shopping than those who drive more often. Thus, the research on e-commerce delivery options is vast both in volume and focus. In a review of research on last mile delivery efficiency, Mangiaracina et al. (2019) display the variety of solutions for last mile-delivery, by referring to

- parcel lockers: boxes owned by retailer or logistics services providers and used by different customers (e.g. Ma et al. (2022)). Lots of operational research related to these solutions
- reception boxes: at the customers house, privately owned
- Pick-up points provide storage and/or delivery services, but not necessarily a box
- crowdsourcing logistics: outsourcing last mile to a network of fellow consumers that take the delivery from one point to another (Chen and Pan, 2016; Wang et al., 2018)
- robotised or automated first and last mile operations (Alverhed et al., 2024; Engesser et al., 2023; Kotlars and Skribans, 2024; Li and Kunze, 2023)
- air or ground drones with drop points (Dorling et al., 2017; Li and Kunze, 2023; Zieher et al., 2024)
- delivery in trunk (Reyes et al., 2017)
- underground delivery

Following the growing number of solutions to enable e-commerce delivery, Mangiaracina et al. (2019) describe the research on innovative last-mile delivery solutions as fragmented and academically unstructured. One missing piece of the puzzle of this research concerns the technological solution at the focal point of this study, smart door locks. Although many of the delivery options mentioned above – such as parcel lockers, reception boxes, delivery in trunk – could all make use of smart locks, smart locks on doors to private homes is absent from the review and research in general. One exception is Buldeo Rai et al. (2021), who conducted an exploratory, qualitative study among 49 e-consumers, dedicated to learn about the acceptance of smart locks. As such, this study is treading new ground to increase knowledge about this specific innovation. However, findings from research on other solutions for home delivery might be useful to develop some expectation to who the potential users of smart door locks are, as well as their potential use of these locks. Thus, the remainder of this section will summarise main findings of published research on digital door locks specifically and unattended home delivery solutions more generally to extract existing knowledge of users and potential use.

### 2.1. Predominant theoretical assumptions regarding use of e-commerce delivery options

Much research on the adoption of different options for delivery of e-commerce refers to the same intertwined theoretical backdrops, which have inspired methodological choices in our study. One set of theories is comprised of Rogers' (1962) theory of Diffusion of Innovations (DOI), the technology acceptance model (TAM) (Davis, 1989; Davis et al., 1989; Venkatesh and Davis, 2000), the unified theory of acceptance and use of technology (UTAUT) (Venkatesh et al., 2003; Venkatesh and Davis, 2000), and theory of reasoned action (TRA)/planned behaviour (TPB) (Ajzen, 1991). DOI theorises five characteristics of innovation that are considered to influence whether or not an individual is prone to adopt a given innovation of technology; the innovation's relative advantage vis à vis existing technologies; its compatibility with the users values, experiences and needs; how complex or easy the innovation is to understand and use; whether or not the results and benefits of the innovation are visible; and whether the innovation could be experimented with (trialability). In research on innovative e-commerce practices, DOI is typically operationalised by reference to TAM and UTAUT. Similarly to DOI, TAM assumes intentions to adopt a technology – its acceptance – to result from the user's perception of the technology.

Specially, TAM emphasises a technology's perceived usefulness to the user, and whether or not the user expects to use the technology effortlessly (perceived ease of use). In an attempt to provide an even more comprehensive framework for technology adoption, TAM has been redeveloped with reference to a series of behavioural models and incorporated more prominently understandings inherent in theory of reasoned action/theory of planned behaviour, assuming that the intentions to adopt a technology is shaped by an individual's attitudes, subjective norms and behaviour attentions. More explicitly than both DOI and TAM, this UTAUT framework not only emphasises the performance of and expected efforts related to the technology or innovation itself, but also highlight the role of factors external to the innovation.

Whereas the above theories deal with innovations more generally, Schade and Schlag (Schade and Schlag, 2003, 2000; Schlag, 1997) have put forth their ideas of acceptability of transport measures specifically. They refer to several aspects that contribute to shape an individual's attitude towards a given measure or innovation, thereby building on assumptions within TRA/TPB. They maintain that acceptability is determined by the individual's perception that there is a problem that needs to be solved; the individual's knowledge and understanding of the innovation in question; the ability of the innovation to solve the problem at hand; the superiority of the innovation compared to other solutions; the fair distribution of gains and losses associated with implementing the innovations; and, impacts that the innovations might have on the individual itself. These understandings, especially related to scheme and problem perception, have directly inspired the design of the questionnaire applied in this study.

Collectively, above ideas suggest that the adoption of a technology derives from the interplay between expectations to and perception of the technology in question, and the subjective beliefs, norms and characteristics of the potential adopter. The theoretical stances describe above are put forth by much of the research investigating the adoption of innovations to improve the last mile of freight transport (e.g. Chuong et al. (2024)). For instance, there is extensive and growing research on the adoption of acceptability of self-service solutions (Chen et al., 2024), automated package stations (Yusoff et al., 2023), parcel lockers (Chen et al., 2023; Encarnación and Amaya, 2024; Peppel et al., 2024), pick up points (Wang et al., 2020), perhaps because innovative delivery options are typically found less appealing among consumers than traditional in-person delivery options (Klink et al., 2024). This study adds to this growing volume of research by taking similar theoretical points of departure in survey design and analyses described in Chapter 3, but applying them to bring about knowledge about a hitherto understudied innovation in last mile logistics, i.e. smart door locks.

#### *Research on smart door lockers and/or unattended home delivery*

Much of the research on adoption of last mile innovations focuses on attributes of the different last mile options listed above to explain consumer preferences for one or the other. However, little research refers to smart door locks as a delivery option. The exception is Buldeo Rai et al. (2021), who conducted focus group interviews to explore consumer acceptance of smart locks as an e-commerce delivery option. As other research, they found that consumers preferred to have their orders delivered at home, and consumers worried that their pets might escape during delivery, or they feared for hacking of the system and theft by courier. Furthermore, Buldeo Rai et al. (2021) found that smart locks were highly context specific and their acceptance varies according to type of dwelling, neighbourhood and relationship with neighbours – which suggests that everyday structures contribute to determine preferred delivery options. These focus groups also revealed that consumers could be interested in using smart door locks to allow friends and family to enter their home, or cleaning services to conduct their business. The authors further highlighted that such additional functions have a direct effect on potential users' willingness to pay for installing such a technology.

In a recent study, Klink et al. (2024) consulted e-food industry experts and German-speaking consumers to investigate attitudes towards last-mile delivery modes for groceries. Among other, they referred to delivery options in-home, in-garage and in-fridge – all of which can be securely enabled by use of smart locks. They found that their consumers preferred in-person delivery, and that consumers hesitated to opt for in-home and in-garage delivery because of privacy concerns – especially if crime rates in their neighbourhood were high. However, the authors highlighted that these concerns could be alleviated by use of smart locks and granting limited access to the consumer's home.

Other studies provide knowledge of home delivery options without referring specifically to smart door locks. For instance, Olsson et al. (2022) sought to identify and describe customer expectations regarding unattended grocery delivery. Given the limitations of conventional home delivery of groceries, they argue, retailers are “pursuing new technological solutions and the development of unattended delivery services, such as in-car or in-fridge delivery” (Olsson et al., 2022, p. 2). The authors highlighted the importance of “technology literacy” in the use of unattended grocery delivery services, i.e. that users can easily adapt to and use required technologies. Further, they found that a main consumer motivation for unattended home delivery of groceries related to personal needs and situational factors related to stress reduction and increasing spare time, as early adopters of these solutions tended to prioritise personal hobbies, family time or other leisure activities over grocery shopping. Thus, in-home delivery of groceries becomes an element of raising the wellbeing of individuals and family alike.

To build a typology of innovations and their use in retail delivery, Ratchford et al. (2023) conducted a national survey to investigate potential adoption of delivery innovations, such as curb-side deliveries, locker points, self-driving vehicles, delivery robots and drones. They especially referred to in-home and in-garage delivery options as solutions to reduce porch piracy (Stickle et al., 2020), and found that 13 percent of respondents were very likely to use either delivery option. Although not distinguishing between different innovative solutions, they did identify certain characteristics among consumers willing to adopt innovative delivery options. They found this group to predominantly comprise tech-savvy millennials, with high income and interested in innovation, focused on environmental concerns and high-quality services.

Although not speaking specifically to smart locks or unattended home delivery, other publications on e-commerce also provide insight into potential use and users of unattended home delivery with smart door locks. For instance, Nguyen et al. (2024) studied consumer shifts from home delivery to parcel locker delivery, which they expected to be the preferred option of delivery for coming generations. They found that consumers opt out of home delivery because they perceive smart lockers to provide higher convenience and flexibilities to the end consumer, because they reduce risks of theft, delivery errors or fail, and reduce the risk of delivered products being damaged at curb side or doorstep. Although not mentioned by the authors, these are challenges that could be alleviated with smart door locks. Similarly, in studying consumer intentions to use smart lockers, Yuen et al. (2019) found that convenience, privacy, security and reliability are important predictors for use of smart lockers.

One increasingly researched innovation within last mile deliveries is drone delivery. Yoo et al. (2018) explored attitudes and willingness to adopt drone delivery services in the US. Although drone deliveries are also home deliveries, they have yet not delivered goods inside homes and buildings and can as such not be compared to smart door lock solutions. However, as drone delivery represent cutting-edge technological innovation in home delivery, the characteristics of early adopters could also shape expectations to early adopter of smart locks for unattended home delivery. For instance, Yoo et al. (2018) argue that personal innovativeness, i.e. willingness to try new technologies, impacts attitudes towards drone delivery positively, suggesting that consumers who like to experiment with new technology have stronger intention of

using innovative delivery options.

### Research on use and users of smart home technology

Although this study treats smart door locks as a potential option for improving home delivery of goods, and as such positions itself within the domain of transport research, the adoption and use of smart door locks are also crucial aspects of research on the development and upscaling of smart home technology (SHT). Considered the limited research on smart door locks in transport research, we have consulted research on SHT to substantiate expectations regarding potential use and users of such delivery options. Research on SHT also often relies on the same theoretical and analytical constructs as research on last mile delivery options (i.e. DOI, TAM, TPB,) (e.g. Alifah and Kusumawati (2022), Vrain and Wilson (2021)). A smart home is a sophisticated arrangement of “cutting-edge technology that makes your home more responsive, efficient, and secure (...) [hereunder] interconnected devices that automate and streamline domestic tasks, such as adjusting room temperature, controlling lighting, and managing security systems”.<sup>1</sup> SHT typically aims at improving healthcare, energy efficiency and home security (Li et al., 2021), whereunder the latter also comprise smart door locks and their many uses. Enhancing safety and security is a main motivation for adoption of smart locks (Mamonov and Benbunan-Fich, 2021), but SHT adoption is also motivated by needs that enhance the convenience of daily tasks and activities (Li et al., 2021), such as receiving in-home deliveries and services. Hence, SHT becomes increasingly relevant as the level of in-home service consumption increases (Tsiotsou and Boukis, 2022). Research tending to the resistance and acceptance of smart home services in consumers find that adoption is shaped by perception of different types of risks (performatory, psychological, financial, privacy), as well as technology uncertainty and service intangibility (Hong et al., 2020). Hence, issues related to reliability, privacy and trust are main issues in the adoption of or resistance towards smart door locks as well (Balta-Ozkan et al., 2013).

As research on last mile delivery options, SHT research primarily tends to focus on attributes of technologies and services available to the consumer (e.g. Ghajargar et al. (2016)) and research calls for more studies of actual adopters of SHT. To mend this gap, Vrain and Wilson (2021) studied adopters and non-adopters of energy related SHT. They found that, compared to non-adopters, adopters of SHT were predominantly male, 35–54 years of age, of high education and income, were active on social media, had stronger social networks, sought more information and relied on expert information rather than interpersonal information. Furthermore, adopters were more prone to use new technologies and applications. Similarly, in a study of SHT diffusion, Shin et al. (2018) found adoption to correlate with perceived ease of use and usefulness, which were greater among men and older age groups, “that people who are older, have a higher income level, and have more large household appliances are more likely to buy a smart home within one year” (Shin et al., 2018, p. 251). Others have found adoption to relate to lifestyle choices (Balta-Ozkan et al., 2013).

### 2.4. Existing research on use of SHT for delivery of goods and services

As mentioned above, the work of Buldeo Rai et al. (2021) showed that consumers perceive the value of smart door locks to increase with its ability to enable other functions and services than mere goods delivery. Research on SHT also includes publications on ways SHT could be applied for in-home delivery of services for the elderly and vulnerable groups (assisted living, e.g. Abe et al. (2021)). However, it appears that literature has yet to discover the promise of in-home delivery of a wide array of services and that this potential of smart door locks have yet not

received attention from scholars. Increasing consumption of in-home services might make this more relevant issues, and this study is a first attempt to gain some empirical insight into potential uses for service delivery behind smart door locks.

### 2.5. Summary on uses and users of smart door locks

Thus, summarising above subsections, current research has yet to systematically explore potentials for in-home services delivery (beyond goods deliveries) enabled by smart door locks. Furthermore, although some research indicated who potential users of such delivery options might be (see Table 1), there is a general tendency of research to be more concerned with characteristics of the service rather than the characteristics of the users. Thus, little research reflects variation among consumer groups. On what’s in it for the consumer, Ratchford et al. (2023, p. 559) argue for a “need to consider specific consumer segments in future research: while the average consumer may be indifferent to various innovations at this time, there appear to be groups of consumers that are more open to specific innovations”. This study responds to this need by investigating potential users and uses of smart door locks.

## 3. Methods

The purpose of this paper is to explore the potential of smart door locks to facilitate home delivery of goods and services to individual consumers. To do so, we rely on an online quantitative survey part of the research project Safe Unlock.<sup>2</sup> The overall purpose of the survey was to gain insight into the general population’s attitudes towards solutions for home delivery of goods and services that make use of smart locks. This section accounts for data collection, sample description and analytical procedure in the data analyses.

### 3.1. Data collection

This study is based on data from a quantitative questionnaire directed at the Norwegian public. The questionnaire was developed with reference to existing research and theoretical understandings related to acceptability of innovations in transport and last mile logistics, as

**Table 1**  
Summary of existing research findings relevant to use and users of smart door locks.

User characteristics	Drivers for use	Barriers against use
Male	Reduce risk of product damage	Theft in-home
Millennials	Reduce delivery failure/error	System hacking
Age 30–50	Reduce risk of porch piracy	Low trust in people and technology
High income	Other functions than goods delivery	High-crime neighbourhood
High education	Low-crime neighbourhood	Escaping pets
Personal innovativeness	High trust in people and technology	
High technology literacy	Stress management	
High technological interest	Time management	
High service tangibility	Convenience and flexibility	
Quality oriented	Enhance safety and security	
Seek expert information		
Active social media		

<sup>1</sup> What Is a Smart Home? Definition, Features & Benefits Explained (techopedia.com).

<sup>2</sup> <https://safeunlock.no/en/>.



referred to in Chapter 2. The questionnaire consisted of six sections: A) socioeconomic background B) shopping habits, C) experiences with and acceptability of smart lock-systems, D) expected future online shopping with smart lock systems, E) expected use and returning of goods with smart lock systems, and F) preferences of e-commerce delivery options. By turning to potential uses and users of smart lock systems, this study focuses particularly on sections A, C and D. Questions regarding the acceptability of delivery options with smart locks were developed with reference to operationalisation of acceptability put forth by Schade and Schlag (2000), thus covering aspects of problem perception, scheme perception, effectiveness, efficiency, justice and equity, and consequences to self.

In the questionnaire, the smart door lock was presented using textual and visual aids (see English translation of text and image in Table 2). This was done to make sure the respondents had the same understanding of the smart door lock system when responding to the questions, (i.e. increasing validity).


The questionnaire was implemented into the CAWI survey tool Walr, which enables the implementation, distribution and analysis of online surveys. The respondents could complete the survey on a PC, tablet and/or smartphone. The response time was estimated to be 10–15 min. In the period 15.11.2023–05.04.2024, the survey was distributed through various distribution channels to reach the general public of Norway aged 18 years and above.

The survey was disseminated online and through the social networks of the researchers, i.e. using snowballing and convenience sampling strategies (Ringdal, 2018). To increase the number of responses, the research project partners' and the research organization's communication department shared the link with their networks (snowballing) and on the social media platforms Facebook and LinkedIn (convenience sampling). We used paid advertising on Facebook to reach as wide an audience as possible. Furthermore, an article about the study was published to "campaign" the survey on our research organisation's home page.<sup>3</sup>

### 3.2. Sample description

In total 496 people responded to the survey. The following respondents were not included in the analysis and treated as "missing" (n = 40): respondents who had missing values on any of the

**Table 2**  
Smart door lock presentation.

Introduction	Smart door lock presentation
We will now show you some solutions that allow you as a consumer to receive goods and services in your own home without being present when these are delivered. Common to these solutions is a smart lock that you can control with an application on your smartphone. This solution allows you to give others access to the smart lock in a secure and traceable way, so that they can safely deliver goods or services you have ordered, behind the smart lock.	 <p>A smart door lock in the front door can give couriers/carriers delivering goods or services, one-time access to the area just behind your front door.</p>

<sup>3</sup> <https://www.sintef.no/siste-nytt/2021/vil-du-fa-varer-levert-uten-a-matte-vare-hjemme/>.

sociodemographic variables used in the analysis or answered "do not wish to respond" on relevant/critical background questions used in the analysis. Thus, 456 responses were included in the analysis.

The sample is described in Table 5. To evaluate the representativity of the sample, the socioeconomic characteristics (distributions in percent) are compared with population statistics from Statistics Norway's Statistics Bank (Statistics Norway, 2024a, 2024b, 2023, n.d., n.d., n.d., n.d., n.d.). Regarding gender, men are overrepresented in our sample. Age groups 30–39 and 60–69 have fairly similar shares in our sample and SSB data. Age groups 18–29 and 70 years and older (commonly hard-to-reach groups in surveys) are underrepresented in our sample, while the age groups 40–49 and 50–59 are overrepresented.

Compared to the general population, our sample of respondents have a higher household income, higher share of higher education, a higher share of employment, and also a higher share living with children under 18 years in the household. Further, a higher share of our respondents lives in a house apartment/attached or semi-attached house than the general population. The share living in a detached house/single family home is fairly similar to the national population, while the share living in a building apartment is lower in our sample than for the general population. The mean household size in our sample is somewhat larger than for the general population.

To summarise, our sample appears to have an overrepresentation of resourceful middle-aged people. Potential consequences of this (limitations) are discussed in chapter 5.

### 3.3. Data analyses

Here, we focus on understanding potential users of smart door lock services, i.e. those willing to unlocking their door to receive goods and services (attended and unattended). This dependent variable was defined with reference to understandings of acceptability put forth by Schade and Schlag (2003, 2000), in which acceptability is an attitudinal construct. Notions put forth by Schade and Schlag also inspired the analytical dimensions that we applied to explain variation in attitudes towards deliveries using smart door locks, relating specifically to scheme perception, problem perception, and consequences to self (see also Table A16 in appendix).

In order to identify potential users of smart door locks, we divided the respondents into two groups (see Table 3 for description) based on their attitude towards smart door locks:

**Table 3**  
Group description.

Group	Value	Original question and recoding description	n	Percent
Potential adopters	1	Responded «positive» (4) or «very positive» (5) to the following question: "How do you feel about using such solutions for the delivery of goods and services? Smart door lock." (Answer options: Likert scale 1 (very negative) – 5 (very positive))	256	56 %
Non-adopters	0	Responded «neither positive or negative» (3), «negative» (2) or «very negative» (1) to the following question: "How do you feel about using such solutions for the delivery of goods and services? Smart door lock." (Answer options: Likert scale 1 (very negative) – 5 (very positive))	200	44 %

- 1) Potential adopters (respondents who are *positive* to using smart door locks for goods and service delivery)
- 2) Non-adopters (respondents who are *uninterested or negative* to using smart door locks for goods and service delivery)

Furthermore, we investigated attitudes towards in-home deliveries made by both transport providers (e.g. couriers of goods) and service providers (e.g. healthcare personnel, cleaners, craftsmen etc.).

The analysis/results chapter is divided into three parts, structured by the research questions. First, to increase knowledge of potential users/adopters of smart door locks for e-commerce, we compare the socio-economic characteristics of the two groups (Potential adopters vs. Non-adopters), as well as potential group differences regarding trust in other people and technological interest and literacy. As [Vrain and Wilson \(2021\)](#) noted, adopters and non-adopters can have varying characteristics (see summary of relevant characteristics in [Table 1](#)). Understanding their attributes can be used to identify market potential(s) and thus useful when developing upscaling strategies. Second, to investigate potential uses of smart door locks, we analyse data regarding the Potential adopters' responses to what service providers they would let into their home using smart door locks, what goods they prefer having delivered to their home using a smart door lock, and previous experience with smart door locks (smart door lock ownership and respondents' self-reported expected future use of digital door locks for goods and service delivery). Third, we discuss and identify barriers and drivers for upscaling in the context of literature presented in chapter 2.

Mainly univariate and bivariate analyses have been conducted to describe and identify differences between Potential adopters and Non-adopters. Means, counts and distributions have been estimated in the process of identifying 1) what characterizes Potential adopters, and 2) drivers and barriers for adoption of smart door locks by comparing Potential adopters and Non-adopters in the sample, using results from the literature review to structure the analysis. A description of variables analysed, and the purpose for doing so are presented in [Table 4](#). The main findings are presented in chapter 4. Detailed/full tables (all results) are provided in the [Appendix](#).

The Statistical software Stata SE was used for the analysis.

## 4. Results

### 4.1. User characteristics

[Table 5](#) presents the result of the comparison of sociodemographic characteristics of the Potential adopters, the Non-adopters, the total sample and the general population. The characteristics studied include gender, age, income (household gross income), education level, employment status, whether the respondents had children below the age of 18 in their household, residential type, smart door lock ownership and household size.

The socio-demographic characteristics with the clearest difference in distribution between Potential adopters and Non-adopters are gender, household gross income, residential type, having children under 18 years and household size. Unsurprisingly, there is also a larger share of Potential adopters (42 percent) who already owns a smart door lock than the Non-adopters (24 percent). Regarding gender, there is a larger share of males amongst Potential adopters (68 percent) than the Non-adopters (54 percent) in our sample. A larger share of Potential adopters has a yearly household gross income of one million NOK or higher (69 percent) than Non-adopters (59 percent). Results indicate that the Potential adopters and Non-adopters have differing household attributes: Compared to Non-adopters, a higher share of Potential adopters have children under the age of 18 in their household (50 percent vs. 38 percent), and they have a larger mean household size (2.95 vs. 2.72). Furthermore, the share living in a building apartment is lower among Potential adopters (15 percent) than among Non-adopters (25 percent), and the share living in a detached or single-family home is higher for Potential adopters (59 percent) than for Non-adopters (48 percent).

Conclusively, we find that adoption of smart door locks for home delivery of goods and services is more likely in the following respondents:

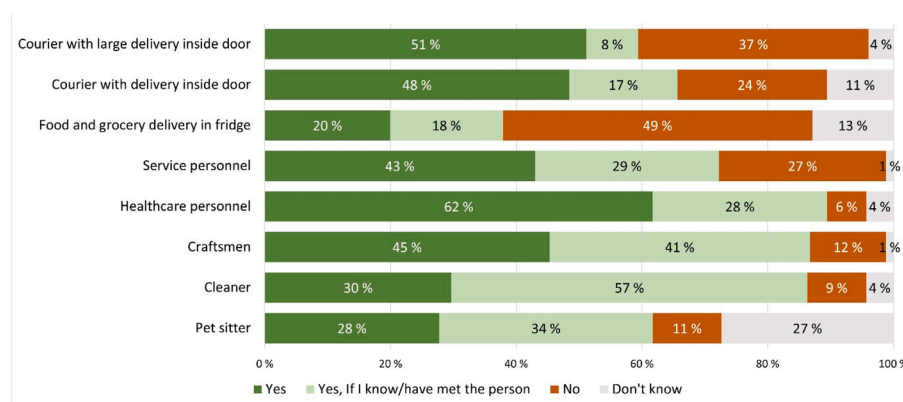
- Men
- Age 30–59
- High income
- High education
- Family with children
- Live in detached house

**Table 4**  
Analysis description.

Analytical dimension	Explored topics	Variables (operationalization)	Variable type	Statistical test (if group comparison)
Background questions (mainly socio-demographic)	User characteristics	Gender, age, income, education, employment, children in household, residential type, smart door lock ownership	Categorical	Pearson's chi-square
	Representativity in sample	Household size (n)	Numerical	t-test
Goods segments	User characteristics	Eight variables on whether the respondent would like to use a smart door lock to get eight types of goods delivered	Categorical	No comparison
Item value	Representativity in sample	A variable describing the self-reported value level (NOK)	Categorical	Pearson's chi-square
	Demand for home delivery of specified goods using smart door lock.	respondents would not want an item to be delivered in mailbox or outside front door (unattended delivery)		
Intrapersonal trust	Critical item value (price) for goods delivery	Two variables with statements (Agreement)	Categorical	Pearson's chi-square
Problem perception: Porch piracy	Social trust	Two variables reporting experiences with theft from 1) doormat or 2) post box	Categorical	Pearson's chi-square
	Experiences with porch piracy could affect potential adopters' interest in smart door locks			
Problem perception: High-crime neighbourhood	Crime-rates in respondents' residence area.	Variable constructed based on reported county of residence and crime statistics (SSB).	Categorical	Pearson's chi-square
	Attitudes to unattended in-home delivery.	Eight variables on which service and goods providers they would let into their home using a smart door lock (unattended)	Categorical	Pearson's chi-square
Acceptability: unattended delivery of goods and services	Trust in digital technology and technological competence.	Three variables with statements (Agreement)	Categorical	Pearson's chi-square
	Stress and time management, convenience/flexibility and experiences with failed delivery.	Six variables with statements (Agreement)	Continuous	t-test

**Table 5**  
Comparison of Potential adopters vs. Non-adopters, and general population description.

	Potential adopters (n = 256)	Non-adopters (n = 200)	Chi2	df	p-value	Total sample (N = 456)	General population (SSB)
Gender			9.284	1	0.002		
Female	32 %	46 %				38 %	50 %
Male	68 %	54 %				62 %	50 %
Age group			8.805	5	0.117		
18–29 years	3 %	7 %				5 %	19 %
30–39 years	23 %	15 %				19 %	17 %
40–49 years	29 %	30 %				29 %	16 %
50–59 years	22 %	28 %				25 %	17 %
60–69 years	15 %	13 %				14 %	14 %
70 years and older	8 %	9 %				8 %	17 %
Household gross income (NOK)			4.582	1	0.032		
Less than 1 million	31 %	41 %				35 %	63 %
1 million or more	69 %	59 %				65 %	36 %
Highest level of completed education			4.134	4	0.247		
Basic school level	3 %	3 %				3 %	23 %
Upper secondary education (incl. tertiary vocational education)	14 %	9 %				12 %	39 %
Higher education (short)	32 %	33 %				32 %	25 %
Higher education (long)	50 %	56 %				53 %	12 %
Employment status			0.322	2	0.851		
Employed	83 %	82 %				82 %	62 %
Retired	13 %	14 %				13 %	18 %
Other	5 %	4 %				4 %	20 %
Children under 18 years in household			6.127	1	0.013		
Yes	50 %	38 %				55 %	43 %
No	50 %	62 %				45 %	57 %
Residential type			8.821	2	0.012		
Building apartment	15 %	25 %				19 %	29 %
House apartment/Attached or semi-attached house	26 %	28 %				27 %	20 %
Detached house/Single family home	59 %	48 %				54 %	51 %
Smart door lock ownership			16.495	2	0.000		
Yes (with app)	42 %	24 %				34 %	
Yes (without app)	13 %	15 %				14 %	
No	45 %	61 %				52 %	
	<b>Potential adopters (n = 256)</b>	<b>Non-adopters (n = 200)</b>	<b>t</b>		<b>p-value</b>	<b>Total sample (N = 456)</b>	<b>General population (SSB)</b>
Household size: Mean (S.E)	2.95 (0.08)	2.72 (0.09)	-1,968		0.0497	2.85 (0.06)	2.12



**Fig. 1.** Potential adopters' responses on whether they would let in different types of services using smart door lock, n = 256.

**4.2. Expected use among potential adopters**

In this subchapter, Potential adopters' expected use of smart digital door locks for at home delivery of goods and services are explored. Fig. 1 presents an overview of the Potential adopters' expected use of smart digital door lock to let in different types of goods and service providers unattended.

The services providers that most respondents would let in using a smart door lock system is healthcare personnel (90 percent) while food and grocery delivery in fridge is the service with the highest share of "no"-responses (49 percent). Although the least popular service provider

listed, it is noteworthy that more than a third of Potential adopters are willing to let in food and grocery deliverers unattended. To summarize Fig. 1, Potential adopters are more inclined to give access to service providers than to couriers. Furthermore, knowing the identity of the deliverer appears to be crucial (i.e. a condition for unlocking the door) for a large share of respondents, although this varies between type of goods/services deliverers. For example, a relatively high share responded "yes" to letting in craftsmen (86 percent) and cleaner (87 percent), indicating that these services are in demand. However, a high share of the same respondents responded that a prerequisite was that they had met or knew the person before unlocking their door for both service

deliverers (41 percent for craftsmen and 57 percent for cleaner). Considering how essential knowing the courier or service provider seems to be, we investigated if trust in other people affected attitudes towards smart door locks. Table A13 in Appendix indicate that those with high interpersonal trust are more inclined to unconditionally allow unattended access to their home, regardless of type of delivery. We do not find similar patterns with regards to respondents' ability to get into contact with people they do not know (Table A12 in Appendix).

Next, we present the results from the goods delivery analysis. Fig. 2 presents the share of Potential adopters who would use a smart door lock for receiving different types of goods by giving courier(s) one time access.

Fig. 2 indicate that sports equipment (67 percent) and furniture and appliances (54 percent) are the goods that most Potential adopters would have unattended delivered using a smart door lock system. The goods with the lowest share of expected use of smart door locks were entertainment items such as books, CD, DVDs (25 percent) and toys and hobby equipment (26 percent). The reported expected usage of smart digital door locks for delivery of clothes and shoes was also on the lower end (27 percent).

The majority of Potential adopters (77 percent) did not expect that a smart door lock would change their shopping habits (see table A9 in Appendix). However, almost a quarter of them (22 percent) expected that an installation of a smart door lock would cause an increase in online shopping, which is a noteworthy share.

To identify the importance of item value and connected security concerns, we asked at what item value (NOK) the respondent would be uncomfortable with unattended home delivery in mailbox or porch. To summarize, we tested whether there were significant differences between Adopters and Non-adopters, between socio-economic groups and type of residence (shared or private door), but did not find any indications of group differences (see Appendix Tables A17-A20). A commonality between the groups was indications of a breakpoint of item value somewhere between NOK 500 and NOK 1000 for accepting items to be left unattended, as illustrated in Fig. 3.

Fig. 3 further present results for the only segments of respondents showing differing risk-assessment related to item value, namely Non-adopters split by how they responded to the statement "I trust people I don't know". Their differing assessment of acceptable value for items to be left unattended, correspond with their responses to this statement: Responses from the Non-adopters who agree with the statement, indicate acceptance of a higher item value to be left unattended, than among the Non-adopters who disagree with the statement. These results show that Non-adopters with low trust in people they do not know are more item value sensitive related to unattended home delivery in mailbox or porch.

#### 4.3. Drivers and barriers for use and adoption of smart door locks

This subchapter details how the Potential adopters and Non-adopters agree (or not) on statements connected to interpersonal trust and technological literacy. Table 6 presents the respective shares of respondents who agree on three statements regarding technological literacy and two statements on interpersonal trust.

Table 7 presents the respondents' mean value on six statements regarding experiences with e-commerce, and statements measuring respondents' problem perception regarding online shopping and home delivery, divided between Potential adopters and Non-adopters. The respondents answered using a Likert scale with values ranging 1 (strongly disagree) to 5 (strongly agree). Full statements are included in the Appendix.

The Potential adopters display a more pronounced problem perception when it comes to delivery of goods than Non-adopters. The Potential adopters have a higher mean on the statement that it is impractical to be at home to let in service providers, indicating that flexibility and convenience is of importance amongst Potential adopters. Regarding stress/time management, Potential adopters had a higher mean on the statement that it is a long way to go to the nearest post office or post-in-store to pick up ordered goods. Potential adopters also had a higher mean on the statement that the offer for in-home delivery of goods is poor in the area they live.

Conclusively, we find that the following are predominant characteristics of potential adopters of smart door locks for home delivery of goods and services:

- More sociable
- Higher problem perception
- More positive to let in cleaners, craftsmen, healthcare personnel, service personnel, in-fridge delivery and pet sitter into their homes
- Most positive towards unattended home delivery of sports equipment and furniture and appliances

## 5. Discussion

The purpose of this article has been to explore the potential of smart door locks to facilitate home delivery of goods and services to individual consumers. By reference to an online survey among 496 Norwegians, we have studied socio-demographic characteristics of Potential adopters of smart door locks, as well as likely Non-adopters. Our results align with findings in existing research on innovation and technology adoption, both within e-commerce and smart home technologies, summarised in Table 1. We find that Potential adopters are predominantly men aged 30–39 years with high income and high education, and live in detached houses with their family and children.

Furthermore, this study provides new knowledge about expected

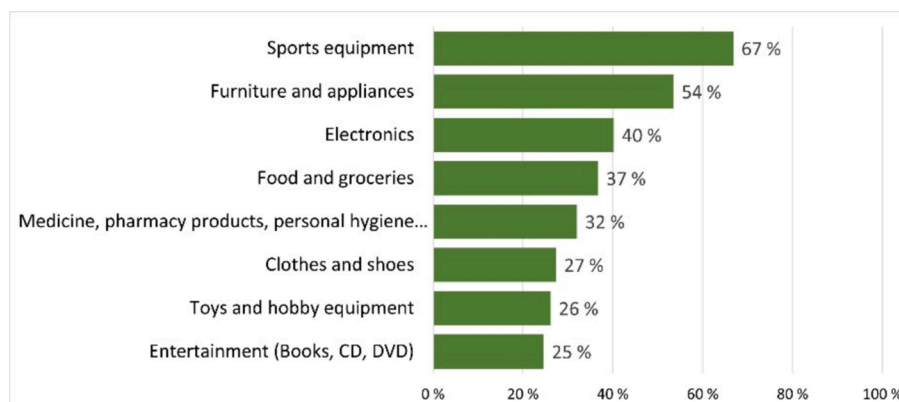


Fig. 2. Potential adopters' preferences for receiving goods using a smart door lock (Multiple choice question), n = 256.



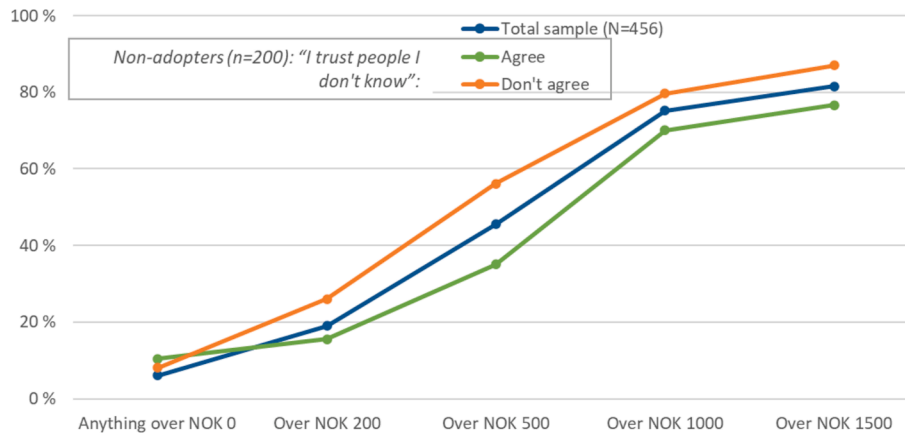


Fig. 3. Item value not acceptable to leave unattended in mailbox or on doormat.

Table 6 Drivers and barriers (Technological literacy and interpersonal trust).

Statement	Potential adopters (n = 256) Percent (%) agree	Non-adopters (n = 200) Percent (%) agree	Chi-square testing Chi2 (df = 1)	p-value	Total sample (N = 456) Percent
<b>Technological literacy</b>					
Learning demands little of me	80 %	73 %	3.558	0.059	77 %
I often need aid when I use technology	5 %	6 %	0.184	0.668	5 %
I believe technology can contribute to solving many societal challenges	92 %	87 %	2.795	0.095	90 %
<b>Trust</b>					
I easily get into contact with people I don't know	67 %	57 %	4.984	0.026	63 %
I trust people I don't know	41 %	39 %	0.395	0.530	40 %

Comparing Potential adopters and Non-adopters on the two trust statements, results indicate a difference between the groups for the first trust statement. A higher share of Potential adopters (67 percent) agreed on this statement than amongst Non-adopters (57 percent), i.e., a higher share of Potential adopters consider themselves as persons that easily get into contact with people they do not know. Potential adopters also describe a slightly higher subjective technological literacy (80 percent vs. 73 percent) and slightly stronger belief in technology as tool for solving problems (92 percent vs. 87 percent) than Non-adopters.

Table 7 E-commerce experience and problem perception, percent who agree with statements.

Statement issue	Potential adopters			Non-adopters			t-test		Total sample N
	n	Mean	S.E	n	Mean	S.E	t	p-value	
Inflexible delivery	255	2.827	0.071	198	3.035	0.079	1.957	0.051	453
House arrest	256	2.863	0.072	199	2.658	0.077	-1.935	0.054	455
Not delivered in time	253	3.138	0.068	197	3.066	0.076	-0.712	0.477	450
Impractical to wait	253	3.854	0.061	198	3.551	0.077	-3.115	0.002	451
Insufficient home-delivery options	256	2.939	0.073	200	2.702	0.072	-2.267	0.024	456
Long distance to pick-up	256	2.203	0.070	200	1.980	0.075	-2.157	0.032	456

uses of smart door locks, both with regard to receiving e-commerce deliveries and receiving different types of services into consumer homes. Potential adopters are most positive toward in-home delivery of sport equipment, followed by furniture and appliances. The indication of a threshold item value of between NOK 500 and NOK 1000 for accepting an item to be left unattended on the doormat or in the mailbox, provides an interesting perspective on the prominent growth in e-commerce especially for low-value items in recent years. Findings from our study indicates that this segment of the e-commerce market is less prone to be affected by any worries the recipient might have about the risk of theft or damage to the goods to be delivered in an unsecure and unattended manner.

Although smart door locks are increasing in popularity, in-home service delivery (attended and unattended) using smart door-locks is not extensively used in Norway, indicating an untapped upscaling potential. The growth of in-house service consumption (Tsiotsou and Boukis, 2022) suggests this will be an increasingly relevant research topic likely to expand beyond current research focus on in-home care and health services (e.g. Hoel et al. (2021), Ferrell (2024)). Although previous research has provided qualitative insights into potential users and uses of smart door locks (Buldeo Rai et al., 2021), this is to our knowledge the first systematic, quantitative survey of in-home service delivery. Our study finds 96 percent of Potential adopters are positive to let in at least one service provider unattended (see table A15), and 26 percent of Potential adopters of smart door locks are positive towards letting in all studied service providers into their homes unattended (see table A14). We find that the Potential adopters are more positive to let in service providers than couriers. A potential explanation for this finding is that service providers need to get inside to provide their service/perform their task, while there are other options for goods delivery. An additional dimension of risk and security assessment related to in-home deliveries of goods concerns the willingness of the couriers themselves (or their unions) to provide unattended “Beyond the doorstep”- service, as this may also represent an unacceptable risk to them. This includes the potential of being accused of theft or other transgressions while being inside the home. They also foresee the potential for other, perhaps

less severe but still unwanted, incidents which might occur, e.g. pets escaping through the entrance door while the courier is delivering the goods items.

Further, we find that unconditional use of smart door locks is most attractive when it comes to allowing health care personnel and goods couriers into the respondents' homes. This implies that the consumers feel no need to know the service providers in order to allow them access to their home. In many cases, we find that expectations of *conditional use* of such locks, i.e. allowing only service providers the consumer already knows to enter, to be prominent. This particularly applies to services provided by cleaners, craftsmen and service personnel. Receiving in-fridge deliveries of food and groceries appear to be the least attractive use of smart door locks.

Finally, this study set out to explore barriers and drivers that might impact upscaling of smart door locks for in-home delivery of goods and services. We find that many drivers and barriers for adoption of other e-commerce innovations and SHT solutions already identified in research are also relevant to the use of smart door locks to receive in-home delivery of goods and services. Specifically, our data show that Potential adopters express greater problems with deliveries and porch piracy; they display higher trust in both people and technology and are both socially and technologically literate; they are concerned with convenience and flexibility in goods and service deliveries. Of the service providers listed, Potential adopters were most positive to letting in healthcare personnel; a potential market that could expand with ageing populations and increasing geographical distances between family members.

This paper has explored potential users and uses of smart door locks within a sample that is fairly typical for early technology adopters in most domains. Despite that the full sample could be considered typical early adopters, we nonetheless see that such traits are more prominent among respondents that are positive to use smart door locks for home delivery of goods and services (i.e. potential adopters) than among respondents that are not positive to do so. This could suggest that smart door locks face particular upscaling challenges, and even more than other innovation need to take into account the perceptions of Potential adopters. Thus, we agree with calls for greater attention to adopter segments from Ratchford et al. (2023) and we consider it necessary to develop typologies of adoption of e-commerce innovations that more explicitly include characteristics of potential adopters.

5.1. An adopter typology for differentiated upscaling strategies

In our study, as well as in previous research (Buldeo Rai et al., 2021; Klink et al., 2024; Nguyen et al., 2024; Olsson et al., 2022; Ratchford et al., 2023; Yuen et al., 2019) it is evident that e-commerce innovation adoption is not merely linked to characteristics of the innovation – which is often main emphasis of research – but also inherent characteristics and perception of individuals and the circumstances of life that influence their decisions. For instance, in our and other studies, adoption is related to an individual's technology literacy and trust, their sociability and social trust, as well as their needs for reducing stress and decreasing the inconveniences in their lives. As a first attempt to build a typology of adopters we have therefore explored a categorizing of potential adopters focusing on characteristics of adopters and their lives, with a particular emphasis on adoption of smart door locks.

Typologies are schematic collections of findings, phenomena or categories, often visualised using four-field models, e.g. with two dimensions (X and Y axis) and four "ideal types" providing synthesised descriptions to describe an essence (Ritzer and Stepinsky, 2014; Svaboe et al., 2023; Tjora, 2021). A typology of different groups of potential adopters can be used to identify differentiated strategies for upscaling of smart door locks as a means for delivering goods and services to consumers.

Our proposed typology is based on three dimensions, drawing upon results from the literature review and quantitative analysis:

*Technological trust*; which is comprised of the individual's interest in technology and innovation, their technological literacy and beliefs in the problem-solving capacity of technology.

*Social trust*; which is comprised of the sociability of individual and the ease with which they connect with others, as well as their trust in people they do not know and their concerns about porch piracy and crime in general.

*Life management needs*; which comprises an individual's need to manage stress and time use, and needs to achieve a desired level of convenience and flexibility.

Based on these we have categorised potential adopters into four groups, which we label Trustful tech-savvy, Distrustful tech-savvy, Trustful analogues, and Distrustful analogues (see Table 8). Throughout the next paragraphs we will discuss potential differentiated upscaling strategies for smart door lock deliveries of goods and services aimed at these groups.

We categorise the typical early adopter as a **trustful tech-savvy** with high life management needs, which implies that they are characterised by high technological and social trust, and leading lives in which smart door locks have an obvious positive impact on flexibility and convenience. Given these traits, upscaling requires little effort beyond disseminating price and availability of door locks and the services that could be delivered by use of such locks. However, upscaling among trustful tech-savvies with low life management needs might be more challenging, as these may not perceive of any *need* to adopt smart door locks. Rather, upscaling could draw on this group's *want* to adopt because of cutting edge technology features that feed their technological curiosity.

This also applies to **distrustful tech-savvies**, who are characterised by high technological trust and literacy, but low social trust. Low needs to manage time, stress and convenience in this group suggests that marketing the technology in itself is a useful upscaling strategy, here-under technological branding, features, promoting possibilities for connecting to other SHT, emphasizing cutting-edge innovativeness, quality of technological components and systems etc. However, in contrast to the trustful tech-savvy, upscaling in this group is inhibited by their lack of social trust. Lack of social trust could be remedied by

**Table 8**  
Proposed upscaling strategies for adoption of smart door locks for home delivery.

	Low life management needs	High life management needs
Trustful tech-savvy	Emphasise technological features Promote in-home services through rendering intelligible the intrinsic potential (benefits)	Price and availability campaigns for smart door locks Promote extensive line of in-home services
Distrustful tech-savvy	Emphasise technological features Promote in-home deliverers of goods and services with sufficient safety certification Connect smart door locks to safety/security enhancing SHT Promote in-home services through rendering intelligible the intrinsic potential (benefits)	Emphasise technological features Promote in-home deliverers of goods and services with sufficient safety certification Connect smart door locks to safety/security enhancing SHT
Trustful analogues	Build technological trust and competence Inform about in-home services	Build technological trust and competence Promote extensive line of in-home services
Distrustful analogues	Build technological trust and competence Promote in-home deliverers of goods and services with sufficient safety certification	Build technological trust and competence Promote in-home deliverers of goods and services with sufficient safety certification Inform about in-home services

promoting trust in deliverers of goods and services, for instance by way of certificates, safe identification procedures and practices, clear distributions of responsibility and liability, transparency and availability of information, keeping consumer in the loop and continuous monitoring when their smart door lock is being used by others. These are all features of a trustworthy digital ecosystem for smart door locks. Trust could also be ensured by emphasising possibilities for connecting smart door locks to other smart home technologies that enhance safety and security.

**Trustful analogues** comprise potential adopters that express high social trust but have little technological trust and competence. Hence, upscaling requires strategies for building technological interest and competence. Potential approaches could be to provide extensive infotainment and simple user manuals, or to include instalment and in-person educational training when selling smart door locks. Furthermore, upscaling in this group could benefit from network sales strategies (i.e. smart door lock home parties) that allow potential adopters to experience and try technologies safely at the homes of friends and families. Providing safe arenas for trial and error with new technologies is essential for reluctant adopters – albeit another challenge arises in successfully recruiting analogues to these arenas.

Such strategies are also important for adoption among **distrustful analogues**, who also express low trust and competence in technology. Furthermore, this group is characterised by low social trust, suggesting that there is a need to build trust in service deliverers. However, adding safety and security enhancing features to smart door locks to remedy lack of social trust is likely less effective in this group than in distrustful tech-savvies, as these add-ons would succumb to the technological distrust of this group. Because of low social trust, creating demand for in-home services might also be more difficult in this group than in trustful analogues. Hence, this group – and especially distrustful analogues with low life management needs – is the most challenging with regard to promoting adoption of smart door locks for home delivery of goods and services. Using diffusion theory (Rogers, 2002), distrustful analogues could be understood as the “laggards” amongst smart door lock adopters, i.e. the last group to adopt smart locks. The laggards will only adopt smart door locks when they are surrounded by people who use, and are satisfied, with it. As such, smart door lock adoption amongst distrustful analogues will most likely happen through informal communication between distrustful analogues and their peers, i.e. adopters sharing positive experiences and opinions about smart door locks with distrustful analogues. Thus, smart door lock adoption for distrustful analogues can happen indirectly through upscaling in the other groups (trustful tech-savvies, distrustful tech-savvies and trustful analogues).

## 5.2. Limitations and further research

The sample described and analysed in sections 3 and 4 of this paper appears descriptive of trustful tech-savvies (Potential adopters in sample) and distrustful tech savvies (Non-adopters in sample), whereof the first group more prominently displays traits corresponding with high life management needs. Hence, this study is particularly descriptive of the group of potential adopters with the highest likelihood of adoption. Although the survey that was investigated in this paper could be considered representative of typical early technology adopters, it is not representative of the general population (see distribution differences between general population and sample in Table 5), which is a limitation. Although an assumption in statistical testing is probability sampling, we have used the tests as analytical tools to study differences between groups (Potential adopters and Non-adopters). Still, using a non-random sample means that the results cannot necessarily be generalized beyond the people studied in the survey (Ringdal, 2018). Thus, there is a need for more research into empirically exploring other adopter groups. Reaching respondents with low technological interest might be challenging when the topic under study is the application of smart home technology, and could be even more difficult when surveys

are conducted digitally. This could exclude potential respondents that are not comfortable with technology altogether creating a bias in the sample. Further research on consumers with low technological trust and literacy should be careful in choices of survey design, as they probably are hard-to-reach groups.

We did not find any differences between Potential adopters and Non-adopters regarding residential area and crime rates. This could be explained by the fact that we could for this study only access information about crime on a county-level. Thus, further research should study the importance of crime and SHT adoption on a neighbourhood-level. Considering rapid development in technological components of SHT, future research could also explore potential synergies with other technological advancements, i.e. automated collection of return shipments, automated detection and retrieval of waste from private dwellings, or automated systems for in-home care delivery. Regardless of its use, the privacy and safety precautions that characterise SHT suggest that any further integration with other technologies – related to first/last mile logistics or not – requires the involvement and evolvement of entire digital ecosystems. This work has focused on user acceptability of unattended delivery of goods and services, and the willingness to allow unattended deliveries. A dimension of the home delivery business to merit further research, is the role and perspective of the courier and service provider, including their assessments and handling of risk and security aspects related to crossing the doorstep to private homes in order to perform the delivery without the recipient being present.

We also welcome discussions, critique and further development of our proposed categorisation of adopter groups, as well as differentiated upscaling strategies. The typology proposed above is largely based on empirical findings in our study and other existing research. Although much of this research draws on understandings from theoretical constructs described in section 2, further development of this or other typologies could benefit from more explicit connections to theories of technology adoption.

## 6. Conclusion

Based on the analyses and discussions above, this paper urges more research into differentiated strategies for adoption and upscaling of smart door locks applied for home delivery of goods and services. We summarise the following potential remedies and capitalization opportunities:

- **Remedies for low social trust:** Promote trust in deliverers of goods and services, for instance by way of certificates, safe identification procedures/practices, clear distributions of responsibility and liability, transparency, provide information, allow consumer to remain in the loop and have continuous updates/monitoring when their smart door lock is being used by others. Connect to other smart home technologies that promote safety and security. Need to push technological features of smart home technologies that remedy lack of social trust.
- **Remedies for low technological trust:** build technological competence and trust, for instance through infotainment and simple user manuals, in-person training lessons, network sales, safe trial and error arenas.
- **Remedies for low life management needs:** This group may not perceive to have a need for smart door locks, as they perceived of their life as sufficiently convenient. Need to develop services/uses of smart door locks that are relevant also to consumers who are not currently regular e-shoppers and are low on in-home consumption.
- **Capitalising on high social trust:** market extensive variation of services.
- **Capitalising on high technological trust:** market extensive variation of services as well as other SHT that could be connected to smart door locks.

- **Capitalising on high life management needs:** Campaigning extensive selection of in-home services that enhance convenience and reduce stress.

### CRediT authorship contribution statement

**Gunnhild Beate Antonsen Svaboe:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Conceptualization. **Kristin Ystmark Bjerkan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Solveig Meland:** Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization.

### Declaration of competing interest

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

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### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.trip.2024.101309>.

### Data availability

The data that has been used is confidential.

### References

- Abe, K., Kawachi, I., Watanabe, T., Tamiya, N., 2021. Association of the frequency of in-home care services utilization and the probability of in-home death. *JAMA Netw. Open* 4. <https://doi.org/10.1001/jamanetworkopen.2021.32787> e2132787.
- Ajzen, I., 1991. The theory of planned behavior. *Org. Behav. Human Dec. Proc. Theor. Cognit. Self-Regul.* 50, 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T).
- Alifah, Q., Kusumawati, N., 2022. Determining determinants and barriers that influence smart home appliances adoption intention using the behavioral reasoning theory method. *Proceedings of the 4th International Conference on Economics, Business and Economic Education Science, ICE-BEES 2021, 27-28 July 2021, Semarang, Indonesia*. Presented at the International Conference on Economics, EAI, Semarang, Indonesia <https://doi.org/10.4108/eai.27-7-2021.2316910>.
- Allen, J., Pieczyk, M., Piotrowska, M., McLeod, F., Cherrett, T., Ghali, K., Nguyen, T., Bektas, T., Bates, O., Friday, A., Wise, S., Austwick, M., 2018. Understanding the impact of e-commerce on last-mile light goods vehicle activity in urban areas: The case of London. *Transp. Res. Part D: Transp. Environ.* 61, 325–338. <https://doi.org/10.1016/j.trd.2017.07.020>.
- Alverhed, E., Hellgren, S., Isaksson, H., Olsson, L., Palmqvist, H., Flodén, J., 2024. Autonomous last-mile delivery robots: a literature review. *Eur. Transp. Res. Rev.* 16, 4. <https://doi.org/10.1186/s12544-023-00629-7>.
- Balta-Ozkan, N., Davidson, R., Bicket, M., Whitmarsh, L., 2013. Social barriers to the adoption of smart homes. *Energy Policy* 63, 363–374. <https://doi.org/10.1016/j.enpol.2013.08.043>.
- Bjerkan, K.Y., Bjørgen, A., Hjelkrem, O.A., 2020. E-commerce and prevalence of last mile practices. *Transp. Res. Procedia* 46, 293–300. <https://doi.org/10.1016/j.trpro.2020.03.193>.
- Buldeo Rai, H., Verlinde, S., Macharis, C., 2021. Unlocking the failed delivery problem? Opportunities and challenges for smart locks from a consumer perspective. *Res. Transport. Econ. E-Groceries Digital. Sustainab.* 87, 100753. <https://doi.org/10.1016/j.retrec.2019.100753>.
- Chen, J., Li, R., Ma, J., An, Q., 2024. Stationary versus mobile parcel lockers: Which self-service technology moves the consumers in the last mile of urban areas? *Travel Behav. Soc.* 35, 100742. <https://doi.org/10.1016/j.tbs.2024.100742>.
- Chen, C., Pan, S., 2016. Using the Crowd of Taxis to Last Mile Delivery in E-Commerce: a methodological research. In: *Service Orientation in Holonic and Multi-Agent Manufacturing*. Springer, Cham, Berlin, pp. 61–70.
- Chen, L., Wu, P., Dou, Y., Wu, Y., 2023. Investigating senders' switching intention to smart lockers: An extension of push-pull-mooring model. *J. Retail. Consum. Serv.* 74, 103414. <https://doi.org/10.1016/j.jretconser.2023.103414>.
- Chuong, H.N., Uyen, V.T.P., Ngan, N.D.P., Tram, N.T.B., Tran, L.N.B., Ha, N.T.T., 2024. Exploring a new service prospect: customer' intention determinants in light of utaut theory. *Cogent Business Manage.* 11, 2291856. <https://doi.org/10.1080/23311975.2023.2291856>.
- Davis, F.D., 1989. Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Q.* 13, 319. <https://doi.org/10.2307/249008>.
- Davis, F.D., Bagozzi, R.P., Warshaw, P.R., 1989. User acceptance of computer technology: A comparison of two theoretical models. *Manag. Sci.* 35, 982–1003.
- Dorling, K., Heinrichs, J., Messier, G.G., Magierowski, S., 2017. Vehicle routing problems for drone delivery. *IEEE Trans. Syst. Man Cybernet. Syst.* 47, 70–85. <https://doi.org/10.1109/TSMC.2016.2582745>.
- Encarnación, T., Amaya, J., 2024. Determinants of parcel locker adoption for last-mile deliveries in urban and suburban areas. *Transp. J.* <https://doi.org/10.1002/tjo.3.12031>.
- Engesser, V., Rombaut, E., Vanhaverbeke, L., Lebeau, P., 2023. Autonomous delivery solutions for last-mile logistics operations: A literature review and research agenda. *Sustainability* 15, 2774. <https://doi.org/10.3390/su15032774>.
- Ferrell, E., 2024. A critical review of in-home services for children with neonatal abstinence syndrome and their families. *J. Child Fam. Stud.* 33, 594–606. <https://doi.org/10.1007/s10826-024-02782-6>.
- Gatta, V., Marcucci, E., Pira, M.L., 2023. Chapter 21: E-commerce and urban logistics: trends, challenges, and opportunities. In: *Geography, Planning and Tourism 2023*, pp. 422–443.
- Ghajargar, M., Zenezini, G., Montanaro, T., 2016. Home delivery services: innovations and emerging needs. *IFAC-PapersOnLine*, 8th IFAC Conference on Manufacturing Modelling, Management and Control, 10.1016/j.ifacol.2016.07.755.
- Goodchild, A., Ivanov, B., McCormack, E., Moudon, A., Scully, J., Machado, J., Gabriela, L., Valderrama, G., 2018. Are cities' delivery spaces in the right places? mapping truck load/unload locations. In: Taniguchi, E., Thompson, R.G. (Eds.), *City Logistics 2: Modelling and Planning Initiatives*. Wiley, London/Hoboken.
- Guthrie, C., Fosso-Wamba, S., Arnaud, J.B., 2021. Online consumer resilience during a pandemic: An exploratory study of e-commerce behavior before, during and after a COVID-19 lockdown. *J. Retail. Consum. Serv.* 61, 102570. <https://doi.org/10.1016/j.jretconser.2021.102570>.
- Hoel, K.-A., Rokstad, A.M.M., Feiring, I.H., Lichtwarck, B., Selbæk, G., Bergh, S., 2021. Person-centered dementia care in home care services – highly recommended but still challenging to obtain: a qualitative interview study. *BMC Health Serv. Res.* 21, 723. <https://doi.org/10.1186/s12913-021-06722-8>.
- Hong, A., Nam, C., Kim, S., 2020. What will be the possible barriers to consumers' adoption of smart home services? *Telecommun. Policy* 44, 101867. <https://doi.org/10.1016/j.telpol.2019.101867>.
- Klink, B.D., Schweizer, S., Rudolph, T., 2024. Identifying and testing drivers of consumers' attitude towards last-mile delivery modes. *Electron. Comm. Res.* <https://doi.org/10.1007/s10660-024-09834-5>.
- Köhler, C., Campbell, A.M., Ehmke, J.F., 2024. Data-driven customer acceptance for attended home delivery. *OR Spectr.* 46, 295–330. <https://doi.org/10.1007/s00291-023-00712-4>.
- Kotlars, A., Skribans, V., 2024. Literature review: Efficiency, environment and robotization in first and last mile logistics. *Transp. Res. Interdiscip. Perspect.* 27, 101215. <https://doi.org/10.1016/j.trip.2024.101215>.
- Le, H.T.K., Carrel, A.L., Shah, H., 2022. Impacts of online shopping on travel demand: a systematic review. *Transp. Res.* 42, 273–295. <https://doi.org/10.1080/01441647.2021.1961917>.
- Leung, E.K.H., Ouyang, Z., Huang, G.Q., 2023. Community logistics: a dynamic strategy for facilitating immediate parcel delivery to smart lockers. *Int. J. Prod. Res.* 61, 2937–2962. <https://doi.org/10.1080/00207543.2022.2073480>.
- Li, F., Kunze, O., 2023. A comparative review of air drones (UAVs) and delivery bots (SUGVs) for automated last mile home delivery. *Logistics* 7, 21. <https://doi.org/10.3390/logistics7020021>.
- Li, W., Yigitcanlar, T., Erol, I., Liu, A., 2021. Motivations, barriers and risks of smart home adoption: From systematic literature review to conceptual framework. *Energy Res. Soc. Sci.* 80, 102211. <https://doi.org/10.1016/j.erss.2021.102211>.
- Ma, B., Wong, Y.D., Teo, C.-C., 2022. Parcel self-collection for urban last-mile deliveries: A review and research agenda with a dual operations-consumer perspective. *Transp. Res. Interdiscip. Perspect.* 16, 100719. <https://doi.org/10.1016/j.trip.2022.100719>.
- Maat, K., Konings, R., 2018. Accessibility or innovation? Store shopping trips versus online shopping. *Transp. Res. Rec.* 2672, 1–10. <https://doi.org/10.1177/0361198118794044>.
- Mamonov, S., Benbunan-Fich, R., 2021. Unlocking the smart home: exploring key factors affecting the smart lock adoption intention. *Inf. Technol. People* 34, 835–861. <https://doi.org/10.1108/ITP-07-2019-0357>.
- Manerba, D., Mansini, R., Zanotti, R., 2018. Attended Home Delivery: reducing last-mile environmental impact by changing customer habits. *IFAC-PapersOnLine* 51, 55–60. <https://doi.org/10.1016/j.ifacol.2018.06.199>.
- Mangiaracina, R., Perego, A., Seghezzi, A., Tumino, A., 2019. Innovative solutions to increase last-mile delivery efficiency in B2C e-commerce: a literature review. *IJPDLM* 49, 901–920. <https://doi.org/10.1108/IJPDLM-02-2019-0048>.
- Morganti, E., Dablan, L., Fortin, F., 2014. Final deliveries for online shopping: The deployment of pickup point networks in urban and suburban areas. *Res. Transport.*



- Bus. Manage. Manag. Freight Urban Areas 11, 23–31. <https://doi.org/10.1016/j.rtbm.2014.03.002>.
- Nguyen, N., Nguyen, M.T., Nguyen, T.T.C., Nguyen, M.H., 2024. Customer switching intention from home delivery to smart locker delivery: Evidence from Vietnam. *Innov. Mark.* 20, 140–151. [https://doi.org/10.21511/im.20\(2\).2024.12](https://doi.org/10.21511/im.20(2).2024.12).
- Olsson, J., Osman, M.C., Hellström, D., Vakulenko, Y., 2022. Customer expectations of unattended grocery delivery services: mapping forms and determinants. *IJRDM* 50, 1–16. <https://doi.org/10.1108/IJRDM-07-2020-0273>.
- Peppel, M., Spinler, S., Winkenbach, M., 2024. Integrating mobile parcel lockers into last-mile delivery networks: an operational design for home delivery, stationary, and mobile parcel lockers. *Internat. J. Phys. Distrib. Log. Manage.* 54, 418–447. <https://doi.org/10.1108/IJPDLM-01-2023-0055>.
- Periyasamy, S., Joghee, M.V., Kaushik, S., Gongada, T.N., Naqvi, S.R., Chandra, A., 2023. Analysis of delivery issues that customer face upon E-commerce. *World J. Manage. Econ.*
- Ratchford, B., Gauri, D.K., Jindal, R.P., Namin, A., 2023. Innovations in retail delivery: Current trends and future directions. *J. Retail.* 99, 547–562. <https://doi.org/10.1016/j.jretai.2023.10.006>.
- Reyes, D., Savelsbergh, M., Toriello, A., 2017. Vehicle routing with roaming delivery locations. *Transp. Res. Part C Emerging Technol.* 80, 71–91. <https://doi.org/10.1016/j.trc.2017.04.003>.
- Ringdal, K., 2018. *Enhet og mangfold*, 4th ed. Fagbokforlaget, Bergen.
- Ritzer, G., Stepinsky, J., 2014. *Sociological Theory*, 9th ed. McGraw-Hill Education, Singapore.
- Rogers, E.M., 1962. *Diffusion of innovations*, 1st ed. The Free Press, New York.
- Rogers, E.M., 2002. Diffusion of preventive innovations. *Add. Behav. Integ. Subst. Abuse Treat. Prevent. Commun.* 27, 989–993. [https://doi.org/10.1016/S0306-4603\(02\)00300-3](https://doi.org/10.1016/S0306-4603(02)00300-3).
- Sawik, B., 2024. Optimizing last-mile delivery: A multi-criteria approach with automated smart lockers, capillary distribution and crowdshipping. *Logistics* 8, 52. <https://doi.org/10.3390/logistics8020052>.
- Schade, J., Schlag, B., 2000. Acceptability of urban transport pricing. *VATT-tutkimuksia. Valtion Taloudellinen Tutkimuskeskus, Helsinki.*
- Schade, J., Schlag, B., 2003. Acceptability of urban transport pricing strategies. *Transport. Res. F: Traffic Psychol. Behav.* 6, 45–61. [https://doi.org/10.1016/S1369-8478\(02\)00046-3](https://doi.org/10.1016/S1369-8478(02)00046-3).
- Schlag, D.B., 1997. *Public acceptability of Transport Pricing*. Dresden University of Technology, Dresden.
- Shin, J., Park, Y., Lee, D., 2018. Who will be smart home users? An analysis of adoption and diffusion of smart homes. *Technol. Forecast. Soc. Chang.* 134, 246–253. <https://doi.org/10.1016/j.techfore.2018.06.029>.
- Siegfried, P., Michel, A., Tänzler, J., Zhang, J.J., 2021. Analyzing sustainability issues in urban logistics in the context of growth of E-Commerce. *J. Soc. Sci. IV* 6–11.
- Singh, R., Söderlund, M., 2022. There is no place like home: home satisfaction and customer satisfaction in online grocery retailing. *Internat. Rev. Retail Distrib. Consumer Res.* 32, 370–387. <https://doi.org/10.1080/09593969.2022.2073555>.
- Statistics Norway, 2023. *Familier og husholdninger* [WWW Document]. SSB. URL <https://www.ssb.no/befolkning/barn-familier-og-husholdninger/statistikk/familier-og-husholdninger> (accessed 6.13.24).
- Statistics Norway, 2024a. *Tilknytning til arbeid, utdanning og velferdsordninger* [WWW Document]. SSB. URL <https://www.ssb.no/arbeid-og-lonn/sysselsetting/statistikk/tilknytning-til-arbeid-utdanning-og-velferdsordninger> (accessed 6.13.24).
- Statistics Norway, 2024b. *Boliger* [WWW Document]. SSB. URL <https://www.ssb.no/bygg-bolig-og-eiendom/bolig-og-boforhold/statistikk/boliger> (accessed 6.13.24).
- Statistics Norway, n.d. 07184: Husholdninger, etter statistikkvariabel og år. Statistikkbanken [WWW Document]. SSB. URL <https://www.ssb.no/statbank/table/07184/tableViewLayout1/> (accessed 6.13.24e).
- Statistics Norway, n.d. 06071: Personer, etter husholdningstype, statistikkvariabel og år. Statistikkbanken [WWW Document]. SSB. URL <https://www.ssb.no/statbank/table/06071/tableViewLayout1/> (accessed 6.13.24f).
- Statistics Norway, n.d. 07459: Befolkning, etter region, kjønn, statistikkvariabel og år. Statistikkbanken [WWW Document]. SSB. URL <https://www.ssb.no/statbank/table/07459/tableViewLayout1/> (accessed 6.13.24d).
- Statistics Norway, n.d. 08921: Personer 16 år og over, etter region, kjønn, alder, utdanningsnivå, statistikkvariabel og år. Statistikkbanken [WWW Document]. SSB. URL <https://www.ssb.no/statbank/table/08921/tableViewLayout1/> (accessed 6.13.24c).
- Statistics Norway, n.d. 09765: Husholdninger, etter boligtype og husholdningstype 1 (prosent) (avslutta serie) 2012 - 2018. Statistikkbanken [WWW Document]. SSB. URL <https://www.ssb.no/statbank/table/09765/> (accessed 6.13.24b).
- Statistics Norway, n.d. Statistikkbanken [WWW Document]. SSB. URL <https://www.ssb.no/statbank> (accessed 6.13.24a).
- Stickle, B., Hicks, M., Stickle, A., Hutchinson, Z., 2020. Porch pirates: examining unattended package theft through crime script analysis. *Crim. Justice Stud.* 33, 79–95. <https://doi.org/10.1080/1478601X.2019.1709780>.
- Strauss, A., Gülpınar, N., Zheng, Y., 2021. Dynamic pricing of flexible time slots for attended home delivery. *Eur. J. Oper. Res.* 294, 1022–1041. <https://doi.org/10.1016/j.ejor.2020.03.007>.
- Svaboe, G.B.A., Blekesaune, A., Tørset, T., 2023. Understanding skepticism of smartphones in travel behavior research: A qualitative approach. *Transp. Res. Interdiscip. Perspect.* 22, 100935. <https://doi.org/10.1016/j.trip.2023.100935>.
- Tjora, A., 2021. *Kvalitative forskningsmetoder i praksis*, 4th ed. Gyldendal akademisk, Oslo.
- Tsiotsou, R.H., Boukis, A., 2022. In-home service consumption: A systematic review, integrative framework and future research agenda. *J. Bus. Res.* 145, 49–64. <https://doi.org/10.1016/j.jbusres.2022.02.050>.
- Venkatesh, V., Davis, F.D., 2000. A theoretical extension of the technology acceptance model: four longitudinal field studies. *Manag. Sci.* 46, 186–204. <https://doi.org/10.1287/mnsc.46.2.186.11926>.
- Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D., 2003. User acceptance of information technology: toward a unified view. *MIS Q.* 27, 425–478. <https://doi.org/10.2307/30036540>.
- Visser, J., Nemoto, T., Browne, M., 2014. Home delivery and the impacts on urban freight transport: A review. *procedia - social and behavioral sciences*. In: Eighth International Conference on City Logistics 17-19 June 2013, Bali, Indonesia 125, pp. 15–27. <https://doi.org/10.1016/j.sbspro.2014.01.1452>.
- Vrain, E., Wilson, C., 2021. Social networks and communication behaviour underlying smart home adoption in the UK. *Environ. Innov. Soc. Trans.* 38, 82–97. <https://doi.org/10.1016/j.eist.2020.11.003>.
- Wang, X., Yuen, K.F., Wong, Y.D., Teo, C.C., 2018. An innovation diffusion perspective of e-consumers' initial adoption of self-collection service via automated parcel station. *IJLM* 29, 237–260. <https://doi.org/10.1108/IJLM-12-2016-0302>.
- Wang, X., Yuen, K.F., Wong, Y.D., Teo, C.-C., 2020. E-consumer adoption of innovative last-mile logistics services: A comparison of behavioural models. *Total Qual. Manag. Bus. Excell.* 31, 1381–1407. <https://doi.org/10.1080/14783363.2018.1485484>.
- Yoo, W., Yu, E., Jung, J., 2018. Drone delivery: Factors affecting the public's attitude and intention to adopt. *Telematics Inform.* 35, 1687–1700. <https://doi.org/10.1016/j.tele.2018.04.014>.
- Yousefi, N., Wang, K., Circella, G., 2023. Factors influencing the types of merchandise purchased online: Evidence from the 2018 California survey of emerging transportation trends. *Transp. Res. Interdiscip. Perspect.* 17, 100734. <https://doi.org/10.1016/j.trip.2022.100734>.
- Yuen, K.F., Wang, X., Ma, F., Wong, Y.D., 2019. The determinants of customers' intention to use smart lockers for last-mile deliveries. *J. Retail. Consum. Serv.* 49, 316–326. <https://doi.org/10.1016/j.jretconser.2019.03.022>.
- Yusoff, F., Mohamad, F., Tamyaz, P., Panatik, S., 2023. Do I need to use it? Factors influencing the intention to adopt automated parcel lockers as last-mile delivery services. *AL* 10, 567–575. <https://doi.org/10.22306/al.v10i4.435>.
- Zieher, S., Olcay, E., Kefferpütz, K., Salamat, B., Olzem, S., Elsbacher, G., Meeß, H., 2024. Drones for automated parcel delivery: Use case identification and derivation of technical requirements. *Transp. Res. Interdiscip. Perspect.* 28, 101253. <https://doi.org/10.1016/j.trip.2024.101253>.