When Smart Products Become Dumb (Again): Voluntary and Legally Required Service Updates and Their Impact on Consumers' Purchase Intention

By *Melina Schleef**, *Nicola Bilstein*, *Paul T. Schrader*, and *Christian Stummer*

Ultimately, it is the software that makes and keeps products smart. Accordingly, the peculiarities of the provision of service updates (i.e., regular software updates allowing all functions of a smart product to work properly) can affect consumers' purchase intention. In our research, we investigate the following: (1) whether the seller's commitment to delivering service updates for a certain time affects consumers' purchase intention, (2) whether it makes a difference if the provision of service updates is mandatory (i.e., legally required) or voluntary, and (3) whether it could be an advisable strategy to complement a mandatory provision by incorporating a voluntary extension. To gain such insights, we conducted two experimental studies in the context of a durable consumer product (i.e., a smart dog collar) in Germany. Our results can be valuable for managers who are responsible for the market introduction of smart offerings.

1. Introduction

Beyond the physical and digital components, such as sensors and data storage, it is ultimately the software that makes and keeps products smart, enabling them to deliver smart services (Henkens et al. 2021; Raff et al. 2020; Wuenderlich et al. 2015). Producers are not obliged to provide regular service updates (i.e., regular software updates that allow all functions of a smart product to work properly) for their smart products. Nonetheless, many producers offer service updates for a certain time and, thus, maintain and sometimes even expand the functions and scope of services enabled by the smart product. Apple, for example, voluntarily provides service updates for iPhone models for up to six years (Richter 2021). However, other producers have stopped offering (free) support for their smart products, making the hardware "dumb" and thus no longer capable of performing smart services. For example, Under Armour removed the app for its smart scale from all app stores and no longer provides customer support or bug fixes for the software. Consequently, the software stopped working, making the scale dumb again, only four years after the smart scale was introduced into the market (Cox 2020). Even worse, Under Armour stopped providing software support for all its connected health gadgets, including a wristband and a chest-strapped heart rate monitor. Hence, these connected health gadgets could no longer communicate with each other, which ultimately brought corresponding

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services, such as the provision of an extensive health and fitness journal, as well as high-level and granular records referring to weight, activity, heart rate, and sleep, to a halt (Garun 2020). In addition to the question of functionality, the lack of regular, long-term service updates for smart products raises other issues, such as security concerns. Sclak's Nello One smart lock is a prime example of a product with severe security holes: When the smart lock's app was not updated, the smart lock could be unlocked by strangers without permission when they rang the doorbell. It took several weeks to remedy this defect (Stern 2020).

Given these challenges, the European Parliament and the Council of the European Union (EU) adopted two directives regarding the provision of service updates for smart products[1] in 2019. All EU member states were obliged to implement these directives at the beginning of 2022. For smart products that rely on a continuous supply of the digital element (e.g., smartphones), the new obligation to provide service updates applies for a minimum of 2 years (unless explicitly waived in the purchasing contract). If service updates are not suitably granted, consumers are entitled to return the smart product to the seller and request a full refund regardless of whether the seller is also the producer or the one in the position to provide the service update. For example, an electronic retail store (company A) selling a smart door lock is responsible for the provision of updates for the product even if the software that makes the lock smart is technically provided by the producer (company B) or by an independent software developer (company C) that developed the software on behalf of the producer.

The aim of this legal development, which, in a way, can be interpreted as a (mandatory) service-level agreement (e.g., Mirobi and Arockiam 2015), is to protect consumers. Therefore, it is likely that consumers will perceive the new legal framework favorably (comparable to the positive effects of the General Data Protection Regulation [GDPR]; see Fox et al. 2022; Hoofnagle et al. 2019; Michler et al. 2022; Paul et al. 2020). However, the positive effects on consumers' behavioral intention caused by the provision of updates could be limited if consumers see the seller as only fulfilling the company's legal duties rather than acting ethically on their own account. Thus, consumers may honor service updates even more if they are provided voluntarily in a similar way to service guarantees, which are not required by law but provide an additional benefit and serve as a promotional tool to differentiate a seller from its competitors in a positive way (Hogreve and Gremler 2009). However, such extended service update periods not only entail higher costs for the provider, but also, from a certain point onward, may not render substantial additional value to customers.

Because it is unclear how legally required versus voluntary service updates will affect consumers' behavior, we examine the following two research questions in the first study: Does the seller's commitment to delivering service updates for a certain time affect consumers' purchase intention? Does it make a difference whether the provision of service updates is mandatory (i.e., legally required) or voluntary? Based on the results of this first study, we conducted a second study to address the third research question: Could it be an advisable strategy to complement a mandatory service update provision by incorporating a voluntary extension?

We address these questions and discuss the implications for both research and management. From a theoretical perspective, we contribute to the sparse knowledge of how legal conditions affect consumer behavior. We do this in three ways. First, we advance research on service update provision by scrutinizing whether the communication of such a provision affects consumer behavior. Second, we assess the impact of communicating legal obligations regarding service updates, compared to a seller's voluntary commitment to provide such updates, on consumers' purchase intention toward smart products. In doing so, we transfer previous findings from the mandatory and voluntary implementation of the GDPR (in EU and non-EU member states) to the new field of service update provision. Third, we shed light on the effects of different service update provision strategies, as in our second study, legally required service updates are expanded by voluntary service updates to find an appropriate duration for the provision of service updates. From a managerial perspective, our results support decision-making about effective service update policies for smart products and their corresponding services.

The remainder of this paper is organized as follows. Section 2 provides an overview of smart products and the current legal framework for the provision of service updates for them. Section 3 outlines our two studies. Sections 4 and 5 describe the two experimental studies with respect to the hypotheses, procedures, samples, measures, and results. In Section 6, we discuss our findings and derive implications. Finally, Section 7 addresses the remaining limitations and promising directions for further research.

2. Background

Smart products can be mapped to one of four archetypes, each of which builds on another: (1) digital products, which constitute the basic type (i.e., all smart products

1 The directives referred to "goods with digital elements," which includes smart products.

are digital); (2) connected products, which also allow for networking and connectivity; (3) responsive products, which are equipped with various sensors and actuators; and (4) intelligent products—the most sophisticated type of smart products—which, to some degree, have reasoning and decision-making abilities (Raff et al. 2020). Technically, smart products represent cyberphysical devices consisting of both tangible and intangible components and have the potential to render smart services and operate in a larger ecosystem (Bilstein and Stummer 2020; Raff et al. 2020).

Our paper focuses on the intangible component (i.e., the software) and whether it is updated. Service updates are usually provided by the producer of the smart product, ensuring that the product remains smart (e.g., it is able to sense the surroundings and deliver the promised smart services) and that security is not compromised. Thus, the risk of smart products becoming dumb or insecure is reduced. It should be noted that we address only updates that are geared toward the proper functioning of the smart product; we do not consider other third-party services. For example, Apple needs to provide updates for its smartphone's operating system but is not responsible for updating the apps downloaded from the app store.

Whereas service updates have been provided on a voluntary basis in the past, the implementation of two EU directives in the laws of EU member states has changed the provision of service updates into a legal obligation. First, the so-called Sale of Goods Directive (EU) 2019/771 of the European Parliament and of the Council of the EU refers to certain aspects concerning contracts for the sale of goods; it amends Regulation (EU) 2017/2394 and Directive 2009/22/EC, and it repeals Directive 1999/44/EC. Second, the so-called Digital Content Directive, Directive (EU) 2019/770 of the European Parliament and of the Council of the EU, refers to certain aspects concerning contracts for the supply of digital content and services. In Germany, the two directives were implemented in the Civil Code in January 2022.

According to the new rules, sellers can proceed in one of three ways (for an overview, see *Fig. 1*): First, they may opt to provide a service update period that is less than the usual lifetime of a smart product or even no service update at all. However, the service update period cannot be contractually shortened by merely placing a notice on the packaging; instead, before the conclusion of the contract (i.e., the purchase), sellers must supply clear information that they will provide either no service updates or service updates for a shorter period than a buyer would usually expect. Sellers and buyers need to express this in a separate agreement regarding the exclusion of service updates; that is, an annex to the sales contract is required. In this annex, buyers waive their right to receive future updates. Second, if the buyers do not forgo this right, the length of the period during which service updates need to be provided depends on the type of supply. In the case of a single act of supply of the digital service (e.g., the single, one-time download of printer software for the computer that is needed to establish the connection between the computer and the printer to enable its proper functioning), service updates must be provided as long as they can be reasonably expected according to the prevailing public understanding. As consumers may have divergent expectations regarding the lifetime of a certain product, this regulation pertains to what the consumer may reasonably expect, but this is to be clarified by future court decisions. In the case of a continuous supply of a smart service (e.g., the tracking of health and fitness indicators, as well as the provision of regular reports based on data collected by a fitness tracker), service updates also have to be provided for the entire period that the service can be reasonably expected to be supplied and—in contrast to the products with a single act of supply—this period has to be at least 2 years. Third, sellers can promise a longer service update period of, for example, 3 years by simply stating this on the packaging (or in another way). It must be noted that in the latter case, the seller is bound by the note from the producer on the packaging; this entails a change in the value proposition, as it guarantees consumers a certain period (i.e., at least the imprinted duration) during which they will receive updates regardless of future court decisions concerning what is deemed a reasonable service period.

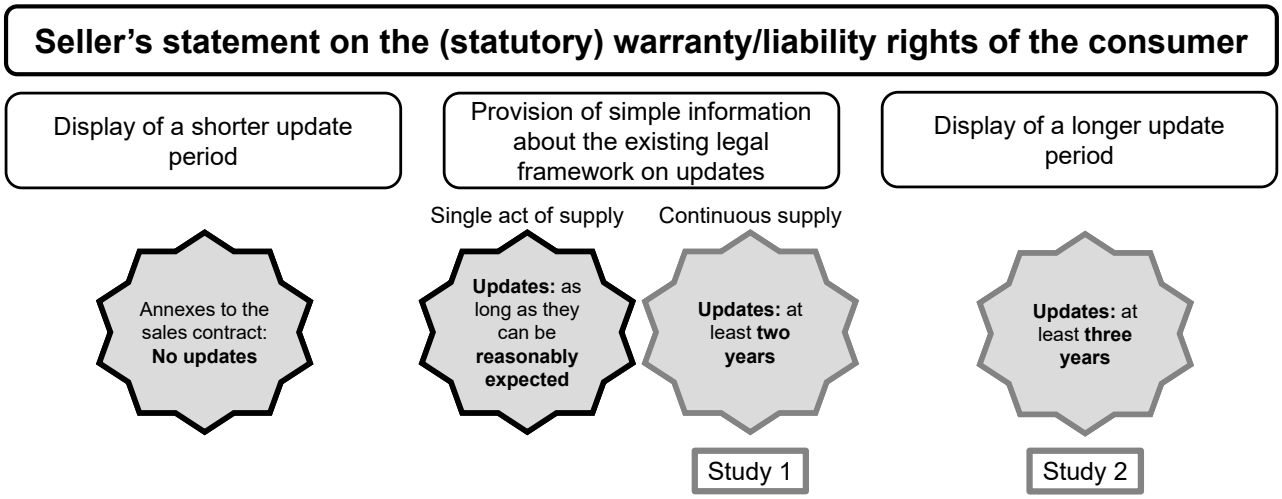


Fig. 1: Legal framework for Study 1 and Study 2

3. Overview of the Studies

We conducted two experimental studies to investigate the effects of different types of service updates for smart products on purchase intention. In Study 1, we investigated the case of a continuous supply of a smart service, in which sellers provided service updates for at least 2 years. Study 2, a follow-up study, referred to a case in which sellers promised a longer service update period by simply stating this on the packaging. The assignment of our two experimental studies to the cases in the legal framework is indicated in *Fig. 1*, in which they are referred to as "Study 1" and "Study 2," respectively. It must be noted that the experiments were performed in Germany at the end of 2021—that is, before the EU directive was implemented and, thus, before study participants would have learned about the new legal regulations. Hence, the manipulation in our experimental settings, including the scenario suggesting the voluntary provision of updates, was realistic at that time. Study 2 also accounts for the durability of the smart product as a mediator because providing service updates for smart products can extend their lifespan (e.g., service updates for smartphones extend the period during which the current smartphones can be used without obvious hazard). As durability is one facet of sustainability, this could have an effect on consumer behavior, particularly in countries such as Germany, where almost 80% of the population seeks to buy sustainable products (Tighe 2022).

4. Experimental Study 1

4.1. Hypothesis Development

Signaling theory (Connelly et al. 2011; Spence 1973) builds the theoretical foundation of our research. The producer represents the signaler, communicating the provision of service updates for the smart product, which serves as a signal that influences the consumers' perceptions of the producer regarding service performance (Liu et al. 2015). Because there are information asymmetries in the marketplace and, thus, consumers do not have access to extensive information regarding the performance or longevity of smart products before actually purchasing and using them, such observable signals can have a major impact on the consumers' purchase intention. They allow companies to credibly communicate unobservable attributes, especially in the case of innovative experience goods (Kirmani and Rao 2000). Customers highly value the objective information provided by companies, and they send feedback by expressing a higher purchase intention (Liu et al. 2015). Therefore, we expect the following:

H1: The information about the provision of service updates for smart products leads to a higher purchase intention among consumers than does no information on the provision of service updates.

We suppose that the signal regarding the provision of service updates may change the consumers' perceptions depending on whether the updates are required by law or provided voluntarily. However, it may not be clear to the consumer whether the provision of the updates is required or voluntary when service updates are presented in a generic way (i.e., no information given regarding the motivation for the updates). Referring to insights on the GDPR's validity for EU member states, we assume that service updates being required by law represent a stronger signal than the mere information that service updates are provided (i.e., generic service updates). GDPR labels positively influence consumers' perceptions of risk, privacy, control, and trustworthiness, and, even further, they enhance consumers' willingness to transact and disclose data to companies (Fox et al. 2022). Follow-

ing this line of argumentation, we formulate the following hypothesis:

H2a: Legally required service updates for smart products will lead to a higher purchase intention among consumers compared to generic service updates.

Voluntary disclosure occurs when a producer reveals information about itself without being legally required to do so. Such voluntary disclosure is a signal of quality because the producer underlines its confidence in itself and its offerings by disclosing additional information (DeKinder and Kohli 2008). For example, consumers from the United States (where the GDPR is not valid) have higher trust, lower privacy concerns, and a higher intention to disclose information when they encounter companies that voluntarily submit to the rules of the GDPR even in the United States (Willis et al. 2021; Zhang et al. 2020). Consequently, we assume that voluntary service updates should be appreciated by consumers and perceived as a stronger signal than generic service updates. Thus, we hypothesize the following:

H2b: Voluntary service updates for smart products will lead to a higher purchase intention among consumers compared to generic service updates.

Finally, voluntary service updates are also related to service guarantees (promising consumers insurance against failures caused by the service provider) that are not required by law. Service guarantees provide an additional benefit, and they serve as a promotional tool to differentiate a producer from its competitors in a positive way (Hogreve and Gremler 2009). Building on this stream of research, we suppose that the signal of voluntary service updates is stronger than the signal of legally required service updates because the seller can differentiate its offerings from those of its competitors by providing voluntary service updates. This stronger signaling effect should result in a higher purchase intention:

H2c: Voluntary service updates for smart products will lead to a higher purchase intention among consumers compared to legally required service updates.

4.2. Study Design

In our experiments, we described a smart dog collar that can be connected to a smartphone via an app to track the dog's fitness, check the dog's health, and identify the dog's location. Furthermore, the app offers several functionalities of a social community platform for (local) dog owners. Dog supplies constitute a substantial market; more than 12 million German citizens live in households with at least one dog (Pawlik 2022). However, in contrast to smartphones, smart TVs, and smart watches, smart dog collars are relatively unknown. Hence, dog owners participated in the survey without bias because they could not refer to previous experiences with this smart product. It is also worth mentioning that a smart dog collar has already been used in a previous study examining consumer behavior, though in a different context (Schleef et al. 2020). In both of our current studies, the smart dog collar was provided by a fictitious firm called YouTrack. We chose this name because the results of a pretest with 80 participants, in which several alternatives for the firm's name were considered, revealed that the majority of participants perceived YouTrack as particularly realistic and appealing. In the same pretest, we tested alternative pictures of dogs and color schemes to be used in the advertisement, and again, we chose the ones that the participants found the most realistic and appealing (e.g., a green seal).

Study 1 was a single-factor plus control group design. In our experiment, the participants were randomly assigned to one of four treatment groups. All participants were asked to pretend that they were shopping for a smart dog collar, and each was presented with the same collar. However, the description of the provision of service updates for the collar differed for each of the four groups. In the first group (the control group), no information on the provision of service updates was given. In the second group, the participants learned that service updates would be provided for at least 2 years and, thus, that all features of the smart dog collar would be available for at least 2 years, but they did not receive any further information in this regard. The participants in the third group were informed that service updates would be provided for at least 2 years according to law, while the fourth group was informed that service updates would be provided for at least 2 years on a voluntary basis.

Procedurally, the participants were first confronted with a fake newspaper article about a smart scale that had lost its smart functions because service updates were no longer provided. This was done to illustrate the current status of missing regulations for the provision of service updates, given that our pretest revealed that most consumers are ill-informed in this respect. Following this, the participants read the scenario containing information regarding the smart dog collar and the service updates (see *Fig. 2*). In addition, they saw a corresponding advertisement (see *Fig. 3*) showing different seals for each of the four manipulations. Then, the participants responded to the following items: (1) items on the dependent variable (i.e., purchase intention), (2) manipulation and realism checks, (3) control variables (i.e., age and gender), and (4) a few follow-up questions. The scenarios and the questionnaire were in German because the study was conducted in Germany.

Basic text used in all four scenarios:

While looking for a smart collar for your dog, you see the following advertisement by the company YouTrack. YouTrack offers the **"Smart Collar"** for dogs.
The "Smart Collar" has different functions: The waterproof smart collar can be connected to your smartphone via an app, and it enables you to trace your dog's fitness, check your dog's health, and identify your dog's location. Furthermore, you can discover new walking routes suggested by the app. You can contact local dog owners and share your daily successes related to the walks (distance, time, etc.).

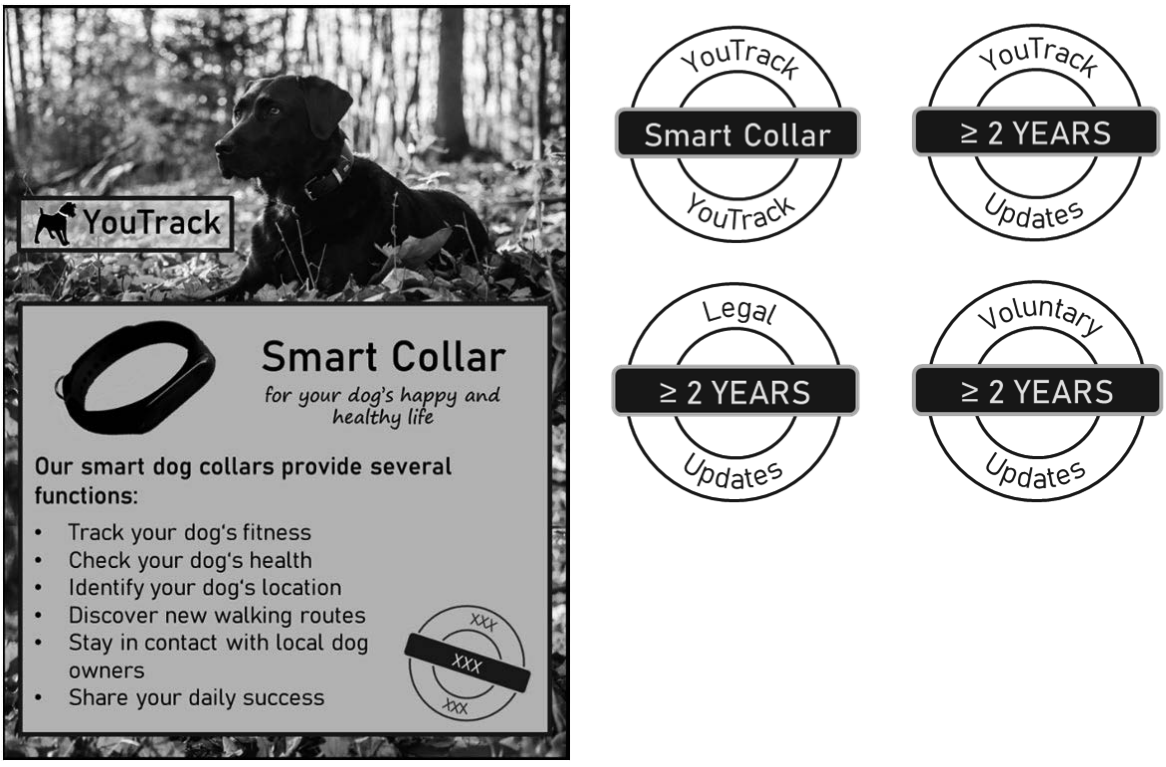
Scenario 1:
On the part of YouTrack, **no information** is available regarding future service **updates** for the "Smart Collar."

Scenario 2:
YouTrack offers service **updates** for a period of **2 years** for the "Smart Collar." Hence, all functions will be available for **at least** the next **2 years**.

Scenario 3:
According to legal requirements, YouTrack offers service **updates** for a period of **2 years** for the "Smart Collar." Hence, all functions will be available for **at least** the next **2 years**.

Scenario 4:
On a voluntary basis, YouTrack offers service **updates** for a period of **2 years** for the "Smart Collar." Hence, all functions will be available for **at least** the next **2 years**.

Fig. 2: Scenario descriptions for Study 1



Note: The seal in the advertisement serves as a placeholder for the corresponding seals on the right.

Fig. 3: Advertisements containing manipulation of Study 1

4.3. Sample

The participants were recruited online via the panel provider respondi (www.respondi.com), which guaranteed that all participants would be dog owners from Germany aged between 18 and 69 years. The sample was representative of the German population with respect to age and gender. We excluded 39 cases because of failed attention checks (e.g., the participants did not tick the cor-

rect box when asked "Please tick the 'strongly disagree' box now"), unusual patterns in response behavior (e.g., ticking the same answer on the scale for most questions), or unusual response times (e.g., extraordinarily long or short response times or extensive pauses between some of the answers given); in nearly all the excluded cases, more than one of the aforementioned issues applied. The final sample comprised 141 respondents (48.20% female; M_{age} = 44.11; *SD* = 15.12).

4.4. Measures

We measured purchase intention using the following three items, which were adapted from Fuchs et al. (2015): "It is likely that I would buy YouTrack's smart dog collar," "I would feel good about buying YouTrack's smart dog collar," and "I would buy YouTrack's smart dog collar" (α = 0.961; AVE = 0.929; CR = 0.975). For all items, including those used in the manipulation and realism checks, we applied a 7-point scale (1 = "strongly disagree" to 7 = "strongly agree"). As additional covariates, we measured gender and age.

4.5. Results

Manipulation and realism checks: To check the manipulation of the provision of service updates, we used the following item: "The scenario description said that YouTrack offers service updates for the smart dog collar." The participants' responses indicated that our manipulation worked. The mean of responses referring to the group of participants who received no information concerning the provision of service updates was significantly lower than the mean of responses from the participants who were told that YouTrack offers service updates for at least 2 years (M_{no_info} = 3.03, $M_{updates}$ = 6.11; t = –8.229, $p < 0.001$). The second manipulation check stated, "The scenario description said that YouTrack offers service updates for the smart dog collar for at least 2 years on a voluntary basis." The results of this check also indicated that our manipulation was successful. The participants from the legal framing group and the generic updates group displayed significantly lower means than the participants from the voluntary framing group ($F_{2,104}$ = 4.517, $p < 0.05$). Planned contrasts indicated higher means for participants from the voluntary framing group in comparison to the legal framing group ($M_{voluntary\_updates}$ = 5.47, $M_{legal\_updates}$ = 4.06; $F_{1,104}$ = 6.934, $p < 0.05$) and the generic updates group ($M_{voluntary\_updates}$ = 5.47, $M_{updates}$ = 4.08; $F_{1,104}$ = 6.775, $p < 0.05$). The difference between participants from the legal framing group and the generic updates group was not significant ($M_{legal\_updates}$ = 4.06, $M_{updates}$ = 4.08; $F_{1,104}$ = 0.002, p = 0.96). A third manipulation check—"The scenario description said that YouTrack offers service updates for the smart dog collar for 2 years according to the implemented directive (EU) 2019/771"—confirmed this indication ($F_{2,104}$ = 20.670, $p < 0.001$). Planned contrasts showed higher means for participants from the legal framing group in comparison to the voluntary framing group ($M_{legal\_updates}$ = 6.11, $M_{voluntary\_updates}$ = 3.65; $F_{1,104}$ = 28.562, $p < 0.001$) and the generic updates group ($M_{legal\_updates}$ = 6.11, $M_{updates}$ = 3.51; $F_{1,104}$ = 33.124, $p < 0.001$). We could not identify a significant difference between participants from the voluntary framing group and the generic updates group ($M_{voluntary\_updates}$ = 3.65, $M_{updates}$ = 3.51; $F_{1,104}$ = 0.085, p = 0.77). Finally, a realism check using three items—"The described situation seems to be realistic," "It is easy to put oneself in the described situation," and "The scenario was easy to understand"—confirmed that participants perceived the situation as realistic (M = 5.22; SD = 1.40).

Hypothesis testing: We conducted a series of analyses of covariance (ANCOVAs), considering age and gender as covariates. The first ANCOVA revealed that the general information on the provision of service updates significantly increased purchase intention (M_{no_info} = 3.28, $M_{updates}$ = 3.99; $F_{1,137}$ = 4.397, $p < 0.05$). Age was a significant covariate ($F_{1,137}$ = 6.697, $p < 0.05$). This result supported H1, in that communicating the provision of service updates for smart products significantly increased consumers' purchase intention compared to no information on the provision of service updates. To test H2a, we conducted a second ANCOVA comparing the group with legally required service updates to the generic service update group. We found that the information on the legal provision of service updates did not significantly influence purchase intention ($M_{generic\_updates}$ = 3.56, $M_{legal\_updates}$ = 3.87; $F_{1,69}$ = 0.562, $p > 0.05$). Both covariates displayed nonsignificant effects. Thus, H2a was rejected. In the third ANCOVA, which compared the voluntary service updates group to the generic service updates group, we revealed that the information on the voluntary provision of service updates significantly increased purchase intention compared to generic service updates ($M_{generic\_updates}$ = 3.56, $M_{voluntary\_updates}$ = 4.66; $F_{1,67}$ = 7.237, $p < 0.01$). Consequently, H2b was supported. Finally, we tested H2c in a further ANCOVA and showed that voluntary service updates outperformed legal service updates in terms of their influence on consumers' purchase intention ($M_{voluntary\_updates}$ = 4.68, $M_{legal\_updates}$ = 3.84; $F_{1,66}$ = 4.956, $p < 0.05$). Age was a significant covariate ($F_{1,66}$ = 4.880, $p < 0.05$). Hence, this result supported H2c.

Discussion: Our results indicate that the provision of service updates leads to a higher purchase intention than does no information on service update provision. A highest purchase intention can be reached when service updates are provided on a voluntary basis. However, even though Study 1 showed that voluntary service updates result in the best performance, providers can no longer claim to provide service updates for their smart

products for at least 2 years on a voluntary basis, because Directive 2019/771, which obliges providers to provide service updates, was introduced at the beginning of 2022. Although providers cannot advertise 2 years of service updates voluntarily, the finding that voluntary service updates lead to a higher purchase intention compared to legally required service updates is still valuable. Thus, providers may want to benefit from the positive effect of voluntary service updates by offering an additional voluntary extension beyond the legally required 2-year period. Given these findings, we conducted Study 2 as a follow-up to scrutinize the following issues: (1) Is it beneficial for providers to offer an additional voluntary extension? (2) Does an optimal update duration exist?

5. Experimental Study 2

5.1. Hypothesis Development

Based on our results from Study 1, we assume that additional voluntary service updates—that is, service updates that are not required by law—provide an additional benefit and can therefore serve as a promotional tool to differentiate a seller from its competitors in a positive way. This can then lead to a higher purchase intention among consumers:

H3a: Additional voluntary service updates for smart products increase consumers' purchase intention.

However, we also expect that this positive effect may diminish over the lifespan of a smart product because smart products also have tangible components (i.e., hardware) that get older and need to be replaced eventually (e.g., the leather used for a smart dog collar wears down). Moreover, the lifespan of a smart product is usually relatively short compared to that of a common nontechnical product, such as a regular dog collar (e.g., the lifespan of smartphones is only 2.64 years; O'Dea 2022). Accordingly, we assume that the expected lifespan of smart products is typically relatively short, and thus, we expect that the perceived benefit (i.e., the added value) from an additional increase in the length of time for which service updates are provided decreases with the length of the overall service update period:

H3b: The positive effect of longer timespans of voluntary service updates increases consumers' purchase intention, but only at a decreasing rate.

We also accounted for the durability of the smart product, as providing service updates for smart products can extend the products' lifespan. For example, instead of purchasing a new smart lock to ensure its proper and secure functioning, the existing smart lock software is updated, and thus, the lock can be used for a longer period. This could have an effect on consumer behavior, particularly in countries such as Germany. The ameliorated perception of durability should be valued by the consumer and should, in turn, have a positive effect on consumers' purchase intention. Accordingly, we considered the durability of the smart product to work as a mediator, explaining the positive total effect of an extended period for the provision of service updates on consumers' purchase intention in relation to smart products:

H4: By increasing the durability of the smart product, additional voluntary service updates for smart products increase consumers' purchase intention.

5.2. Study Design

Study 2 had the same format as Study 1, that is, it also was a between-subjects experiment. Participants in Study 2 were randomly assigned to one of five treatment groups, for which the description of the provision of service updates for the smart dog collar differed. In one setting, the participants received the information that service updates were provided for at least 2 years because of legal requirements. The participants in the other four settings were informed that service updates were provided for at least 2 years on a legal basis and 2, 4, 6, or 8 additional years on a voluntary basis. These timespans were chosen because smartphones are often replaced after 2 years, whereas regular (i.e., non-smart) dog collars can be used for 10 (or more) years. To corroborate our assumption, we asked participants in a pretest (n = 80) for the timespan within which they would expect service updates for a smart dog collar. The average expectation was nearly 6 years ($M_{exp\_duration}$ = 5.92 years, SD = 3.57 years).

As in Study 1, we initially presented the participants with a fake newspaper article about the smart scale before asking them to pretend that they were shopping for a smart dog collar. Then, we referred once more to the fictitious firm YouTrack. Again, the participants read the scenario description containing information regarding the smart dog collar (see *Fig. 4*) and saw a corresponding advertisement (see *Fig. 5*) containing the manipulation in the seal. Next, they responded to the items related to the following elements: the dependent variable (i.e., purchase intention), mediator (i.e., durability), manipulation and realism checks, and control variables (i.e., age and gender).

Basic text used in all five scenarios:

While looking for a smart collar for your dog, you see the following advertisement by the company YouTrack. YouTrack offers the **"Smart Collar"** for dogs.
The "Smart Collar" has different functions: The waterproof smart collar can be connected to your smartphone via an app, and it enables you to trace your dog's fitness, check your dog's health, and identify your dog's location. Furthermore, you can discover new walking routes suggested by the app. You can contact local dog owners and share your daily successes related to the walks (distance, time, etc.).

Scenario 1:
According to legal requirements, YouTrack offers service **updates** for a period of **2 years** for the "Smart Collar." Hence, all functions will be available for **at least** the next **2 years**.

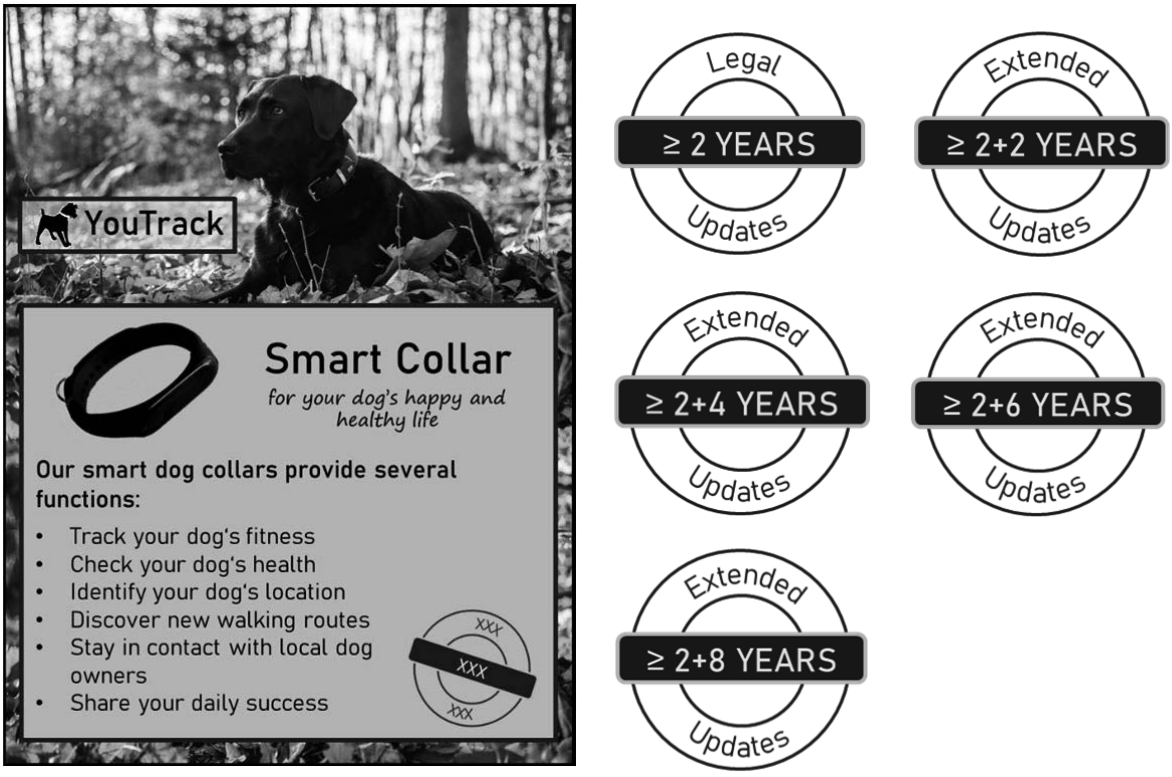
Scenario 2:
According to legal requirements, YouTrack offers service **updates** for a period of **2 years** for the "Smart Collar." **On a voluntary basis**, YouTrack offers service **updates** for **2 additional years**. Hence, all functions will be available for **at least** the next **4 years**.

Scenario 3:
According to legal requirements, YouTrack offers service **updates** for a period of **2 years** for the "Smart Collar." **On a voluntary basis**, YouTrack offers service **updates** for **4 additional years**. Hence, all functions will be available for **at least** the next **6 years**.

Scenario 4:
According to legal requirements, YouTrack offers service **updates** for a period of **2 years** for the "Smart Collar." **On a voluntary basis**, YouTrack offers service **updates** for **6 additional years**. Hence, all functions will be available for **at least** the next **8 years**.

Scenario 5:
According to legal requirements, YouTrack offers service **updates** for a period of **2 years** for the "Smart Collar." **On a voluntary basis**, YouTrack offers service **updates** for **8 additional years**. Hence, all functions will be available for **at least** the next **10 years**.

Fig. 4: Scenario descriptions for Study 2



Note: The seal in the advertisement serves as a placeholder for the corresponding seals on the right.

Fig. 5: Advertisements containing manipulation of Study 2

5.3. Sample

With the help of the panel provider respondi, we collected a sample of 270 dog owners who were representative of the German population in terms of age and gender. The participants were between 18 and 69 years old. After cases were excluded for the same reasons as in the previous study, the final sample contained 222 respondents (50.00% female; M_{age} = 44.42; *SD* = 14.10).

5.4. Measures

We measured purchase intention using the same three items as before (α = 0.953; AVE = 0.914; CR = 0.970). To avoid unintended priming effects of the mediator, we later measured the perceived durability of the smart product by adapting three items from Jiang et al. (2016): "YouTrack's smart collar has durable usability," "YouTrack's smart collar has enduring usability," and "YouTrack's smart collar is long-lasting" (α = 0.937; AVE = 0.889; CR = 0.960). Gender and age were covariates.

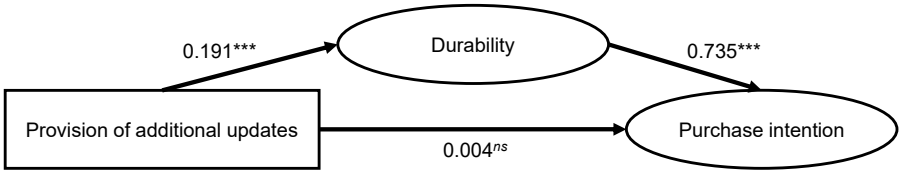
5.5. Results

Manipulation and realism checks: To check for the manipulation of the timespan for the voluntary service update extension, we asked the participants the following: "For how many additional years does YouTrack offer service updates on a voluntary basis for the smart dog collar?" Participants could choose from the following options: "0 years (2 years in total)," "2 years (4 years in total)," "4 years (6 years in total)," "6 years (8 years in total)," and "8 years (10 years in total)." A chi-square test was used to compare the expected and observed values for this manipulation check, and the results showed a significant relationship between the two ($\chi^2(16) = 525.17$, $p < 0.001$, $\varphi = 0.769$). A realism check using the same three items as in the first study confirmed that the situation was perceived as realistic (*M* = 5.45; *SD* = 1.23).

Hypothesis testing: We used a multistep hierarchical regression to examine the relationship between the increasing timespan of additional voluntary service updates and consumers' purchase intention. For the analysis, we recoded the five timespans (i.e., 2, 4, 6, 8, or 10 years of service update provision) such that we had a quasi-metric variable replacing the number of the treatment group by the number of years during which updates are provided. We then centered the independent variables. Next, we calculated Model 1, which included only the covariates, and then added the linear, quadratic, and cubic terms of the timespan of additional voluntary service updates stepwise. The amount of explained variance increased when we added the linear term to Model 1 ($\Delta R^2 = 0.045$, $F = 10.985$, $p < 0.001$) but did not change significantly after the inclusion of quadratic and cubic terms. Thus, we stayed with the linear model. The positive and significant linear term (*B* (unstandardized) = 0.144, *SE* = 0.044, $p < 0.001$) suggested a positive relation between longer timespans of voluntary service update provision and consumers' purchase intention.

We followed up the results of the multistep hierarchical regression with an ANCOVA (covariates were age and gender) and found a significant main effect of voluntary service update provision ($F_{4,215} = 3.324$, $p < 0.05$). Age was the only significant covariate ($F_{1,215} = 12.199$, $p < 0.01$). Looking at the numerical results of the pairwise comparisons (see *Tab. A1* in the appendix), we found that the means increased significantly when additional voluntary service updates beyond the legally required 2 years were granted. These results also match the positive linear effect found in the multistep hierarchical regression. Thus, H3a was supported. Nonetheless, longer timespans of additional voluntary service updates did not lead to significantly higher purchase intention, in line with H3b. At the same time, because we did not observe either a quadratic or cubic effect in our multistep hierarchical regression, H3b was only partially supported.

H4 was tested using Hayes's PROCESS macro (Version 4.0; Model 4, 10,000 bootstrap samples; Hayes 2018), which also included the two covariates. We reported unstandardized path coefficients for our mediation analysis (see *Fig. 6*). The results indicated that durability mediated the effect of the additional voluntary provision of service updates for smart products on purchase intention (*B* = 0.141, *SE* = 0.032; 95% confidence interval [0.080; 0.205], $p < 0.001$). We found an indirect-only mediation (Zhao et al. 2010), as the direct effect of additional voluntary service updates for smart products vanished in the presence of the mediator (*B* = 0.004, *SE* = 0.034; 95% confidence interval [–0.063; 0.071], not significant). Hence, H4 was supported.



Indirect effect: Provision of additional updates → durability → purchase intention: 0.141***

Total effect: Provision of additional updates → purchase intention: 0.144**

Notes: * = significant at p < 0.05, ** = significant at p < 0.01, *** = significant at p < 0.001, ns = not significant.
Control variables: age and gender

Fig. 6: Results of the mediation analysis

Discussion: The findings from Study 2 indicate that smart product providers may benefit from extending the legally required service update timespan of 2 years by incorporating an additional voluntary extension. However, following our results, it does not seem beneficial to offer overly long timespans for these additional voluntary service updates. In the context of smart dog collars, 2 years appeared to be sufficient.

6. Discussion and Implications

Until 2021, smart product sellers were not obliged to offer service updates. This led to "dumb" smart products that could no longer offer smart services or even became a security problem for their owners. From the beginning of 2022, EU member states were obliged to implement two EU directives that make the provision of service updates for smart products obligatory for a minimum of 2 years (if not explicitly waived in the purchasing contract). In light of recent developments, we sought to determine whether and how these legally required service updates affect consumers' perceptions and behavior. Moreover, we strove to understand the meaning of mandatory legal versus voluntary service updates for consumers and to assess the optimal service update timespan.

While we expected that service updates for smart products in general would increase consumers' purchase intention toward the respective smart product, our findings were mixed in this respect. On the one hand, we did not observe higher means for legally required service updates compared to generic service updates (i.e., no information was given regarding the motivation for the updates). One explanation for this result may be that consumers typically expect to receive service updates for at least 2 years, although sellers were under no such legal obligation until the new regulations entered into force at the beginning of 2022. In other words, consumers simply believed that service updates were part of the implied warranty (which was not actually the case). On the other hand, our results show that the signaling effect is stronger for voluntary service updates than for both generic and legally required service updates. Thus, customers appear to value voluntary service updates because they perceive this willingness to provide such updates as an additional benefit; this can serve as a promotional tool to differentiate the specific products from the smart products offered by other sellers. This finding is in line with related observations on the voluntary application of the GDPR (Willis et al. 2021; Zhang et al. 2020) and the voluntary provision of service guarantees (Hogreve and Gremler 2009). Therefore, the lesson learned for managers in other (non-EU) countries could be that the voluntary provision of service updates for smart products may indeed increase purchase intention.

While sellers in Germany cannot promote and boast about the provision of a 2-year service update period (as this is already obligatory in Germany for smart products that rely on a continuous supply of the digital element), providers can still voluntarily offer an extension of the mandatory period for service updates. According to our results, such a measure can increase consumers' purchase intention. However, the effect is limited insofar as we could not find a significantly higher purchase intention for timespans of additional voluntary service updates longer than 2 years. This is interesting, as consumers expect to use a smart dog collar for 6 years, as indicated in our pretest, and not for only 4 years. The reason for this may be that the proper functioning of a smart dog collar enabled by the provision of service updates plays a more prominent role in the first years of product usage—consumers would be rather unhappy if updates stopped right after the minimum period of 2 years set by the legal regulations—but the provision of updates loses relevance after 4 years of usage when these consumers start thinking about replacing the smart dog collar with a new one. Given that longer service update timespans are also connected to higher costs for the provider, smart product providers need to carefully assess the optimal duration of additional voluntary updates for their particular smart

product, because extensions beyond this optimal duration do not add significant economic value.

However, other issues may also play a role. For example, longer service update periods may increase consumers' perception of the durability of the smart product. As durability represents one facet of sustainability, perceived sustainability should be positively affected (Tukker 2015; Tukker and Tischner 2006), which can serve as a convincing sales message. This, of course, holds true only as long as the company is not blamed for greenwashing (e.g., Schmuck et al. 2018) because the service update timespans are not reasonably high. Granting only 2 voluntary years after the legally required 2 years may therefore not suffice if the expected period of usage is much longer (e.g., 5 to 10 years for smart TVs; Proschofsky 2019). However, consumers' perceptions of the smart product's durability in terms of perceived sustainability may also increase the closely related transformative value (i.e., value creation for people and the planet; see Bilstein et al. 2022). Consequently, in terms of transformative value, it may be worthwhile to offer longer service update timespans. Showing commitment in this respect might have a positive effect on corporate image, as many consumers expect profit-making companies to reward society and the environment; these companies might therefore want to integrate this into their marketing strategies (Larivière and Smit 2022).

7. Limitations and Further Research

The limitations of our findings give rise to several promising avenues for further research. First, we collected data for a single product (i.e., a smart dog collar). Therefore, our findings cannot be generalized to other smart product categories, especially more expensive ones (e.g., smart TVs) or smart products with a longer expected lifespan (e.g., smart cars). Hence, further studies should seek to replicate our results in the context of smart products. In doing so, it will also be interesting to account for different types of products (e.g., products that are connected or integrated into a smart home, which may present quite a different story given the higher stakes that come into play). Second, we conducted our study in Germany. Future research should scrutinize the proposed effects in different countries, such as other EU member states that were also obliged to implement the EU directives in their civil codes and non-EU member states that do not have a legal framework for the provision of service updates for smart products. Third, further outcome variables—such as willingness to pay, intention to use, and willingness to recommend—could be considered. Fourth, it could be worthwhile to include additional mediators (e.g., trust or different facets of sustainability) and moderators (e.g., consumers' attitudes toward innovation). Fifth, it would be interesting to determine whether explicitly excluding service updates (with an annex to the sales contract; see *Fig. 1*) would have a devastating effect on consumers' behavioral intention or whether consumers would still be content with such a condition.

References

Bilstein, N. & Stummer, C. (2020). Multidisciplinary Perspectives on Challenges in Managing Smart Products and Services, *Schmalenbach Business Review*, 72 (4), 479–483.

Bilstein, N., Verlegh, P. W. J., Klostermann, J. & Akpinar, E. (2022). Better Together: Involving Consumers in the Ideation, Creation and Dissemination of Transformative Value, *Journal of Service Management*, 33 (4/5), 520–530.

Connelly, B. L., Trevis Certo, S., Ireland, R. D. & Reutzel, C. R. (2011). Signaling Theory: A Review and Assessment, *Journal of Management*, 37 (1), 39–67.

Cox, K. (2020). *Smart Scale Goes Dumb as Under Armour Pulls the Plug on Connected Tech*, https://arstechnica.com/information-technology/2020/01/smart-scale-goes-dumb-as-under-armour-pulls-the-plug-on-connected-tech.

DeKinder, J. S. & Kohli, A. K. (2008). Flow Signals: How Patterns over Time Affect the Acceptance of Start-Up Firms, *Journal of Marketing*, 72 (5), 84–97.

Fox, G., Lynn, T. & Rosati, P. (2022). Enhancing Consumer Perceptions of Privacy and Trust: A GDPR Label Perspective, *Information Technology & People*, 35 (8), 181–204.

Fuchs, C., Schreier, M. & Van Osselaer, S. M. J. (2015). The Handmade Effect: What's Love Got to Do with It? *Journal of Marketing*, 79 (2), 98–110.

Garun, N. (2020). *Under Armour's Smart Scale and Fitness Tracker Have Stopped Tracking Weight, Steps, and Sleep*, https://www.theverge.com/2020/1/21/21075858/under-armour-healthbox-ua-record-discontinued-app-support-internet-of-things.

Gatti, L., Vishwanath, B., Seele, P. & Cottier, B. (2019). Are We Moving Beyond Voluntary CSR? Exploring Theoretical and Managerial Implications of Mandatory CSR Resulting from the New Indian Companies Act, *Journal of Business Ethics*, 160 (4), 961–972.

Hayes, A. F. (2018). *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach*, 2nd ed., New York, Guildford Press.

Henkens, B., Verleye, K. & Larivière, B. (2021). The Smarter, the Better?! Customer Well-Being, Engagement, and Perceptions in Smart Service Systems, *International Journal of Research in Marketing*, 38 (2), 425–447.

Hogreve, J. & Gremler, D. D. (2009). Twenty Years of Service Guarantee Research: A Synthesis, *Journal of Service Research*, 11 (4), 322–343.

Hoofnagle, C. J., van der Sloot, B. & Zuiderveen Borgesius, F. (2019). The European Union General Data Protection Regulation: What It Is and What It Means, *Information & Communications Technology Law*, 28 (1), 65–98.

Jiang, Y., Gorn, G. J., Galli, M. & Chattopadhyay, A. (2016). Does Your Company Have the Right Logo? How and Why Circular-and Angular-Logo Shapes Influence Brand Attribute Judgments, *Journal of Consumer Research*, 42 (5), 709–726.

Kirmani, A. & Rao, A. R. (2000). No Pain, No Gain: A Critical Review of the Literature on Signaling Unobservable Product Quality, *Journal of Marketing*, 64 (2), 66–79.

Larivière, B. & Smit, E. G. (2022). People–Planet–Profits for a Sustainable World: Integrating the Triple-P Idea in the Marketing Strategy, Implementation and Evaluation of Service Firms, *Journal of Service Management*, 33 (4/5), 507–519.

Liu, Y., Eisingerich, A. B., Auh, S., Merlo, O. & Chun, H. E. H. (2015). Service Firm Performance Transparency: How, When, and Why Does It Pay Off? *Journal of Service Research*, 18 (4), 451–467.

Lu, J. Y. & Castka, P. (2009). Corporate Social Responsibility in Malaysia–Experts' Views and Perspectives, *Corporate Social Responsibility and Environmental Management*, 16 (3), 146–154.

Michler, O., Stummer, C. & Decker R. (2022). Can the GDPR Allay Privacy Concerns Towards Smart Products? The Effect of a Compliance Seal on Perceived Data Security, Trust, and Intention to Use. *Proceedings of the International Conference on Electronic Government and the Information Systems Perspective (EGOVIS), LNCS 13429*. Cham, Springer, 77–91.

Mirobi, G. J. & Arockiam, L. (2015). Service Level Agreement in Cloud Computing: An Overview. *International Conference on Control, Instrumentation, Communication and Computational Technologies (ICCICCT)*, 753–758.

O'Dea, S. (2022). *Average Lifespan (Replacement Cycle Length) of Smartphones in the United States from 2014 to 2025*, https://www.statista.com/statistics/619788/average-smartphone-life.

Paul, C., Scheibe, K. & Nilakanta, S. (2020). Privacy Concerns Regarding Wearable IoT Devices: How it is Influenced by GDPR? *Proceedings of the 53rd Hawaii International Conference on System Sciences (HICSS)*, 4388–4397 (2020)

Pawlik, V. (2022). *Pet Owners in Germany by Number of Dogs in Households from 2018 to 2021*, https://de.statista.com/statistik/daten/studie/181167/umfrage/haustier-anzahl-hunde-im-haushalt.

Proschofsky, A. (2019). *Smart-TV? Nein, danke!*, https://www.derstandard.at/story/2000111364110/smart-tv-nein-danke.

Raff, S., Wentzel, D. & Obwegeser, N. (2020). Smart Products: Conceptual Review, Synthesis, and Research Directions, *Journal of Product Innovation Management*, 37 (5), 379–404.

Richter, F. (2021). *How Long Does Apple Support Older iPhone Models?* https://www.statista.com/chart/5824/ios-iphone-compatibility.

Schleef, M., Bilstein, N. & Stummer, C. (2020). "Shh! … I Got Help to Become Smart": Should Incumbent Firms Disclose Their Cooperation with a Startup? *Proceedings of the International Conference on Information Systems (ICIS)*, AIS Electronic Library, Paper 2144.

Schmuck, D., Matthes, J. & Naderer, B. (2018). Misleading Consumers with Green Advertising? An Affect–Reason–Involvement Account of Greenwashing Effects in Environmental Advertising, *Journal of Advertising*, 47 (2), 127–145.

Spence, M. (1973). Job Market Signaling, *Quarterly Journal of Economics*, 87 (3), 355–374.

Stern (2020). *Einladung für Einbrecher: Smarter Türöffner lässt ungefragt auch Fremde in die Wohnung*, https://www.stern.de/digital/technik/nello-one--smarter-tueroeffner-laesst-ungefragt-auch-fremde-in-die-wohnung-9115988.html.

Tighe, D. (2022). *Leading Sustainable Habits to Minimize Their Impact on the Environment among Consumers in Germany in 2021*, https://www.statista.com/statistics/1271814/sustainable-habits-among-consumers-in-germany/.

Tukker, A. (2015). Product Services for a Resource-Efficient and Circular Economy: A Review, *Journal of Cleaner Production*, 97, 76–91.

Tukker, A. & Tischner, U. (2006). Product-Services as a Research Field: Past, Present and Future. Reflections from a Decade of Research, *Journal of Cleaner Production*, 14 (17), 1552–1556.

Willis, B., Jai, T. C. & Lauderdale, M. (2021). Trust and Commitment: Effect of Applying Consumer Data Rights on U.S. Consumers' Attitudes toward Online Retailers in Big Data Era, *Journal of Consumer Behavior*, 20 (6), 1575–1590.

Wuenderlich, N., Heinonen, K., Ostrom, A., Patricio, L., Sousa, R., Voss, C. & Lemmink, J. (2015). "Futurizing" Smart Service: Implications for Service Researchers and Managers, *Journal of Services Marketing*, 29 (6/7), 442–447.

Xu, M., Lai, I. K. W. & Tang, H. (2020). From Corporate Environmental Responsibility to Purchase Intention of Chinese Buyers: The Mediation Role of Relationship Quality, *Journal of Consumer Behavior*, 20 (2), 309–323.

Zhang, Y., Wang, T. & Hsu, C. (2020). The Effects of Voluntary GDPR Adoption and the Readability of Privacy Statements on Customers' Information Disclosure Intention and Trust, *Journal of Intellectual Capital*, 21 (2), 145–163.

Zhao, X., Lynch, J. G. & Chen, Q. (2010). Reconsidering Baron and Kenny: Myths and Truths about Mediation Analysis, *Journal of Consumer Research*, 37 (2), 197–206.

Appendix

Tab. A1: Numerical results of the pairwise comparisons in Study 2

Setting	Mean	Compared setting	Difference of mean	Standard error
2 years of service updates	3.371	4 years of service updates	–0.835*	0.393
		6 years of service updates	–0.887*	0.380
		8 years of service updates	–0.961*	0.382
		10 years of service updates	–1.390***	0.393
4 years of service updates	4.206	2 years of service updates	0.835*	0.393
		6 years of service updates	–0.051	0.379
		8 years of service updates	–0.126	0.382
		10 years of service updates	–0.555	0.393
6 years of service updates	4.257	2 years of service updates	0.887*	0.380
		4 years of service updates	0.051	0.379
		8 years of service updates	–0.074	0.368
		10 years of service updates	–0.504	0.380
8 years of service updates	4.332	2 years of service updates	0.961*	0.382
		4 years of service updates	0.126	0.382
		6 years of service updates	0.074	0.368
		10 years of service updates	–0.429	0.382
10 years of service updates	4.761	2 years of service updates	1.390***	0.393
		4 years of service updates	0.555	0.393
		6 years of service updates	0.504	0.380
		8 years of service updates	0.429	0.382

Note: * = significant at $p < 0.05$, *** = significant at $p < 0.001$

Keywords: Smart Product, Smart Service, Service Updates, Legal Regulations, Experimental Study