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Careless product use in access-based services: A rebound effect and how to address it

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ABSTRACT

The sharing economy promises to alleviate environmental pressures by optimizing the distribution and use of resources, for example, shifting from ownership to access-based services. Services that grant users access for a long period only improve sustainability if they extend product lifetimes. However, careless use of accessed products reduces product lifetimes. We investigate the problem–solution space of product care in access-based services. A user survey reveals significantly lower product care for accessed than owned washing machines. We then systematically develop solutions to stimulate product care in access-based services, resulting in ten strategies and 23 design solutions. Levers and barriers to promoting product care are uncovered through interviews with access-based service providers; the range of products impacts providers' ability to implement product-specific care strategies, the service can be designed to deter or attract user groups, and providers' control over the supply chain determines which product care strategies they can implement.

1. Introduction

Sharing practices have been commonplace for millennia, but digitalization has unlocked new ways of sharing over the last two decades (Belk, 2014). In the sharing economy, consumers take center stage as they access products and services. Consumers share, lend, borrow, trade, lease, and rent products.

Examples of sharing economy business models are access-based services. These allow consumers to use products' functionalities for a fee without transfer of ownership. Access-based services are often conceptualized as part of the sharing economy (Acquier et al., 2017; Curtis and Mont, 2020; Frenken and Schor, 2017; Klarin and Suseno, 2021). These services differ in temporality (Bardhi and Eckhardt, 2012; Tunn et al., 2021); for example, shared laundry facilities and rented washing machines are both access-based services; the former grants short-term access (typically for the duration of a washing cycle), while the latter grants long-term access (also referred to as leasing), for months or years (Belk, 2014; Tunn et al., 2021).

Recent literature scrutinized the sustainability assumptions on which the sharing economy is built (Acquier et al., 2017; Frenken, 2017; Geissinger et al., 2019; Gossen et al., 2019; Meshulam et al., 2021;

Parguel et al., 2017). Similarly, the sustainability potential of access-based services is debated (Kjaer et al., 2019; Tukker, 2004). While both concepts initially gained attention for their sustainability potential, this potential is often not (fully) realized in practice. For instance, Wasserbauer et al. (2020) found that wide adoption of shared washing machines could significantly reduce greenhouse gas emissions. Yet, access-based services only improve sustainability under specific conditions (Agrawal et al., 2012; Wasserbauer et al., 2020; Zamani et al., 2017).

The sustainability potential of access-based services hinges on increased utilization and extended product lifetimes. For example, research on access-based services shows that some users treat accessed products carelessly (Bardhi and Eckhardt, 2012; Sumter et al., 2018), decreasing their sustainability. Product care is particularly crucial in services granting consumers long-term exclusive access (Agrawal et al., 2012), as users' product care, or lack thereof, influences product lifetimes. Therefore, a lack of product care constitutes a potential rebound effect of access-based services; rebound effects diminish or offset expected sustainability improvements (Hertwich, 2005). However, the problem–solution space of product care in long-term access-based services has received little attention so far. It is neither clear to what extent

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product care levels differ between ownership and long-term access nor have solutions to alleviate this problem been investigated systematically.

We contribute to theory and practice in the following three ways. First, we contribute to the service literature by systematically exploring the problem–solution space of product care in access-based services. To this end, we first delineate the terms product care, originating from the design literature (Ackermann et al., 2018; van Nes and Cramer, 2005), and customer misbehavior, originating from the service literature (Fisk et al., 2010; Schaefers et al., 2016), in the context of access-based services. Careless behavior in access-based services has been mentioned (Bardhi and Eckhardt, 2012; Sumter et al., 2018) but we have yet to find conclusive insights on how care levels compare in ownership and access business models. We address the problem space by investigating product care levels of access-based service users and owners of similar products. The solution space is also largely unexplored; only Schaefers et al. (2016) and Srivastava et al. (2021) provide some suggestions to improve product care based on their empirical investigation of customer misbehavior. We contribute ten systematically developed and validated design strategies to stimulate product care in access-based services and identify three levers and barriers.

Second, we contribute to the sustainability literature on rebound effects. In the recent literature on the rebound effects of access-based services, the effects of careless product use are missing (Amatuni et al., 2020; Castro et al., 2022). We argue and empirically demonstrate that careless use of products constitutes a rebound effect of access-based services.

Third, we contribute to practice by providing design strategies and solutions to stimulate product care that providers of access-based services can implement. This research highlights the importance of considering product care in access-based business models to realize the sustainability potential of long-term access-based services² that are framed as promising in the sharing economy. Using a design perspective and involving service users and providers in the research ensures the practical relevance of the outcomes.

2. Theoretical background

2.1. Access-based services - environmentally promising business models?

The business model concept describes a firm's way of doing business (DaSilva and Trkman, 2014; Osterwalder et al., 2005). Richardson (2008) decomposed the business model concept into three components: value proposition, value creation and delivery, and value capture. The core business model of access-based services entails a firm granting customers temporary access to products (value proposition) by obtaining products, organizing their distribution and maintenance (value creation and delivery), and charging customers a fee for either usage or temporary exclusive access (value capture).

Access-based services might reconcile environmental and business objectives. Wasserbaur et al. (2020) concluded that the wide adoption of shared washing machines could significantly reduce greenhouse gas emissions due to fewer washing machines needed and extended lifetimes of professional machines. However, Agrawal et al. (2012), who investigated the sustainability of leased durable goods, obtained mixed results. While “leasing can be a win–win strategy for products that have a higher use impact (compared to their production and disposal impacts) and low durability such as personal printers and photocopiers [...] products that have a high use impact but higher durability, such as washers, dryers, and refrigerators, leasing can be a win–win strategy only if the product durability is higher under leasing” (Agrawal et al.,

2012, p. 529). Research has also investigated clothing libraries using lifecycle assessment. While clothing libraries can reduce the demand for new garments, the required logistics can offset this (Zamani et al., 2017). Furthermore, clothing libraries only improve sustainability for target segments with high fashion consumption (Piontek and Müller, 2023).

The sustainability potential of access-based services hinges on two assumptions. Accessed products are assumed to substitute owned products, reducing the overall number of products needed (e.g., shared laundry facilities substitute washing machine ownership). In addition, accessed products are expected to be used more often during their lifetime because different users access them sequentially, and providers maintain and repair them to profit from their use for as long as possible (Tukker, 2004).

2.2. Product care in access-based services

Product care comprises “all activities initiated by the consumer that leads to the extension of a product's lifetime” (Ackermann et al., 2018, p.1). Apart from maintenance and repair, this concept also includes careful handling of products and protective measures such as covers for laptops or smartphones. Product care helps maintain products at the highest utility and value (see also Ghisellini et al., 2016; Wieser and Tröger, 2018), contributing to sustainability. Thus, product care is highly relevant in access-based services as their sustainability is partly based on extended lifetimes.

Research suggests that product care might be lacking in access-based services. Consumers take care of products they feel attached to and see as parts of their extended selves (Belk, 1988). However, research has shown that consumers perceive low psychological ownership in access-based services (Bardhi and Eckhardt, 2012; Fritze et al., 2020). Several authors have mentioned the issue of product care in access-based services. Tukker (2004, p. 256) cautioned, “The fact that the user no longer owns the product could even lead to negative effects, such as careless use shortening its useful life span”. Bardhi and Eckhardt (2012) noted the careless behavior of car-sharing users. Further evidence was provided by Sumter et al. (2018) through a case study of a long-term access-based service for strollers. They noted that “one third of the returned strollers were highly damaged” (Sumter et al., 2018, p.9).

A concept related to product care is *customer misbehavior* (Schaefers et al., 2016; Srivastava et al., 2021). Schaefers et al., (2016, p.5) define customer misbehavior in access-based services as “inappropriate handling, damage, or overuse of the accessed good”. Both Schaefers et al. (2016) and Srivastava et al. (2021) investigated customer misbehavior in short-term access-based services. Schaefers et al. (2016) showed a contagious effect of customer misbehavior; for instance, previous misbehavior of customers influences others' behavior. Building on this work, Srivastava et al. (2021) found that strengthening customer-company identification as well as injunctive norms can reduce this effect.

The concept of customer misbehavior was developed in the service literature with a focus on customer-firm interaction to improve the quality and financial viability of such services (Fisk et al., 2010; Schaefers et al., 2016). The product care concept, on the other hand, arose in the sustainable design literature (see also Bhamra et al., 2011; Daae et al., 2018; van Nes and Cramer, 2005), focusing on behavior change through design to extend product lifetimes. Design researchers promote strategies for product lifetime extension that focus on technical aspects of product design, such as the use of standard connectors to enable easy disassembly during repair and maintenance or modular product design (e.g., Bocken et al., 2016; Charter and Tischner, 2001; Cooper, 2010). However, product care highly depends on consumers, requiring their initiative, time, and effort. Consequently, their role must be considered more (Ghisellini et al., 2016; Sonogo et al., 2022; Wastling et al., 2018). Ackermann et al. (2021a) provide eight strategies that consider consumers' perspectives on product care and can be used to stimulate product care during the design phase. These strategies have

² For brevity, we refer to long-term access-based services as access-based services in the remainder of this manuscript unless service temporality requires explicit highlighting.

been developed and tested for owned products (see also Ackermann et al., 2021c).

2.3. Careless product use in access-based services - a rebound effect?

Goedkoop et al. (1999) found that car-sharing services lead to financial savings that were spent on higher-impact consumption. Vivanco et al. (2015) confirmed this; they concluded that bicycle sharing and car sharing increase overall emissions because of consumers' cost savings. These are examples of the economic rebound effect in access-based services. Several rebound effects have been found, such as shifts of consumption to other economic sectors (Chitnis et al., 2013) and economy-wide effects (Brookes, 2000). We adopt Hertwich's (2005, p.86) definition: "the rebound effect refers to a behavioral or other systemic response to a measure taken to reduce environmental impacts that offsets the effect of the measure". A lack of product care in access-based services may yield a behavioral rebound effect as it creates a gap between the environmental potential and the realized environmental gains of such services.

So far, product care has only been studied in short-term access-based mobility services. Analogous to ownership, long-term access-based services grant exclusive access to products; extending product lifetimes is crucial for the sustainability potential of such services (Agrawal et al., 2012; Wasserbauer et al., 2020). Due to the long period of exclusive access, responsibility for regular product care lies with the users. The problem-solution space of careless user behavior in long-term access-based services² needs to be better understood to help realize the sustainability potential of such services. A comparison of product care levels of users and owners of products is lacking, and available product care design strategies have been developed for products owned by consumers (see Ackermann et al., 2021a). We pose the following research questions to address this:

1. How do consumers treat products they use through access-based services?
2. How can access-based services stimulate product care among users?
 - a. How can access-based service business models be designed to increase product care among users?
 - b. How do providers of access-based services address consumer product care through their business model design?

We study product care for washing machines because product care differs between products (see also Ackermann et al., 2021a). We investigate washing machines as they provide a high functional value in daily life, are used by most people, are designed for consumers to execute product care activities that extend the product lifetime (e.g., cleaning filters), and are already available through access-based services. As a pre-study, we conducted a survey with users of access-based and owned washing machines to compare their product care levels. We found significantly lower product care for accessed washing machines. The main study, therefore, systematically develops and evaluates design strategies to stimulate product care in access-based services. First, we conduct a qualitative survey with designers to obtain specific design strategies. Second, we interview providers of access-based washing machines to evaluate the design strategies and to collect their strategies to stimulate product care.

3. Pre-study: Consumer product care in access-based services

3.1. Method: User survey

Through an online survey, we explored product care behavior and product perception of users of access-based services and consumers owning comparable products. First, participants were asked about their consumption mode of washing machines (owned vs. used through access-based service). Subsequently, we presented relevant care

activities for washing machines (e.g., inspecting the hoses, not overloading the machine and asked how often these activities are conducted. To determine participants' levels of product care we used the scale by Ackermann et al. (2021b; $\alpha = 0.94$). We added several established scales to measure participants' attitudes towards their products (for more details see Tunn and Ackermann, 2020). For the sake of brevity, we only report our findings on attachment, measured by four items based on Schifferstein and Zwartkruis-Pelgrim (2008), $\alpha = 0.75$, as these insights were used as input for the main study, part 1.

Consumer adoption of access-based services still needs to be improved outside the mobility sector (e.g., De Bruyne and Verleye, 2022; Tunn et al., 2021), making it difficult to reach a large number of users. We thus resorted to recruiting a non-probability sample through social media (Stern et al., 2017) between September and October 2019. The sample comprises Dutch participants as well as students and expats living in the Netherlands. Seventy surveys were completed; 86 were sufficiently filled in to be included in the analysis. Of the participants, 42 were aged 30 or younger, with 29 males and 41 females. We obtained $n = 37$ responses for access-based products and $n = 49$ responses for owned products (bought new or second-hand). Participants could enter a prize draw to win €10 gift vouchers.

3.2. Results

Product care differs significantly between owners of washing machines and users of access-based washing machines ($t(84) = 2.12, p = .037$), with the mean value for owned washing machines being higher ($M_{\text{owned}} = 4.48, SD = 1.44$) than for accessed washing machines ($M_{\text{access}} = 3.79, SD = 1.55$). The use frequency differs significantly between owners ($Mdn =$ several times per week) and users of access-based services ($Mdn =$ once a week), $U(N_{\text{owned}} = 49, N_{\text{access}} = 37) = 527, p < .001$, as well as the frequency of some care activities (not overloading the machine, using the right type and amount of detergent, cleaning the interior and dispensers, cleaning filters, making sure the washing machine is level). However, for other care activities (inspecting the hoses, wiping down the drum and door, transferring clean laundry to the dryer as soon as possible, leaving the door ajar after a load), no significant differences are found, leading to the conclusion that a higher frequency of use does not necessarily lead to more frequent care activities. Owners' attachment towards their washing machines ($M_{\text{owned}} = 3.56, SD = 1.39$) is significantly higher than that of users accessing washing machines ($M_{\text{access}} = 2.58, SD = 1.07, t(68) = 3.22, p = .002$).

The pre-study quantitatively confirms that consumers take less care of accessed than owned products, as anecdotally suggested by previous studies (Bardhi and Eckhardt, 2012; Sumter et al., 2018). We can, therefore, establish a lack of product care as a rebound effect of access-based services. Thus, fostering product care in such services is paramount to contributing to sustainability. The lack of attachment indicates the absence of an emotional consumer-product relationship. A limitation of this pre-study is that we did not assess the condition in which the washing machines were bought or received from the service provider. For example, washing machines in access-based services might have been repaired and cleaned before, resulting in an overall good state and therefore requiring less product care than owned washing machines of the same age products. The washing machines' age might also be a relevant factor: Older washing machines could, on the one hand, require more product care than new products; on the other hand, consumers might be less willing to take care of a product that is already considered old (see also Braithwaite et al., 2015; Wieser et al., 2015).

4. Main study: Solution ideation and practitioner evaluation

The main study develops and evaluates design strategies to stimulate product care in access-based services to address the low product care levels of accessed products identified in the pre-study.

4.1. Method: Qualitative survey with designers

We distributed a qualitative online questionnaire among design experts to develop design solutions that stimulate product care in access-based services. These experts were chosen as creative solutions are a core aspect of their profession and to ensure that design solutions have the potential to be implemented in practice.

The questionnaire (see Appendix A) introduced access-based services, the critical challenges regarding product care based on the pre-study, and an outline of what product care entails for washing machines. We used the product care design strategies by Ackermann et al. (2021a) as a starting point for the ideation process. The task was to redesign the business model of access-based washing machines, which included different aspects, for example, product and service elements, user-provider and user-product interaction, and cost structure. We provided a brief explanation of each design strategy (see Appendix B). The experts provided their suggestions for implementing these strategies in open-text fields.

4.1.1. Sample of sustainable design experts

Through our networks and snowballing, we sampled sustainable design experts who were either trained as designers or had been working in the field of sustainable design for at least two years. We invited 22 experts to complete our survey and received nine responses (response rate 41 %). We collected the data between February and April 2022. The respondents are based in the Netherlands, Germany, and Austria. In Table 1, an overview of the participating experts is presented.

4.1.2. Clustering and analysis

Each expert provided one or more design suggestions for each of the eight design strategies (Appendix B), resulting in 164 design suggestions. After eliminating 27 suggestions that were either unclear, generic, or mentioned more than once by the same expert, 137 design suggestions were left, which were then combined into 72 unique suggestions. The design strategies by Ackermann et al. (2021a) inspired the design experts' ideation, but some solution suggestions did not match these strategies. Therefore, the suggestions provided by experts were clustered into ten design strategies and 24 design solutions. The design solutions were clustered according to the existing product care strategies (see Ackermann et al., 2021a). Not all design solutions fit into the existing strategies, resulting in two additional strategies (Rewards & fines, Investing). In total, ten design strategies for product care in access-based services were identified.

4.2. Method: Interviews with providers of access-based services

We conducted semi-structured interviews with access-based washing machine providers. These interviews had two purposes: to evaluate the design strategies with experts of the investigated business models from practice and to serve as input for the cases to analyze how providers experience and stimulate product care in practice. To use the interviews

Table 1
Demographics and expertise of the sustainable design experts.

Expert #	Age	Gender	Position	Design experience
E1	38	female	Creative director and strategist	10 years
E2	34	male	Designer & researcher	3 years
E3	33	male	Strategic brand developer	3 years
E4	29	male	Strategic product designer	3 years
E5	29	male	Industrial designer	5 years
E6	32	male	Designer & researcher	14 years
E7	28	female	Designer & researcher	6 years
E8	32	female	Strategic product designer & researcher	6 years
E9	40	female	Designer	10 years

as case studies, we supplemented them with information from the providers' websites (see HOMIE, 2023; Mieten statt kaufen, 2023; Skala, 2023; Splash, 2023) and documents provided by the interviewees.

The interviews consisted of three parts. First, the washing machine business models were discussed, as well as consumer behavior within these business models and how it affected the companies. Second, the ways the companies try to stimulate desirable behavior and their effects were explored. Third, the interviewees evaluated the previously developed design. This evaluation led to reflections on related measures that the company had taken and insights into the perceived feasibility and effectiveness of these strategies.

4.2.1. Sample of access-based washing machine providers

Through desk research, we identified 11 companies providing access-based washing machines to consumers in the Netherlands, Germany, and Austria. We selected these countries to match the scope of the main study, part 1. Furthermore, these Western European countries fall under similar regulations and have comparable cultures. All 11 companies were contacted, and five were interviewed between April and June 2023. The company name of the Subsidiary of an original equipment manufacturer (OEM) was anonymized upon the interviewee's request. Details about the interviews are provided in Table 2.

4.2.2. Analysis and interpretation

Given the different purposes of the interviews, the analysis differed between the sections. To evaluate the strategies developed by design experts, we summarized the responses per strategy and, if applicable, added examples of how the provider has implemented this strategy. We infer that strategies that many providers have implemented are perceived as both feasible and effective. Strategies that had not yet been implemented were discussed in more detail, which resulted in an evaluation of the perceived feasibility and effectiveness and sometimes sparked providers to come up with ideas for implementation. We interpret strategies that were not evaluated as feasible and effective, and that did not spark ideas for implementation as the least suitable strategies for access-based washing machines.

While analyzing the interviews, we realized that some differences between the providers were more fundamental than the design strategies developed by the design experts. To obtain additional insights into how providers' business models do or do not stimulate product care, we compared the five providers' business models, their perception of product care, and the implemented changes. Using Richardson's (2008) business model framework, we identified business model elements that either enabled providers or that providers leveraged to improve product care.

5. Results and discussion

In this section, we present the design strategies for product care proposed by design experts (main study part 1) and discuss them in light of the insights and evaluations obtained from access-based washing machine providers (main study part 2). Finally, we provide insights into how providers' business models affect product care (also main study part 2).

Table 2
Overview of interviews with access-based washing machine providers.

Provider	Country	Position	Interview duration
Mieten statt kaufen (in English: Rent instead of buying)	AT	Founder & CEO	64 min
HOMIE	NL	CEO	71 min
Elbuco (Skala)	NL	Operational director	78 min
Subsidiary of OEM	DE	Head of Design	65 min
Splash	NL	Founder & CEO	84 min

5.1. Strategies to design access-based services for product care

Eight of the ten strategies align with those presented to the experts (Appendix B): Informing, Short-term awareness, Long-term awareness, Enabling, Controlling, Social interaction, Appropriating, and Bonding (Ackermann et al., 2021a). Some strategies were renamed for better alignment with design solutions. Two additional unique strategies for access-based services were identified: Rewards & fines and Investing. In the following, we provide a brief description of each strategy, discuss relevant prior research, and share insights from the interviews with providers of access-based washing machines (main study part 2). A comprehensive overview of the design strategies and solutions can be found in Table 3.

The *Informing* (1) strategy involves providing users with product care information through various channels and personal interactions. This strategy helps overcome the lack of knowledge about the product and care for it (Amend et al., 2022; Laitala et al., 2021). Encouraging information exchange from users to providers can help track the condition of accessed products (Srivastava et al., 2021). Providers employing this strategy (HOMIE, Elbuco, Splash) utilize QR codes on washing machines, online resources, instructional videos, care-related emails, or physical instructions. In the case of Mieten statt kaufen, which lacks direct customer contact, they use manuals provided by the washing machine manufacturer.

The *Short-term awareness* (2) strategy involves notifying users of the immediate need for product care and utilizing reminders such as countdowns and warnings. This strategy aligns with the eco-feedback approach proposed by Bhamra et al. (2011) and helps integrate product care into users' daily routines. Currently, only one provider (Elbuco) employs this strategy by sending an exit email to remind customers about returning the washing machine in good condition. Other providers' interviewees (HOMIE, Subsidiary of OEM, Splash) acknowledge the strategy's usefulness and have ideas for implementing it, such as through push notifications by an app (HOMIE). However, contacting users in scenarios like shared machine usage or intermediaries as primary contacts (Mieten statt kaufen) poses challenges due to limited contact details. Emphasis should be placed on meaningful communication: "It is important at this point that you make sure that the warnings or communication with the customer is understandable." (interviewee Subsidiary of OEM).

The *Long-term awareness* (3) strategy aims to educate users of access-based services about the impact of their behavior on product lifetimes. This is important as consumers' assumptions influence how they treat the products (Braithwaite et al., 2015; Wieser et al., 2015), and consumers often underestimate their own role in extending product lifetimes (Jaeger-Erben, 2019). Similarly, Srivastava et al. (2021) recommend providers to communicate the inconvenience caused for users by careless behavior. Although this strategy aims for customer awareness, similar to the strategy above, we have decided to define them as separate strategies because their implementation in practice differs. None of the providers from our interviews has used this strategy so far. On the one hand, it is often difficult to reach all users in practice (Mieten statt kaufen, HOMIE, Splash), and the effectiveness could depend on the customer segment; on the other hand, simply making information available does not lead to a change in behavior: "However, the aim is not to create awareness, but to bring about a change in behavior" (interviewee Subsidiary of OEM).

The *Enabling* (4) strategy helps facilitate product care through care-friendly product design and by offering different service options ranging from an app with a chat function to personal assistance, making product care as convenient as possible for users. Previous research found that consumers feel that they do not have the necessary skills to repair or take care of products (Cox et al., 2013; Dewberry et al., 2017), especially when electronic components are involved (Ackermann et al., 2018). Based on these insights, design strategies that foster easy repair, such as Design for Standardization and Compatibility and Design for

Table 3

Design strategies, design solutions, and example suggestions provided by the design experts.

Strategy	Design solution	Example suggestions
(1) Informing	Provide product care information via digital channels	"videos with information about maintenance & care within an app or easy to navigate website." (E5) "through media such as mailing lists, dedicated apps, or UI of the washing machine itself" (E7)
	Staff member provides product care information Design information material well	"Let the installer give information about good product care" (E9) "manual that comes with the product (...): Even though people do not tend to read this, it should be included in this manual. Maybe also separately as stickers or at least with graphics/color to make it seem like a special section of the manual and that the company took 'good care' of developing these instructions carefully." (E8)
(2) Short-term awareness	Product indicates need for product care	"something could be done with the glass window of the washing machine. It changes color with a led light (starting from green and gradually becoming red) if repair is needed." (E6) "I would use technology to alert me (the business provider) and, as a result, the user who is leasing the WM that it requires caring." (E2)
	Display care status using warnings and countdowns	"The device could have something like a stress level, indicating how urgent certain actions are to be performed. The device could also change certain sounds as the stress level increases in order to emphasize its maintenance request (e.g., a bright beep increasingly becomes a dull, muffled beep)." (E3*)
(3) Long-term awareness	Personal statistics related to product care	"a product dashboard with current stats of specific key values, particles in your filter / soap traces in your runoff etc. compared to preferred values" (E5)
	Make consequences of product care visible	"non-level washing machine could be made to produce more noise/vibrations" (E7) "user is informed that washing machine cycle takes longer because filter is not cleaned" (E9)
(4) Enabling	Facilitate contact with maintenance providers	"an email with a potential service app[ointment]t time and date could work" (E1) "have an app with a chat/video call function with a repair specialist" (E8)
	Facilitate care through product design	"create a space in the product for the right tools that they do not need to be stored in a separate place (making them easy to forget, lose, or toss)" (E1) "vulnerable elements should be easily accessible and highlighted with colors/signs. Use cues should help customers in the sequence of dismantle the product" (E4)
(5) Controlling	Subscription for care consumables	"consumables needed for maintenance are included in subscription and are restocked automatically" (E5)
	Product takes care of itself	"if the door should be left ajar then maybe before it automatically turns off (after being idle), the door can pop open (slightly)" (E1)

(continued on next page)

Table 3 (continued)

Strategy	Design solution	Example suggestions
(6) Social interaction	Product stops working	“cleaning cycle is automatically run when user doesn't innate it” (E9) “I would say in serious maintenance cases I would design the machine to stop working until maintenance is done (with a buffer period). I would also prioritize the most critical maintenance points for this type of design for product care - so maybe it won't start if the machine is overloaded, but of course it will if you don't wipe the door down.” (E1)
	Rate previous user(s)	“maybe creating some history of ownership – and you can give stars based on the state of the product upon arrival (which could reflect back to its past owner).” (E1)
	Foster product care for products used by multiple users	“public rewarding or shaming in app to encourage/discourage good/bad product care in case of shared ownership” (E9)
(7) Appropriating	Create an online community of users	“users of a same type of washing machine could share tips on maintenance/repair on a dedicated app/forum” (E7)
	Individualized visual product appearance	“maybe a simple covering choice (sticker or other cover) to make the washing machine fit more to their bathroom design” (E1)
(8) Bonding	Individualized interaction with the product	“there are some standard presets, but after a while, the washing machine should adapt to the consumers behavior (e.g. white laundry at 30 °C and 800[rpm], no rinsing each Sunday)” (E4)
	Create a product personality	“give product a personality which you should care for / take care of for it to be happy. Almost like a pet or household member, without making it weird” (E8)
(9) Rewards & fines	History between user and product	“self-maintenance stickers (like a vehicle inspection sticker) that come with the purchase can prove your own work and indicate when the next maintenance is due.” (E3*) “let the washing machine 'grow old' with the user. when it grows older it becomes wiser and you'll have access to more programs” (E8)
	Extended warranty	“scheduled professional service offerings through professional parties, a “guarantee enhancer” if these services are used” (E5)
	Incentivize timely product care	“good behavior leads to unique products (or elements). Or good behavior leads to free detergent, or a price reduction” (E4) “stimulate product care through rewards or discourage certain behavior with fines” (E9)
(10) Investing	Reward user for learning about product care	“I would reward customers who make use of informing documents/videos.” (E4)
	Use high-quality materials and components	“Within PSS's [product-service system = access-based service], I feel cheapness is expensive. The components should be of high quality, which should also be communicated” (E4)

Note: *E3 completed the survey in German, the quotes were translated by the authors.

Reparability have been proposed (e.g., Cooper, 1994; van Nes and Cramer, 2005). Elbuco and Splash implement the Enabling strategy by offering welcome boxes with care products, such as cleaning supplies for washing machines. Subsidiary of OEM's interviewee emphasizes the importance of product care-friendly design (e.g., avoidance of joints and corners where dirt can accumulate). However, Mieten statt kaufen and HOMIE do not currently employ this strategy.

The *Controlling (5)* strategy ranges from a product that takes care of itself to a product that stops working if the user has not taken care of it. Control was the most controversial strategy in our study. Some experts expressed explicit opposition to its application (E3), while others advised caution (E6). Similar reactions were found when these strategies were discussed with consumers (Ackermann et al., 2021c). This strategy has also been proposed in the form of geofencing for vehicles by Srivastava et al. (2021) to reduce user misbehavior in access-based mobility services. While Mieten statt kaufen does not use this strategy because users will only perform the absolute minimum of product care anyway, HOMIE, Elbuco, Subsidiary of OEM, and Splash rated the strategy positively, with the interviewee from HOMIE claiming: “*The best thing is if the appliance signals: “Hey, I need care!”*”. However, the interviewees also said that this strategy would have to be implemented by the manufacturers and that they, as service providers, have little influence on it.

The *Social interaction (6)* strategy aims to stimulate product care through interactions between consumers or between the provider and consumers. Research on access-based mobility services suggested that social interactions could be harnessed through rating systems (Srivastava et al., 2021). Repair cafés are common means to foster product care for owned products (Keiller and Charter, 2016) but are likely too cumbersome for users of accessed products given that these usually promise convenience. Establishing personal relationships between providers and users could help mitigate careless behavior (Schaeffers et al., 2016). Nonetheless, providers in our study questioned whether customers would be excited enough to discuss washing machines: “*It is a washing machine. Will people talk enthusiastically about it?*” (interview Splash). Currently, implementation of this strategy is limited to offering a personal introduction by an employee upon delivery (HOMIE, Elbuco).

The *Appropriating (7)* strategy involves customizing the accessed product. Previous research has shown that customization of accessed products can enhance consumer preference (Tunn et al., 2019). However, it should be noted that the willingness to appropriate shared cars in short-term access-based services was found to be low (Bardhi and Eckhardt, 2012). Nonetheless, for long-term access-based services, this strategy may have more potential for success. The effectiveness and feasibility of this strategy are assessed rather critically (“*I find this a difficult one.*”, interviewee Splash). Optical appropriation, specifically, was considered ineffective by several providers (Mieten statt kaufen, Subsidiary of OEM, Splash), with suggestions limited to offering a choice of colors for washing machines (Elbuco). On the other hand, the appropriation of functions was seen as potentially effective by some providers (Mieten statt kaufen, Subsidiary of OEM).

The *Bonding (8)* strategy aims to establish an emotional bond between the user and the product. Previous research has highlighted the importance of emotional attachment in influencing product care (Mugge et al., 2010; Schifferstein and Zwartkruis-Pelgrim, 2008). In the context of washing machines, this strategy is considered unsuitable by most providers, as it is challenging to envision an emotional attachment to a washing machine (Mieten statt kaufen, Elbuco). However, HOMIE focuses more on fostering an emotional connection between the user and the provider, which could be facilitated through social media activities. The interviewee from Subsidiary of OEM acknowledges the potential of implementing this strategy, such as when the product praises users for their product care, thus establishing a connection in that manner.

The *Rewards & fines (9)* strategy involves incentivizing users through rewards related to product care. Previous research has emphasized the role of incentives in promoting sustainable behavior (White et al., 2019).

However, there is a concern that users may revert to careless behavior once the incentives are removed (Bolderdijk and Steg, 2015). While penalties may not always be effective in driving behavior change, they could be applicable in access-based services (Bardhi and Eckhardt, 2012) as long as they do not undermine consumers' moral obligation to care for the products (Bolderdijk et al., 2018). Srivastava et al., (2021, p.857) also suggest "identifying and penalizing offenders" to demonstrate that such behavior is unacceptable. Among the providers, there is no consensus on whether punishments (Mieten statt kaufen) or rewards (Elbuco, Subsidiary of OEM, Splash) are more suitable for promoting product care. HOMIE has previously utilized a deposit system, which has now been replaced with a one-off fee.

The *Investing (10)* strategy seeks to reduce the impact of careless behavior through high-quality products. Previous research supports this notion, as cheap products are often associated with shorter lifespans, making them less likely to be repaired or cared for (Cooper, 2004; Dewberry et al., 2017; Park, 2019). Similarly, Schaefer et al. (2016) recommend that access-based service providers invest in the quality of the products they offer to prevent customer misbehavior. The washing machines offered by the providers cover all price segments (HOMIE, Elbuco, Splash). The feasibility of the strategy is at least currently being assessed critically: Interviewees from Mieten statt kaufen and Subsidiary of OEM claim that higher investments for providers are, at the moment, not profitable. While the interviewee from Mieten statt kaufen assumes that high-quality machines will not lead to a higher degree of product care, the interviewee from Subsidiary of OEM emphasizes that customer acceptance takes priority when considering the use of new and possibly

more sustainable materials.

Among the strategies identified, the most effective and feasible strategies for promoting product care were Informing (1), Short-term awareness (2), Enabling (4), and Rewards & fines (9). These strategies are, to some extent, already applied by providers, or their perceived effectiveness and feasibility were rated predominantly positively. Other strategies were seen as less feasible or effective: Social Interactions (6), Appropriating (7), and Bonding (8). These strategies were barely applied, did not spark inspiration for implementation, and/or were seen as less suitable by the providers. However, these strategies might be more suitable for other products, "such as a surfboard" (interviewee Splash). Providers also seldomly use the strategies Long-term awareness (3), Controlling (5), and Investing (10), albeit for other reasons: Long-term awareness as well as Controlling require technical solutions to a) monitor users' usage and care behavior and b) provide feedback or and/or control the washing machine's reaction. These solutions have to be implemented by the manufacturer, and as long as providers are not closely associated with the manufacturer, they are dependent on the available products. For the Investing strategy, providers can buy products of higher quality or – again, in the case of Subsidiary of OEM – play an active role in designing more robust products.

5.2. Insights from comparing providers' business models

Our cases capture a wide variety of access-based washing machine providers (see Table 4). While HOMIE and Subsidiary of OEM have been established fairly recently, Elbuco, Splash, and Mieten statt kaufen have

Table 4

Overview of the business models of access-based washing machine provider cases. Information based on interviews and providers' websites. *Number of washing machine (WM) customers in 2022: small < 2000, medium 2000–5000, large > 5000.

Provider	Founded	Key aspects of business model	Size of access-based WM business*	Customer segment(s)	Consumer product care levels & product lifetimes
Mieten statt kaufen	Founded in 1995, started in 1999	WMs, white goods and a few other electronic products for a monthly fee. Responsible for the contract etc. while local shops lend WM and are responsible for delivery and service. Standard lease duration is 66 months; customers can keep WM afterwards. Fee: 15-25€/month	Small	Mostly (but not only) people who cannot afford to buy a WM.	Consumers take care pretty well because the contract states that only technical faults are covered by the provider (but not the results of lacking care such as dirty filters leading to failing pumps).
HOMIE	Founded in 2016	WMs and a few other household electronics for a monthly fee. The minimum contract duration is 6 months (though a minimum of 12 months is encouraged). Founded to test academic research on encouraging sustainable washing behavior. Delivery and refurbishment of WMs are in-house. Fee: 10-20€/month	Medium	Expats, students, small households and people who do not want to buy a WM (but pass the credit check).	Product care was not on top of our agenda so far - we were busy surviving and building a company. Approximately 90 % of WMs are returned in a good state.
Elbuco/ Skala	Founded in 1973	WMs and many other electronic products for a monthly fee. Several brands offer B2C access-based washing machines for different conditions. Delivery and refurbishment of WMs are in-house. Fee: 10-38€/month	Small	Different per brand: <i>Skala</i> targets people who cannot or do not want to buy a WM (but pass a credit check). <i>Smart student deals</i> targets students.	Could not provide specifics about product care, was not perceived as a major issue. They do not have data on the average lifetime of WMs but estimate that more than 50 % of WMs are leased for 2 cycles. Products are reused in different business models depending on their state.
Subsidiary of OEM	Started in the 2010 s	WMs and other electronic products for a monthly fee. Minimum contract duration is 12 months. Repair, refurbishment and service in-house. Fee: 12-35€/month	No information provided	Young people, singles, couples, students and families.	Products are returned in a good / very good state and 97 % can be used again. Usually products are only cleaned and disinfected before they are given to the next customer; repair is usually not necessary. The provider is too new to have data on average WM lifetimes. They expect each machine to serve 1–2 customers.
Splash	Founded in 1990	WMs and other white goods for a monthly fee. The minimum contract duration is 12 months. Delivery and refurbishment of WMs are outsourced. Fee: 13-18€/month	Large	Students and student houses.	Average lifetime of WM is 4.8 years. Users take little care of the WMs and they are often returned very dirty or full of stickers. This impedes refurbishment as the cleaning can take so much time that it is not economically viable. The provider weighs the remaining economic value of WM versus the costs of the refurbishment contractor.

existed for several decades. The providers also integrate refurbished devices differently. Mieten statt kaufen only reuses washing machines when contracts are terminated prematurely, as lessees can keep washing machines at the end of the lease period. Splash uses refurbished washing machines exclusively as replacements for broken washing machines of existing customers. Other providers cascade the washing machines, offering refurbished ones for a reduced monthly fee (Subsidiary of OEM, Elbuco). HOMIE does not distinguish between new and refurbished products.

The five cases also differ in their product care awareness and data availability on product lifetimes. Some had the average lifetimes of their washing machines and the refurbishment percentages readily available, while others could not retrieve this information. All interviewees recognized that product care influences the success of their business models, but the severity of careless behavior reported by providers differed (see Table 4). We identified several business model elements described by Richardson (2008) that influence product care, namely product and service, customer segments, and key activities and partners.

The *range of products* offered by access-based service providers impacts their ability to implement product-specific care strategies. The interviewed access-based washing machine providers differ in their products and services. Splash, Homie, and Subsidiary of OEM lease out washing machines and also offer some other household appliances. Elbuco and Mieten statt kaufen offer a wide assortment of household appliances and consumer electronics. The broader product ranges are likely to impede the development and implementation of washing machine specific product care strategies. The service components also influence care; whilst most providers reported that all repair services are included, Mieten statt kaufen reported that only repairs that would fall under warranty are included and not repairs related to poor product care (e.g., failures caused by a clogged filter).

Customer segments differ in their product care levels and in the effectiveness of product care strategies. Providers can redesign their services to enable specific customer segments to take care of the products or to deter specific customer segments. For example, Splash exclusively provides access-based washing machines to students and student houses. Thus, the users frequently change, are inexperienced with washing machine usage and maintenance, and a sense of responsibility might be lacking. Therefore, Splash developed care information specifically tailored to this segment. Similarly, Elbuco reported employing different product care strategies for different segments; student houses receive printed washing and care advice, and stickers with provider contact details are placed on the washing machines to ensure that all users know how to use the product and can contact the provider. We also found that some providers actively shape customer segments to obtain desirable behavior, for example, by introducing a minimum contract duration, credit checks, and initial fees or deposits. While this approach can be beneficial for the company and sustainability, it does not have to be desirable for society. This should not be instrumentalized to justify discrimination.

Providers' *control over the supply chain* determines which product care strategies they can implement. We identified three types of access-based washing machine providers: subsidiaries of original equipment manufacturers, complete control over access-based service, and intermediaries. Providers that are subsidiaries of original equipment manufacturers can influence the design and manufacturing of accessed products and control downstream activities. Subsidiary of OEM is part of an original equipment manufacturer of white goods and can thus enhance the product design for access-based services. Subsidiary of OEM markets the access-based service, and repairs and refurbishes the washing machines. Second, some providers control all activities related to the access-based service. Homie and Elbuco market the service, deliver products, and provide customer service, including maintenance, repair and refurbishment. Third, some providers act as intermediaries and control few activities. Mieten statt kaufen markets the service and sets up contracts but then hands customers over to local shops in charge

of delivery and customer service related to repair and maintenance. Splash acquires customers and remains their contact point during the lease period, while delivery, repair, and refurbishment are outsourced to other companies.

6. Conclusion

6.1. Theoretical implications

Our study contributes insights into the problem–solution space of product care in long-term access-based services, which had previously been neglected. Building on the insights of extant research (e.g., Tukker, 2004; Bardhi and Eckhardt, 2012; Sumter et al., 2018), we quantitatively show the difference in product care between used and owned products. Product care is significantly lower for products used through long-term access-based services than owned ones. In addition, we systematically developed design strategies addressing product care in access-based services by drawing on previous research that focused on owned products (Ackermann et al., 2021a). We also demonstrate that business model design has an immense effect on product care. A lack of product care can diminish the environmental potential of access-based services and is thus a rebound effect of access-based services.

Our main study evidences that involving practitioners in this type of research is highly beneficial. The applicability of the developed strategies differs based on the product placed in an access-based service and the providers' core business model. Presenting strategies that designers developed to providers of access-based services added strategies on the more abstract level of business model design rather than service and product design.

We introduce the concept of product care in the business literature. Product care is linked to customer misbehavior, but the latter encompasses a broader scope (see Fisk et al., 2010). In the context of access-based services, instances of lacking product care constitute customer misbehavior (Schaefers et al., 2016; Srivastava et al., 2021), while product care comprises cumulative behaviors and misbehaviors that impact product lifetimes. We anticipate that a higher product care tendency corresponds to fewer instances of misbehavior. The concept of product care is a valuable addition to the business literature as it emphasizes the long-term consequences of misbehavior and the possibility of stimulating careful behavior rather than merely avoiding misbehavior.

6.2. Managerial implications

By bridging theory and practice, our research paves the way for more sustainable and consumer-centric access-based services. We, therefore, present the following implications for practitioners:

(1) Design business models consciously: A lack of product care in access-based services is an economic and environmental concern. Our research shows that decisions related to product and service, customer segments, and key activities and partners impact product care by imposing limitations on applicable strategies. Carefully designing and redesigning business models can simultaneously enhance their environmental and economic viability.

(2) Anticipate and monitor user behavior: Assumptions of perfect user behavior are unrealistic. Instead, providers should anticipate and monitor careless behavior, assessing product care and deterioration. By extrapolating real-time data from smart home appliances, providers can predict care requirements, prevent downtime through maintenance, and assess the effectiveness of product care measures. This could enhance user satisfaction.

(3) Finetune access-based services for product care: Providers of access-based services, designers, and entrepreneurs should prioritize product care and sustainability when designing their services and products. Our research shows that access-based services present opportunities to effectively and feasibly promote product care. The

provider-customer relationship can be leveraged to encourage care by sharing care information and sending reminders for maintenance appointments.

(4) Act on careless user behavior: Positive reinforcement is preferred to stimulate careful behavior. At the same time, the consequences of careless behavior (for the user and the environment) should be communicated to users and enforced when such behavior occurs. This can maintain service appeal while ensuring products are well-maintained and careless behavior is reduced.

6.3. Limitations and avenues for further research

Due to limited access-based service adoption, the samples of users and providers are relatively small. With increased service usage, additional research can enhance the findings' generalizability. While we gathered self-reported behavior, the frequency and severity of careless product use remain unquantified. We recommend analyzing data on repair/maintenance frequency from service providers or using data from accessed products. Collaborating with access-based service providers to implement the proposed design strategies for product care is the logical next step to test their effectiveness.

In addition, when similar services are implemented, more data can be obtained from the providers. This data might be helpful to explore strategies such as *Investing* in more detail. This strategy has the potential to increase product care and thereby contribute to the environmental sustainability of access-based services. However, their implementation also increases costs for the providers, which in turn negatively affects the economic viability of such offers.

Although we observed significant differences in product care

between accessed and owned products, the underlying causes could not be statistically determined. To comprehend why some consumers exhibit careless behavior with accessed products, we recommend qualitative research. Potential causes include consumers not carrying the financial risks for excessive wear and tear, psychological effects of access models (e.g., reduced ownership and attachment), or contextual factors (e.g., time constraints, lack of experience). Behavioral observation and subsequent interviews with users can provide valuable insights.

CRedit authorship contribution statement

Laura Ackermann: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization. **Vivian S.C. Tunn:** Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Conceptualization.

Data availability

Data generated and analysed during the pre-study and main study part 1 are available in the 4TU.ResearchData repository, DOI: 10.4121/20657205. Data from main study part 2 is available on request.

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Appendix A.: Introductory information provided to the design experts for main study part 1

Introduction

Please activate your inner designer now!

Background:

- Leasing products can potentially be more sustainable than buying a new product.
- However, consumers do not take care of leasing products they use, decreasing the sustainability potential of such business models

The challenge:

Help us identify design strategies that can stimulate product care in leasing business models!

Please take the time to answer the questions on the next page as this is the main part of our survey.

We will only ask you a few demographic questions afterwards.

Leasing washing machine

Leasing business models entail monthly payments for the use of the washing machine and can include additional services (e.g., repair, maintenance).

However, research shows that consumers do not feel attached to washing machines they lease thereby reducing the sustainability of such business models.

Imagine you design a leasing business model for washing machines.

How would you as a designer stimulate product care among users?

Typical product care activities for washing machines are:

- inspect the hoses
- not overload the machine
- use the right type as well as the right amount of detergent
- clean the interior and dispensers
- wipe down the drum and door
- leave the door ajar after a load
- transfer clean laundry to the dryer as soon as it's done
- clean filters
- make sure the washing machine is level

You can think of business model aspects such as the relationship with the customer, distribution, use of technology, product/service design and cost structure.

Appendix B: Description of product care design strategies provided to the design experts for main study part 1

Product care design strategy	Explanation as provided to the experts in main study part 1
Informing	This strategy aims to heighten consumers' knowledge of product care to facilitate the care activities. Informing is related to different kinds of information. Besides written manuals and instructions, this strategy can also be implemented through interactive means, such as online tutorials, workshops for consumers etc., that can be offered as a service by the producer.
Enabling	Enabling facilitates product care activities by offering the right tools together with the product at purchase. Another part of this strategy is to enhance the flexibility for repair and maintenance by designing the product in a way that standard tools can be used. The establishment of a network of service providers can also enable product care.
Control	This strategy includes products and services elements that trigger product care themselves. Some examples are a product that automatically opens when it needs cleaning or a product that refuses to work if it is not taken care of. In other cases, the product encourages the consumer to take care of it regularly, so it can be seen as an unconscious take-over of control, as product care becomes a habit. Service examples include automatically planned visits for maintenance or periodically delivered maintenance materials.
Social connections	This strategy describes the facilitation of product care through social connections. Specific communities can support consumers in their care activities, such as repair cafés or shared private garages to work on cars. Social connections can also be seen as the result of product care activities when interactions are created through product care. Shared ownership, which means that a product is used by several consumers, is also part of this strategy, because the users can feel obligated to take care of the product so that they do not experience social rejection.
Awareness	Simple reminders, such as an alarm on the smartphone or an email by the service provider, can make the consumer aware of the need to take care of his/her product. Furthermore, the product's appearance might change, such as a surface that looks unappealing when it is not being cared for. Also, a decrease in the product's functionality can raise awareness.
Appropriation	This strategy describes the adaptation and/or personalization of a product according to the consumer's needs. This can be achieved by modular, ever-changeable products that allow the replacement of certain parts when an upgrade is desired. Appropriation also describes a product design that encourages the consumer to change the product in a creative way, such as upcycling and do-it-yourself activities. As a consequence of these creative activities, the consumer will feel more attached to this product and thus will take care of it.
Antecedents & consequences	Antecedents and consequences of product care – but also of non-care – can be communicated to the consumer or shown through the product's design. For example, the advantages of a well-maintained bicycle, such as less effort while cycling, can motivate the consumer to conduct these care activities. When a product is especially shiny or well working after product care, it might also motivate the consumer for future care activities.
Reflecting	This strategy refers to meaningful memories and traces that are created through the interaction with the product in general and lead to a higher motivation to take care of it. An example might be a skateboard with scratches, which can be seen as traces of usage. This valuable memory can also be created through the care activity itself. For example, painting a wooden piece of furniture can generate a unique value for the consumer, because he/she remembers that activity in a positive way.

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