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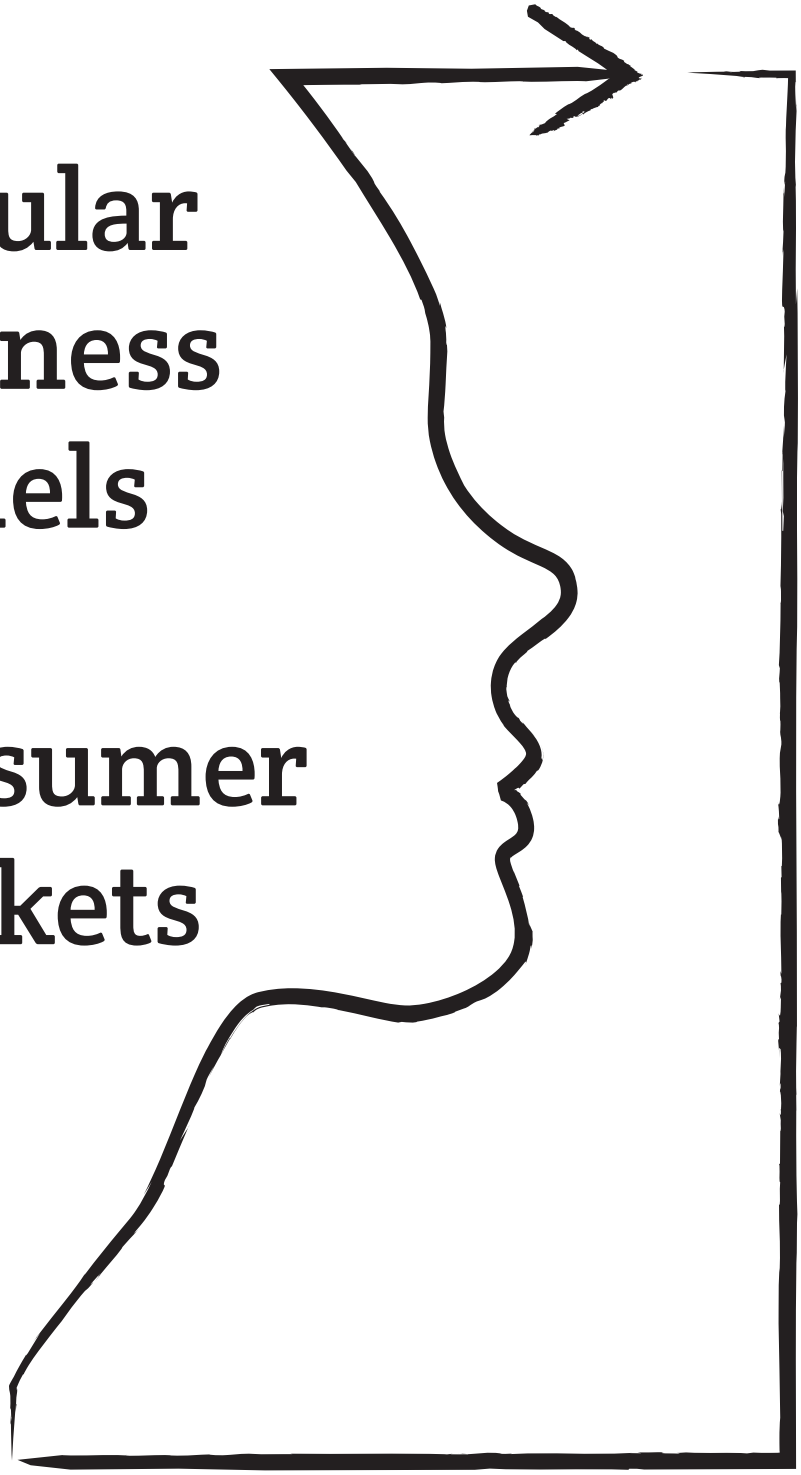

Vivian S.C. Tunn

Circular Business Models for Consumer Markets

Dissertation

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Dedicated to Inge Tunn, my late grandmother, the strongest and most loving person I have ever met. Many times, I imagined telling you about my PhD, seeing your proud smile, and feeling your tight, loving hugs. I still remember how we turned the cut-off sleeves of my dad's shirt into shorts for me when I was a child. The only childhood trousers I still remember. You taught me that there is no such thing as waste and that it is not material goods and possessions that make people happy. Thank you for your love. You are in my heart for ever.

Contents

Summary

Over the last decade, the circular economy has gained traction as a concept to transform the society and economy into more sustainable systems. In this context, research into circular business models arose to implement circular economy strategies at the company level. In this thesis, a consumer perspective on circular business models is taken.

The research explored how business models can help achieve a circular economy and lead to sustainable consumption (Chapter 2). Business model elements concerning the production and consumption side need to be considered; namely the resource strategy, revenue model, consumer effort, and the companies' objective regarding consumption levels. These elements contributed to the development of a framework for the design of such business models.

Subsequently, the research focus shifted towards a specific category of circular business models - access-based product-service systems (AB-PSS). AB-PSS allow consumers to use products for a fee without needing to purchase the products. In AB-PSS, different consumers use products sequentially. This can reduce the overall number of products and thereby improve sustainability; because products are either used more intensively by many consumers (e.g., bicycle sharing) or because professional maintenance and repair by the provider extend product lifetimes.

While some AB-PSS have been available for a while, many still lack wider adoption in consumer markets. This thesis presents a literature review of consumer AB-PSS adoption barriers (Chapter 3). Interviews with users of mobility AB-PSS (e.g., bicycle sharing and car sharing) elucidate factors that motivate consumer adoption of these services. Many barriers and motivators relate to similar topics (e.g., low effort to access can motivate adoption while high effort creates a barrier).

For companies to be able to design AB-PSS for consumer markets, it is important to determine which adoption barriers are important and in what circumstances adoption barriers are important to consumers (Chapter 4). From a consumer perspective, the duration of use (i.e., whether a product is used for 1 hour or 6 months) and the type of product (i.e., clothes or bicycles) are the two most important dimensions to discern AB-PSS. In short-term AB-PSS adoption barriers related to service aspects (e.g., effort to access the product) are especially important. In contrast, adoption barriers related to product aspects (e.g., lack of intangible value) are more important in long-term AB-PSS. In addition, aspects that are crucial for consumers when purchasing products are even more important in AB-PSS (e.g., fear of contamination for clothing AB-PSS).

Temporary customisation can potentially alleviate the lack of intangible value in long-term AB-PSS (Chapter 5). Generally, typical products (i.e., standard products of the category that look familiar to consumers) are placed in AB-PSS as they are acceptable for many consumers. Yet, this results in a lack of intangible value in long-term AB-PSS. To increase a product's relevance for a consumer, products can be customised. Indeed, products placed in AB-PSS can be temporarily customised by adding a small, easily-detachable attribute that matches the consumer's personality. The better the match between consumer and product personality the higher the preference for the AB-PSS.

Many AB-PSS available to consumers today have been enabled by digitalisation (Chapter 6). Hence, the effects of digitalised AB-PSS on consumer attitudes and use experiences in these services was explored. In addition, consumers have different levels of digital confidence that might influence their attitude towards digitalised AB-PSS. In general, digital aspects support service aspects and are consequently more important in short-term AB-PSS. The research showed that digitally confident consumers have a more positive attitude towards short-term AB-PSS than less digitally confident consumers. Indeed, actual users of short-term mobility AB-PSS seem to be generally highly digitally confident and described insightful positive and negative use experiences resulting from the digital aspects of AB-PSS.

Consumers' use behaviour can negatively influence product lifetimes and thereby the sustainability potential of AB-PSS (Chapter 7). Hence, consumer product care for washing machines and bicycles was quantitatively compared across business models. Product care is lower for products used through long-term AB-PSS than for products consumers bought new or second-hand. However, product care for both products was only moderate across the three analysed business models. Hence, the product design, communication, and contract of AB-PSS should be geared towards ensuring product care for them to contribute to environmental sustainability.

Finally, the findings of this thesis are summarised, implications discussed, and recommendations for theory and practice are provided (Chapter 8). Overall, business models such as AB-PSS are interesting as they could quickly improve environmental sustainability if they are designed and implemented well. The design of circular business models and sustainable AB-PSS for consumer markets requires continuous iterations to assess, improve, and realise their sustainability potential.

Samenvatting

In het afgelopen decennium heeft de circulaire economie het aan kracht gewonnen als concept om de maatschappij en economie richting duurzamere systemen toe te bewegen. Ten behoeve van de implementatie bij bedrijven is er een toename aan onderzoek naar circulaire businessmodellen ontstaan. In dit proefschrift worden circulaire bedrijfsmodellen bekeken vanuit een consumentenperspectief.

We onderzochten hoe bedrijfsmodellen kunnen bijdragen aan een circulaire economie en aan duurzame consumptie (hoofdstuk 2). Hierbij is het belangrijk om rekening te houden met elementen van het bedrijfsmodel met betrekking tot de productie- en consumptiekant, namelijk: de strategie voor grondstofwinning, het verdienmodel, de inspanningen van de consument en de doelstelling van de bedrijven met betrekking tot consumptieniveaus. Deze elementen hebben bijgedragen aan de ontwikkeling van een raamwerk voor het ontwerp van dergelijke bedrijfsmodellen.

Vervolgens verschoof de focus van het onderzoek naar een specifieke categorie van circulaire bedrijfsmodellen: op toegang gebaseerde product-dienstsystemen (AB-PSS). Met AB-PSS kunnen consumenten producten tegen betaling gebruiken zonder de producten te hoeven kopen. In een dergelijk model gebruiken verschillende consumenten producten na elkaar. Omdat producten op deze manier intensiever worden gebruikt vanwege de vele gebruikers (bijvoorbeeld door het delen van fietsen) of omdat de aanbieder onderhoud en reparatie op professioneel wijze kan inrichten en zo de levensduur van producten kan verlengen, kan het totale aantal benodigde producten verminderd worden en zal daarmee de duurzaamheid verbeteren.

Hoewel AB-PSS al langer gebruikt worden, ontbreekt de bredere acceptatie op consumentenmarkten nog vaak. Dit proefschrift presenteert een literatuuroverzicht van de barrières tot acceptatie van AB-PSS door consumenten (Hoofdstuk 3). Hierin verduidelijken interviews met gebruikers van AB-PSS voor mobiliteit (bijv. deelfietsen en deelauto's) de factoren die de acceptatie van deze diensten door de consument kunnen bevorderen. Veel barrières en kansen hebben betrekking op dezelfde onderwerpen (bijv. een toename in gemak om toegang te krijgen kan acceptatie bevorderen, terwijl te hoge inspanningen juist weer een belemmering vormen).

Voor bedrijven is het belangrijk om te bepalen wanneer welke adoptiebarrières belangrijk zijn om succesvol AB-PSS voor consumentenmarkten te kunnen ontwerpen (hoofdstuk 4). Vanuit een consumentenperspectief zijn de gebruiksduur (of een product nu 1 uur of 6 maanden wordt gebruikt) en het type product (d.w.z. kleding of fietsen) de twee belangrijkste dimensies om AB-PSS te onderscheiden. Bij de acceptatie van AB-PSS met een korte gebruiksduur zijn barrières die verband houden met serviceaspecten

(bijv. inspanningen om toegang te krijgen tot het product) bijzonder belangrijk. Daarentegen zijn voor AB-PSS met een lange gebruiksduur acceptatiebarrières die verband houden met productaspecten (bijv. gebrek aan immateriële waarde) belangrijker. Daarnaast zijn aspecten die normaliter cruciaal zijn voor consumenten bij het kopen van producten van nog groter belang in AB-PSS (bijv. het risico op besmettingen wanneer het een kleding AB-PSS betreft).

Tijdelijke personalisatie van producten kan mogelijk het gebrek aan ontastbare waarde in AB-PSS voor de lange termijn compenseren (hoofdstuk 5). Over het algemeen worden doorsnee producten (d.w.z. standaardproducten uit een categorie waar consument het best bekend mee zijn) in AB-PSS geplaatst, omdat ze voor veel consumenten acceptabel zijn. Dit resulteert echter in een gebrek aan ontastbare waarde in AB-PSS op de lange termijn. Om de nodige relevantie van een product voor een consument te vergroten, kunnen producten worden gepersonaliseerd. Producten die in AB-PSS zijn geplaatst, kunnen inderdaad tijdelijk worden aangepast door een klein, gemakkelijk te verwijderen, attribuut toe te voegen dat past bij de persoonlijkheid van de consument. Hoe beter de match tussen consument en productpersoonlijkheid is, hoe groter de voorkeur voor de AB-PSS zijn zal.

Veel AB-PSS die vandaag de dag beschikbaar zijn voor consumenten, zijn mede mogelijk gemaakt door digitalisering (hoofdstuk 6). Daarom zijn de effecten van gedigitaliseerde AB-PSS op de houding van de consument en de gebruikservaringen in deze diensten ook onderzocht. Een bijkomende reden om dit te onderzoeken is dat consumenten verschillende niveaus van digitaal vertrouwen hebben, die de houding ten opzichte van gedigitaliseerde AB-PSS kunnen beïnvloeden. In het algemeen ondersteunen digitale aspecten de serviceaspecten en zijn ze bijgevolg belangrijker in AB-PSS met korte gebruiksduur. Uit het onderzoek bleek dat digitaal zelfverzekerde consumenten een positievere houding hebben ten opzichte van AB-PSS met korte gebruiksduur dan minder digitaal zelfverzekerde consumenten. De daadwerkelijke gebruikers van mobiliteits AB-PSS met korte gebruiksduur lijken over het algemeen zeer digitaal zelfverzekerd te zijn en beschrijven inzichtrijke positieve en negatieve gebruikerservaringen die voortvloeienden uit de digitale aspecten van AB-PSS.

Het gebruiksgedrag van consumenten kan een negatieve invloed hebben op de levensduur van producten en daarmee op het duurzaamheidspotentieel van AB-PSS (hoofdstuk 7). Daarom werd de zorg van consumenten voor wasmachines en fietsen tussen verschillende bedrijfsmodellen kwantitatief vergeleken. De productzorg is lager voor producten die worden gebruikt via langdurige AB-PSS dan voor producten die consumenten nieuw of tweedehands hebben gekocht. De productzorg voor beide producten was echter matig in alle drie de geanalyseerde bedrijfsmodellen. Daarom

moeten het productontwerp, de communicatie en het contract van AB-PSS erop gericht zijn productzorg te garanderen om bij te dragen aan ecologische duurzaamheid.

Tot slot worden de bevindingen van dit proefschrift samengevat, de implicaties besproken en worden aanbevelingen voor theorie en praktijk gegeven (Hoofdstuk 8). Over het algemeen zijn bedrijfsmodellen zoals AB-PSS interessant omdat ze de ecologische duurzaamheid op korte termijn kunnen verbeteren, indien ze goed worden ontworpen en geïmplementeerd. Het ontwerp van circulaire bedrijfsmodellen en duurzame AB-PSS voor consumentenmarkten vereist continue iteraties om het duurzaamheidspotentieel te beoordelen, verbeteren en realiseren.

Zusammenfassung

In den letzten zehn Jahren hat das Konzept der *Circular Economy* an Bedeutung gewonnen, da es verspricht zu einem Wandel der Gesellschaft und Wirtschaft in Richtung eines nachhaltigeren Systems beizutragen. In diesem Zusammenhang wurden Geschäftsmodelle erforscht, um so Circular Economy Strategien auf Unternehmensebene umzusetzen. Diese Doktorarbeit bietet einen Blick aus der Verbraucherperspektive auf Circular Economy Geschäftsmodelle.

Die erste Studie untersuchte, wie Geschäftsmodelle dazu beitragen können, gleichzeitig eine Circular Economy und nachhaltigem Konsum zu erreichen (Kapitel 2). Dazu müssen Geschäftsmodellelemente auf der Produktions- und Verbrauchsseite berücksichtigt werden; nämlich die Ressourcenstrategie, das Ertragsmodell, der Aufwand für Verbraucher, und das Ziel des Unternehmens in Bezug auf das Konsumniveau. Diese Elemente trugen zur Entwicklung eines Modells für die Gestaltung solcher Geschäftsmodelle bei.

Anschließend verlagerte sich der Forschungsschwerpunkt auf eine bestimmte Kategorie von Circular Economy Geschäftsmodellen – zugangsbasierte Produkt-Service-Systeme (AB-PSS, in dieser Arbeit wird der englischen Ausdruck *access-based product-service system* genutzt). Mit AB-PSS können Verbraucher Produkte gegen eine Gebühr nutzen, ohne die Produkte kaufen zu müssen. AB-PSS können zur Nachhaltigkeit beitragen, da Produkte von verschiedenen Verbrauchern nacheinander verwendet werden und deshalb potentiell intensiver genutzt werden. Des Weiteren können AB-PSS die Lebensdauer von Produkten verlängern, da Produkte professionell durch den Anbieter gewartet und repariert werden. Beides kann die Gesamtzahl der Produkte verringern und dadurch Ressourcen einsparen.

Während einige AB-PSS schon seit einiger Zeit verfügbar sind, fehlt vielen AB-PSS noch weite Verbraucherakzeptanz. Diese Arbeit enthält eine Literaturübersicht über die AB-PSS Akzeptanzbarrieren von Verbrauchern (Kapitel 3). Interviews mit Nutzern von Mobilitäts-AB-PSS (z. B. Fahrrad-Sharing und Car-Sharing) ermitteln die Faktoren, die die Akzeptanz dieser Dienste durch Verbraucher motivieren. Viele Barrieren und Motivatoren beziehen sich auf ähnliche Themen (z. B. kann ein geringer Aufwand für den Zugang die Akzeptanz motivieren, während ein hoher Aufwand eine Barriere schafft).

Damit Unternehmen AB-PSS für Konsumentenmärkte entwickeln können, ist es wichtig zu bestimmen, wann welche Akzeptanzbarrieren relevant sind (Kapitel 4). Aus Konssicht sind die Verwendungsdauer (d. h. ob ein Produkt 1 Stunde oder 6 Monate lang verwendet wird) und die Art des Produkts (d. h. Kleidung oder Fahrräder) die beiden

wichtigsten Dimensionen von AB-PSS. Bei der kurzfristigen Einführung von AB-PSS sind Hindernisse in Bezug auf Serviceaspekte (z. B. Bemühungen um Zugang zum Produkt) besonders wichtig. Im Gegensatz dazu sind Adoptionsbarrieren in Bezug auf Produktaspekte (z. B. Mangel an immateriellem Wert) bei langfristiger AB-PSS wichtiger. Darüber hinaus sind Aspekte, die für Verbraucher beim Kauf von Produkten von entscheidender Bedeutung sind, bei AB-PSS noch wichtiger (z. B. Sorge vor Kontamination bei AB-PSS-Kleidung).

Durch die vorübergehende Anpassung kann möglicherweise der Mangel an immateriellem Wert bei langfristigen AB-PSS behoben werden (Kapitel 5). Im Allgemeinen werden typische Produkte (d. h. Standardprodukte der entsprechenden Kategorie, die den Verbrauchern bekannt vorkommen) in AB-PSS aufgenommen, da sie für viele Verbraucher akzeptabel sind. Dies führt jedoch zu einem Mangel an immateriellem Wert bei langfristigen AB-PSS. Um die Relevanz eines Produkts für ein Verbraucherprodukt zu erhöhen, können Produkte angepasst werden. In AB-PSS platzierte Produkte können vorübergehend personalisiert werden, indem ein kleines, leicht abnehmbares Attribut hinzugefügt wird, das der Persönlichkeit des Verbrauchers entspricht. Je besser die Übereinstimmung zwischen Verbraucher- und Produktpersönlichkeit ist, desto höher ist die Präferenz für das AB-PSS.

Viele AB-PSS, die den Verbrauchern heute zur Verfügung stehen, wurden durch die Digitalisierung ermöglicht (Kapitel 6). Daher wurden die Auswirkungen von digitalisiertem AB-PSS auf die Einstellungen und Nutzungserfahrungen der Verbraucher in diesen Diensten untersucht. Verbraucher haben ein unterschiedliches Maß an digitalem Vertrauen, das ihre Einstellung zu digitalisiertem AB-PSS beeinflussen kann. Im Allgemeinen unterstützen digitale Aspekte Servicefunktionen und sind daher bei kurzfristigen AB-PSS wichtiger. Die Untersuchung ergab, dass digital selbstbewusste Verbraucher eine positivere Einstellung gegenüber kurzfristigen AB-PSS haben als weniger digital selbstbewusste Verbraucher. Tatsächlich scheinen die Nutzer von Mobilitäts-AB-PSS im Allgemeinen sehr digital selbstbewusst zu sein. Diese Nutzer beschrieben positive und negative Nutzungserfahrungen, die sich aus den digitalen Aspekten von AB-PSS ergeben.

Das Nutzungsverhalten der Verbraucher kann die Produktlebensdauer und damit das Nachhaltigkeitspotenzial von AB-PSS negativ beeinflussen (Kapitel 7). Daher wurde die Pflege von Waschmaschinen und Fahrrädern durch Kosumenten zwischen Geschäftsmodellen quantitativ verglichen. Die Produktpflege ist bei Produkten, die im Rahmen eines langzeit-AB-PSS verwendet werden, geringer als bei Produkten, die Verbraucher neu oder gebraucht gekauft haben. Die Produktpflege für beide Produkte war jedoch in den drei analysierten Geschäftsmodellen nur mäßig. Daher sollten Produktdesign, Kommunikation und Vertragsgestaltung von AB-PSS darauf ausgerichtet

sein, die Produktpflege sicherzustellen, damit AB-PSS zur ökologischen Nachhaltigkeit beitragen.

Abschließend werden die Ergebnisse dieser Arbeit zusammengefasst, Implikationen diskutiert und Empfehlungen für Theorie und Praxis gegeben (Kapitel 8). Insgesamt sind Geschäftsmodelle wie AB-PSS interessant, da sie die ökologische Nachhaltigkeit potentiell direkt verbessern können, wenn sie gut konzipiert und umgesetzt werden. Das Design von Circular Economy Geschäftsmodellen und nachhaltigen AB-PSS für Konsumentenmärkte erfordert kontinuierliche Iterationen, um so deren Nachhaltigkeitspotenzial zu analysieren, zu verbessern und zu realisieren.

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wedding in Germany just before you started your PhD at TU Delft. Thank you for motivating me to swim VERY early in the morning; I love how new plans just naturally and continuously emerge every time we meet up. And then Corona happened, a time that was lonely for many but I was lucky and had time to get know *Leila* better. Our socially-distanced walks, chats, and outside yoga sessions definitely saved me during thesis writing under Corona conditions. There are more of you but I guess I should save a few words for the content of my thesis.

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♥

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♥

Chapter 1
Introduction

1.1 Rationale for this research

Since the start of this PhD project in November 2016, public awareness of sustainability issues has increased dramatically. Many sustainability issues were already mentioned in the Brundtland report in 1987 and their urgency has been stressed in recent reports (e.g., IPCC, 2018). Increasing interest in sustainability issues and solutions has been further accelerated by organisations such as Greenpeace and the World Wide Fund for Nature, and recent movements such as Extinction Rebellion and Fridays for Future. For example, the peaceful movement Fridays for Future was famously started by young climate activist Greta Thunberg's school strike. Activists of these movements are demanding actions to guarantee a liveable planet for future generations echoing Brundtland's (1987) seminal definition of sustainable development.

These movements were triggered by human-induced environmental sustainability issues, such as climate change, ocean acidification, and the rapid rate of biodiversity loss (Rockström et al., 2009). The issues are caused and accelerated by current consumption and production practices. More and more waste is created around the world; in the European Union (EU 28) 488kg of municipal waste were generated per capita in 2018 (Eurostat, 2020a) of which only 47% was recycled (Eurostat, 2020b). While material consumption has slightly decreased in some developed regions over the last two decades (Eurostat, 2020c), global waste levels are predicted to increase by 70% by 2050 without major actions (Kaza et al., 2018). This trend is driven by increased consumption of a growing world population with rising material wealth (United Nations, 2020).

Unsustainable production practices drive overconsumption and are themselves fuelled by high levels of consumption (Druckman and Jackson, 2016; Marques et al., 2019; Veraart, 2018). This vicious cycle is intensified by shortening product lifetimes; caused by the fast pace of technological developments, companies' practices to build obsolescence into products to ensure future revenues, and consumers' quickly changing preferences (Bakker et al., 2014a; Cooper, 2005). In addition, individual consumers seek variety of and newness in products, and discard products prematurely, while companies

spur buying by creating ever new consumer needs and wants, and niftily integrating more and more products into consumers' lifestyles (e.g., Statista, 2020). These practices contribute to an underutilisation of products and an overconsumption of resources (Cooper, 2005). Recognising these issues, the United Nations (2020) stated "ensur[ing] sustainable consumption and production patterns" as one of its sustainable development goals.

The circular economy concept has emerged during the last decade promising to deliver economic and environmental benefits. In the circular economy virgin material input and waste generation are minimised by creating economic value through narrowing, slowing, and closing resource flows (Bocken et al., 2016). Championed and disseminated by the Ellen MacArthur Foundation (EMF, 2015), the circular economy has gained widespread attention and enticed policy makers and industry alike. A crucial question is how the circular economy can help to break the vicious cycle of overproduction and overconsumption. Yet, the consumption side has received little attention so far (Camacho-Otero et al., 2018; Elzinga et al., 2020).

Companies play a key role in the transition to the circular economy as they can potentially transform production and consumption patterns. While Druckman and Jackson (2010) demonstrated that a low-emission lifestyle is possible in western countries, the question remains how consumption levels can be curbed sufficiently in practice. Companies could help to achieve sustainable consumption by transforming their business models to satisfy consumer needs while limiting overall resource consumption and environmental impacts. Many large companies now report on their sustainability performance (United Nations, 2020); other companies have committed to sustainable practices or were founded on sustainability principles (e.g., Tunn and Dekoninck, 2016; Stubbs, 2017). While companies have implemented some circular business models, these cases are still scarce and a lack of consumer adoption is major barrier to wider implementation (Kirchherr et al., 2018; Rizos et al., 2016; Vermunt et al., 2019). It has not yet been sufficiently understood how companies can develop and successfully implement circular business models. This thesis contributes insights enhancing the development of sustainable, circular business models for the consumer market.

1.2 Definitions and concepts

In this section, the key concepts used in this chapter and throughout this thesis are defined. First, the concepts of sustainable consumption and circular economy are defined. Then sustainable and circular business models are outlined. Finally, product-service systems are presented as one business model category with sustainability and circularity potential.

1.2.1 Sustainable consumption

Current consumption patterns are material-intense and wasteful. Humans do not consume materials to merely sustain themselves but also to create conditions such as comfort, pleasure, and convenience (Allwood et al., 2012). For example, in the Netherlands consumption of materials amounted to 9.7t per capita in 2017 (CBS, 2019). The finite resources of the planet cannot sustain these high levels of consumption in the long term and thus the concept of sustainable consumption emerged. Consumption needs to change and should satisfy the three pillars of the triple bottom line, namely environmental, social, and economic aspects (Elkington, 1997).

A frequently cited definition of sustainable consumption was proposed at the Oslo Symposium (1994) where sustainable consumption was defined as satisfying basic need through products and services and improving the quality of life while minimising material input, use of toxic materials as well as the release of emissions and pollutants in order to ensure that future generations can satisfy their needs. This definition emphasises the decoupling of economic activities and well-being from material inputs. The understanding of sustainable consumption put forward by the United Nations (2020) echoes this need for decoupling and simply describes sustainable consumption as “doing more and better with less”. That this is possible has been demonstrated by the European Union over the last two decades: while the economic output (gross domestic product) increased by nearly 30% between 2000 and 2018, material consumption decreased by 6% (Eurostat, 2020c).

1.2.2 Circular economy

The circular economy has emerged as a response to traditional linear take-make-waste practices. In a linear economy resources are extracted, turned into products that are eventually discarded in landfills or incinerators. In contrast, in the circular economy the value of products and materials is maintained and prolonged through strategies such as reuse, repair, remanufacture, refurbishment, and recycling (EMF, 2015). The circular economy is an umbrella concept (Blomsma and Brennan, 2017) that builds on elements of previous sustainability concepts. For example, circular material flows are taken from Industrial Ecology (Graedel and Allenby, 2010) which aims to loop material flows in industrial systems similarly to those in ecosystems. The circular economy also builds on the ‘Cradle to Cradle’ concept, in which the impacts of material choices are considered when developing products in order to enable the recycling of the embedded materials and eliminate toxic materials (McDonough and Braungart, 2002). The circular economy also builds on ‘The Performance Economy’ (Stahel, 2010), which suggests a shift from selling products to selling outcomes that are delivered as resource-efficient services.

Kirchherr et al. (2017, p. 229) reviewed 114 definitions and subsequently defined the circular economy as "an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes […] with the aim to accomplish sustainable development, thus, simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers." Similarly, Korhonen et al. (2018, p. 39) explain that the "circular economy is an economy constructed from societal production-consumption systems that maximizes the service produced from the linear nature-society-nature material and energy throughput flow." The circular economy definition used in this thesis draws on the definitions by Kirchherr et al. (2017) and Korhonen et al. (2018) because they illustrate the general understanding of the circular economy. Switching the economic system to a circular economy does not automatically contribute to sustainability as product and material loops could be speed up (Desing et al., 2020; Korhonen et al., 2018; Zink and Geyer, 2017). Hence, the aim of the circular economy, to create a society that is sustainable, is explicitly stated in the definition developed for this thesis: *The circular economy aims to deliver a sustainable society that exists in harmony with the natural environment and in which people's needs are satisfied through reuse of products, components, and resources while minimising material and energy inputs, throughputs, and waste.*

1.2.3 Sustainable and circular business models

In the transition to a circular economy, business models are frequently highlighted as enablers. Business models have been described as a "blueprint of how a company does business" (Osterwalder et al., 2005, p. 2) holistically and at system-level (Zott et al., 2011). Fundamentally, business models describe a company's value proposition and target group, how the offering is created and delivered, and how value is captured from these transactions. Business models thus govern companies' relationships with their customers (Richardson, 2008). By redesigning business models, companies can change "the way they organize and engage in economic exchanges, both within and across firm and industry boundaries" including "the ways in which firms interact with suppliers as well as with customers" (Zott et al., 2011, p. 1025). For instance, the relationship with customers can be shaped in order to enable sustainable production and consumption (Boons and Lüdeke-Freund, 2013; Schaltegger et al., 2016).

Since the development of the business model concept, it has been adapted to the sustainability and circular economy context. Lüdeke-Freund (2009, p. III) defined that "[a] business model for sustainability is the blueprint of a company's business logic which internalizes the business case for sustainability". Sustainable business models offer and capture environmental, societal, and economic value (Elkington, 2004; Evans

et al., 2017; Lüdeke-Freund, 2009; Stubbs and Cocklin, 2008). In these business models, sustainability becomes "an integral part of the company's value proposition and value creation logic" (Schaltegger et al., 2012, p. 102) and the company adopts a long-term perspective (Geissdoerfer et al., 2018a). From the sustainable business model literature, circular business models have emerged as a sub-category (Geissdoerfer et al., 2018b) to guide the implementation of circular strategies at company level (Nußholz, 2017). Circular business models describe the value creation logic of companies in a circular economy (Antikainen and Valkokari, 2016) and apply resource efficiency strategies to create more sustainable production and consumption patterns (e.g., Lüdeke-Freund et al., 2019; Nußholz, 2017).

In literature several circular business models have been identified. Lüdeke-Freund et al. (2019) analysed 26 typologies of circular business models and identified patterns. Their findings are complemented with additional literature to provide a concise overview of circular business models. *Repair and maintenance*, *Reuse and redistribution*, and *Refurbishment and remanufacturing* (Lüdeke-Freund et al., 2019) are circular business models that aim to extend product lifetimes (Vermunt et al., 2019; Rosa et al., 2019). Further, Lüdeke-Freund et al. (2019) recognised circular business models that reuse products at the material level once they have reached their end of life; *Recycling* business models usually entail reusing specific non-organic material waste streams to produce new products and *Organic feedstock* business models extract value from organic materials, for example, by processing organic waste to obtain biofuel. In the final business model identified by Lüdeke-Freund et al. (2019), *Cascading and repurposing*, specific waste streams are turned into production inputs, for example, the company Freitag turns old truck tarpaulins into backpacks and accessories (see www.freitag.ch). Other authors have suggested business models that dematerialise consumption through *Virtualisation* such as the shift from physical CDs to applications such as Spotify (EMF and McKinsey, 2015; Lewandowski, 2016) or through providing *Product-service systems*, through which consumers can use products but do not purchase them (Lewandowski, 2016; Rosa et al., 2019; Tukker, 2015; Vermunt et al., 2019). Companies often combine several circular business models or operate them in parallel with established, linear business models (Whalen, 2017).

1.2.4 Product-service systems (PSS)

Product-service systems (PSS) are business models that combine product and service aspects, and have a sustainability and circularity potential (Mont, 2002a; Roy, 2000; Tukker, 2015). More precisely, a PSS is "a system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models" (Mont, 2002a, p. 239). PSS can support and incorporate other circular business models, such as

remanufacturing, and refurbishment as extending product lifetimes is in the interest of companies providing PSS. In addition, in PSS long-term relationships between companies and customers are established that could theoretically enable the return of products and thereby facilitate circular strategies such as reuse, repair and recycling. Further, providing PSS rather than selling products is hoped to incentivise companies to redesign products so that they last longer and require less maintenance. However, under what circumstances these business models truly contribute to a circular economy and sustainability is still debated.

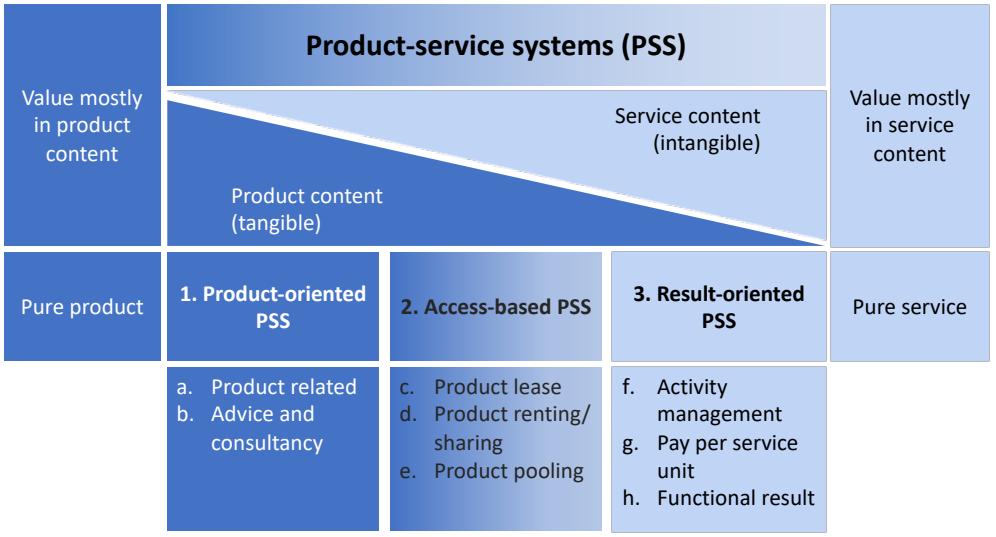

Figure 1: Classification of product-service systems (adapted from Tukker, 2004).

Tukker (2004) distinguished three categories of PSS based on the share of product and service aspects in the offering as visualised in Figure 1. Product-oriented PSS (1) involve products that are sold to consumers with supporting service components such as warranty or maintenance. Access-based PSS (2) temporarily grant consumers access to products when their functionalities are needed. Result-oriented PSS (3) are services that sell outcomes, the products used to deliver these are of less importance to consumers. The sustainability potential of PSS increases with the share of the service aspects; while product-oriented PSS can only lead to incremental efficiency improvements of products, result-oriented PSS are believed to reduce the overall number of products and even spur the development of new technologies that could substantially reduce environmental impacts (Tukker, 2004).

Several studies included in this thesis explore *access-based PSS* (AB-PSS). An example AB-PSS is car sharing: through this service a consumer can use cars without purchasing one. AB-PSS, one category of PSS, can be implemented with current products and technologies while potentially reducing the total number of products needed. Note, that this category of PSS has been referred to as use-oriented PSS in research taking a company and sustainability perspective (Tukker, 2004), as access-based consumption in consumer research (Bardhi and Eckhardt, 2012), and as access-based services in service research (Schaefers et al., 2016). This thesis combines the aforementioned fields and terminologies and takes a *consumer perspective* on circular business models and therefore uses the term *access-based PSS*.

1.3 Implementing circular business models in consumer markets

In this section the relationships between the concepts defined in the previous section are outlined in the context of the scope of this thesis. First, it is outlined how the circular economy relates to sustainable consumption. This is followed by a summary of key challenges that companies face when implementing circular business models. Then, insights from previous literature into consumer adoption and use of circular business models are presented.

1.3.1 Circular economy: A path towards sustainable consumption?

In theory, the circular economy could facilitate sustainable consumption, as literature has suggested that "the ultimate goal of promoting CE [circular economy] is the decoupling of environmental pressure from economic growth" (Ghisellini et al., 2016, p. 11). For the circular economy to reduce environmental impacts, strategies to use products and materials more efficiently need to be combined with strategies to decouple consumer satisfaction from material consumption to reduce overall consumption levels (Mont and Heiskanen, 2015). In other words, a sustainable circular economy necessitates sustainable consumption in addition to sustainable production.

Circular economy research so far has largely focused on the production side and paid less attention to the demand side and consumer behaviour (Camacho-Otero et al., 2018; Elzinga et al., 2020). This seems a broader trend; the literature on the circular economy in general largely focuses on delivering environmental and economic sustainability, while social sustainability is discussed rarely (Geissdoerfer et al., 2017; Murray et al., 2017). Yet, the focus on the production side might impede the translation of sustainability potential into actual sustainability gains in the circular economy as

consumption drives production, consumer choices influence company decisions, and consumer behaviour can potentially render circular offerings less sustainable than the 'linear' alternatives (Tukker, 2004; Zink and Geyer, 2017). For example, if consumers consume more of a circular offering than they previously consumed of the linear alternative (e.g., changing furniture every few years because second-hand furniture is cheaper than new furniture).

Recent research has shed some light on the consumption side of the circular economy and identified desired and required consumer behaviours in a circular economy (Camacho-Otero et al., 2020; Van der Laan and Aurisicchio, 2019; Wastling et al., 2018) or consumer perception, adoption, and use of circular business models (e.g., Antikainen et al., 2015; Edbring et al., 2016; Van Weelden et al., 2016). For instance, Wastling et al. (2018) described activities that consumers need to conduct in the circular economy, such as take care of products and repair them, and eventually either enable reuse, return the products or dispose of them appropriately. Still, despite this emergent body of literature and the importance of sustainable consumption, this topic is not yet prominent in the circular economy discourse.

1.3.2 Companies' challenges when implementing circular business models

Despite increasing interest in the circular economy concept in industry, policy, and academia, the implementation of circular business models has been slow (Bocken et al., 2017; Geissdoerfer et al., 2018b; Kirchherr et al., 2018). While academic output on the topic dramatically increased from 2017 to 2019 (Salvador et al., 2020), business practices globally have become less 'circular' in the same period, meaning that virgin material extraction has increased at a faster pace than the reuse of materials and products (De Wit et al., 2020). Several companies have piloted circular business models in the consumer market, operate them as a small part of their business, or serve niche markets (Linder and Williander, 2017; Weiguny, 2018; Van Weelden et al., 2016). Several case studies have been conducted in different industries to better understand circular business models in practice (Bocken et al., 2018; Bressanelli et al., 2018; Geissdoerfer et al., 2018b; Guldmann, 2016; Oghazi and Mostaghel, 2018). Unfortunately, only few circular business models have been widely implemented so far (e.g., Kirchherr et al., 2018; Linder and Williander, 2017).

Some researchers have specifically focused on identifying implementation barriers of circular business models. To identify implementation barriers and help overcome them, several single case studies (e.g., Heyes et al., 2018; Linder and Williander, 2017; Sousa-Zomer et al., 2018) and multiple case studies (e.g., Guldmann and Huulgaard, 2020; Rizos et al., 2016; Tura et al., 2019; Vermunt et al., 2019) have been conducted. These

revealed company internal implementation barriers such as financial challenges, problems in the integration and collaboration of departments, and a lack of technical and technological knowledge, as well as external barriers such as a lack of support from the supply and demand network, and institutional barriers (see Guldmann and Huulgaard, 2020; Rizos et al., 2016; Sousa-Zomer et al., 2018; Vermunt et al., 2019). Comparing implementation barriers across different circular business models, Vermunt et al. (2019) found that many companies pursuing circular business models struggled with consumer adoption. Likewise, many other scholars also identified customer or consumer demand for, and adoption of, circular business models as crucial barriers (e.g., Guldmann and Huulgaard, 2020; Heyes et al., 2018; Rizos et al., 2016; Sousa-Zomer et al., 2018; Tura et al., 2019; Vezzoli et al., 2015).

1.3.3 Consumer adoption and use of circular business models

Circular business models need to appeal to consumers and should lead to sustainable behaviour. Viciunaite and Alfnes (2020) recommended considering consumers when designing circular business models. Indeed, the shift towards a circular economy requires consumers to change their lifestyles (Mont and Heiskanen, 2015; Planing, 2015). For example, consumer-provider and consumer-product relationships are different in circular business models compared to linear business models (Baxter and Childs, 2017; Elzinga et al., 2020). Hence, many circular business models have only slowly taken off in the consumer market. Researchers have investigated consumer perception, adoption, and use of circular business models in order to improve the business models. For example, Armstrong et al. (2015) examined consumer adoption of several circular business models for clothing and Edbring et al. (2016) for furniture. Other researchers investigated more technically complex products: Bardhi and Eckhardt (2012) explored the behaviour and attitudes of car sharing users and Poppelaars et al. (2018) compared consumers' experiences in access models for smartphones and cars. Van Weelden et al. (2016) and Wallner et al. (2020) explored consumer acceptance of refurbished smartphones and consumer electronics. Overall, two major challenges of circular business models hinder their success in the consumer market. First, a lack of consumer adoption of circular business models impedes wider implementation. Second, consumers' use behaviour can diminish the sustainability potential of implemented and adopted circular business models.

Consumer adoption of circular business models is generally low. Many barriers inhibiting consumer adoption of circular business models have been identified in extant literature. For example, some consumers lack awareness or understanding of circular offerings and thus do not consider them at all (Edbring et al., 2016; Poppelaars et al., 2018; Van Weelden at al., 2016). Yet, even sustainability-aware consumers who report a purchase intention for sustainable offerings often do not act on their intention

(McDonald et al., 2015; White et al., 2019). Further, many consumers distrust recycled, refurbished, or remanufactured products, product-service systems, or the service provider (Armstrong et al., 2015; Kuah and Wang, 2020; Poppelaars et al., 2018; Van Weelden at al., 2016). Consumers also envisage receiving inferior quality products through circular business models (Durgee and O'Connor, 1995; Kuah and Wang, 2020; Wang et al., 2013) and fear contamination (Baxter et al., 2017; Edbring et al., 2016; Magnier et al., 2019; Camacho-Otero et al., 2017). In addition, consumers seem unwilling to accept changes that some circular business models imply (Daae et al., 2018; Planing, 2015; Wastling et al., 2018). Moreover, even adopters of circular business models (i.e., PSS) might discontinue using them if their use experience is unsatisfactory (Poppelaars et al., 2018).

Consumers' use behaviour can have a major influence on the environmental sustainability of circular business models. Yet, understanding of consumer behaviour and experiences within circular business models is still limited. Circular business models are intended to substitute unsustainable, linear business models but in practice consumers might displace other (more) sustainable consumption modes. For example, for car sharing to be sustainable it should substitute individual car ownership, increase product utilisation, and decrease the number of cars owned. However, some car sharing adopters use shared cars in addition to owned cars (Meijkamp et al., 1998) or instead of public transport until they can afford to purchase a car (Bardhi and Eckhardt, 2012). In addition, research has found that circular business models such as clothing libraries only improve sustainability if product lifetimes are extended (Zamani et al., 2017). Yet, several studies suggest that product-service systems might lead to less careful consumer behaviour, thereby reducing components' and products' lifetimes (Bardhi and Eckhardt, 2012; Schaefers et al., 2016; Sumter et al., 2018; Tukker, 2004). These types of consumer behaviours can impede the potential of circular business models to reduce resource consumption (Kjaer et al., 2019; Zink and Geyer, 2017).

1.4 Purpose and research question

Circular business models are a pillar of the transition towards a circular economy and key to transforming unsustainable production and consumption patterns. Circular business models are a new research topic emerging in the field of sustainable business models. In order to successfully develop and implement circular business models and leverage their sustainability potential, more studies are needed to inform circular business model development and alleviate consumer adoption barriers. In addition, consumer behaviour within these business models is not yet fully understood although it may be detrimental to their sustainability potential. This thesis addresses three challenges of circular business models in the consumer market:

1. Uncertainties regarding the design of circular business models that lead to sustainable consumption.
2. A lack of consumer adoption of circular business models.
3. A lack of understanding of consumers' use experiences and behaviours in circular business models.

It is not yet clear how to design circular business models that simultaneously appeal to consumers and lead to sustainable consumption. The purpose of this thesis is to develop insights for the design of sustainable, circular business models for the consumer market by addressing the following research question: How can circular business models be developed to enable sustainable consumption? To answer this question, the design of circular business models for sustainable consumption as well as consumer adoption and use of these business models need to be investigated. Consumer research exploring the adoption and use of circular business models can inform their design. Thereby, this thesis seeks to contribute insights that inform the development of sustainable, circular business models for the consumer market.

1.5 Approach and thesis outline

The studies presented in this thesis contribute to three areas that are outlined in the following and visualised in Figure 2. Chapter 2 explores how business models could be designed to achieve sustainable consumption in a circular economy. One major challenge to realise the sustainability potential of circular business models is a lack of consumer adoption. To study this topic further, the focus of the subsequent chapters is primarily on product-service systems, one category of circular business models. The Chapters 3, 4, and 5 present research on barriers to consumer adoption of product-service systems, factors influencing the relevance of adoption barriers, and how specific barriers can be alleviated. These insights can inform the design of circular business models that are attractive for consumers. To realise the sustainability potential of circular business models and retain users, exploring the use phase of these business models is crucial. Therefore, Chapters 6 and 7 study the influence of digitalisation on consumers' use experience and consumer product care in circular business models. Chapter 8 discusses the overarching findings of this thesis and concludes with recommendations for practice and future research. In the following, a brief outline of the conducted studies (Chapters 2-7) and the applied research approaches is provided.

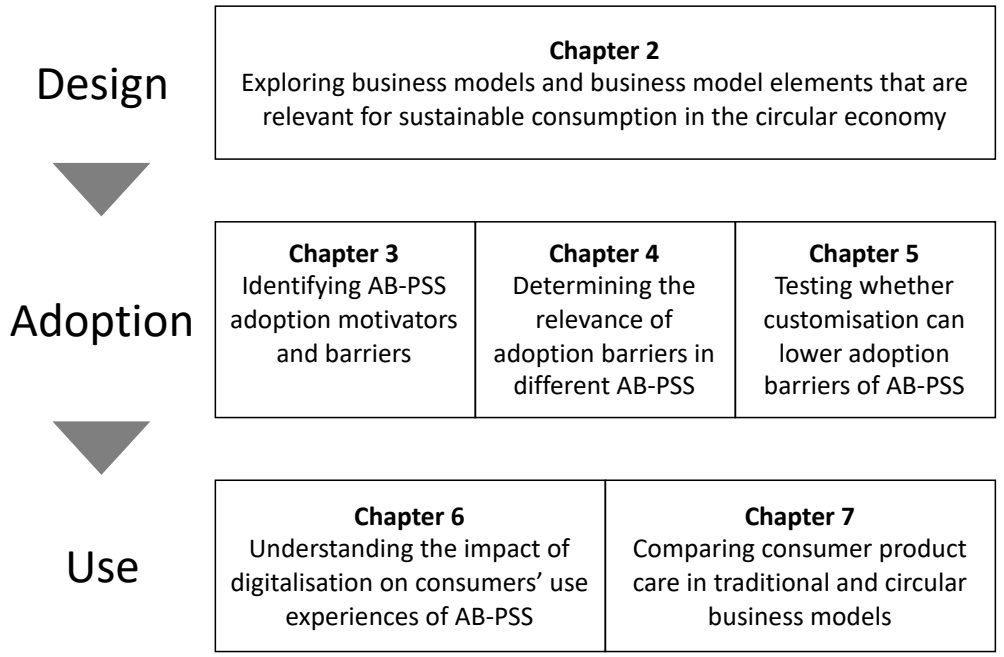

Figure 2: Visual outline of the research presented in this thesis; design, adoption, and use of circular business models.

It is unclear which business model elements need to be redesigned and how they should be combined to obtain business models that lead to sustainable consumption in the circular economy. Therefore, a framework for business models for sustainable consumption was developed in **Chapter 2**. Interviews with 22 experts from academia, industry, and policy were conducted. The business model elements Resource strategy, Revenue model, Consumer effort, and companies' Objective to (decrease/increase) consumption levels were identified as levers for sustainable consumption in the circular economy. Based on these elements, a framework for business models for sustainable consumption was developed which experts used during the second interview round to envision future business models for sustainable consumption of clothing. The findings of this study suggest that the most promising business models for sustainable consumption are those that reduce overall consumption levels and consumer effort. Further, we found that a range of diverse business models can potentially enable different customer segments to consume sustainably.

There is consensus among scholars that a lack of consumer adoption is a major barrier to the implementation and success of circular business models. Therefore, barriers and motivators of consumer adoption of AB-PSS were examined through an innovation management lens in **Chapter 3**. Adoption barriers were identified in literature and then

explored through interviews with providers and users of AB-PSS on how they are addressed in practice. The resulting barriers and motivators were clustered according to innovation attributes of an innovation diffusion model. Many barriers relate to the benefits and hindrances perceived by consumers in AB-PSS compared to the traditional alternatives. It transpired that consumer adoption of AB-PSS is more complex than the diffusion of product innovations because by nature AB-PSS are bundles of product, service, and infrastructure elements.

Many barriers to consumer adoption of AB-PSS were found in literature. However, it is unclear which barriers matter most and to which AB-PSS these apply. Thus, the identified adoption barriers were taken as the point of departure in **Chapter 4** to determine which adoption barriers are important and in what circumstances these adoption barriers are important to consumers. Through experiments consumers' perceived importance of adoption barriers was elicited for four AB-PSS. The adoption barriers Effort to access, Contamination, Lack of trust, Product quality, and Product characteristics were investigated. We hypothesised that the duration of use, the time a consumer obtains exclusive access to a specific product (short-term vs. long-term), and the type of product (bicycles vs. clothing) influence the importance of AB-PSS adoption barriers to consumers. The study showed that the duration of use and type of product indeed significantly influence the importance of adoption barriers; service-related barriers were more important in short-term AB-PSS while product-related barriers were more important in long-term AB-PSS.

The lack of intangible value is a major barrier to consumer adoption of long-term AB-PSS. In **Chapter 5**, temporary product customisation is proposed and tested as a way to increase intangible value provided by long-term AB-PSS to thereby increase consumer adoption. We investigated whether customisation through modifying the appearance of an easily changeable attribute of a typical product, thereby changing the product personality, could improve consumer adoption while limiting the impact on sustainability. To explore this, an experiment was conducted with consumers who are familiar with offerings similar to the AB-PSS we tested. The results indicate that respondents have a strong preference, as is widely recognised, for typical products in AB-PSS. Yet, a better match between consumer and product personality further increased preference. Infusing meaning and intangible value into accessed products through temporary customisation can lead to wider adoption by increasing individual consumers' satisfaction.

Many contemporary AB-PSS are based on digital platforms; with sensors embedded in the products, and reliance on users' smartphones. Yet, how these digital aspects along with consumers' digital confidence influence AB-PSS use experiences has not been explored. In **Chapter 6**, the effects of digitalised AB-PSS on consumers' use experiences

and attitudes are explored. We applied a mixed methods approach consisting of a consumer survey and user interviews to explore this phenomenon. Our findings suggest that short-term AB-PSS largely owe their recent success to digitalisation while digitalisation plays a lesser role in long-term AB-PSS. Further, consumers' digital confidence influences their attitude towards short-term AB-PSS. Users value the convenience and time savings of these digitalised services while they dislike phoning customer service. Digitalisation also made short-term mobility AB-PSS susceptible to disruptions because they rely on the functioning of many digital service components.

It has been established in literature that circular business models such as AB-PSS have a sustainability potential. However, it has also been found that the way in which users treat accessed products can negatively influence the sustainability potential of AB-PSS. In **Chapter 7**, we tested the influence of traditional and circular business models, person-related factors, and product-related factors on consumer product care. Data on consumer care for bicycles and washing machines obtained through traditional sales, second-hand sales, and long-term AB-PSS was collected through an online survey. We empirically showed that product care depends on the business model with consumers taking most care of products they bought new through traditional sales models and least care of products used through AB-PSS. The choice of business model is in turn strongly influenced by consumers' level of environmental concern and by product characteristics such as satisfaction and emotional attachment. Organisations developing circular business models and especially AB-PSS should thus consider not only the design of the products themselves, but also the implementation and communication of the business model to achieve long product lifetimes and sustainability improvements.

Chapter 2
Circular business models for sustainable consumption

This chapter is based on: Tunn, V.S.C., Bocken, N.M.P., van den Hende, E.A., Schoormans, J.P.L., 2019. Business models for sustainable consumption in the circular economy: An expert study. Journal of Cleaner Production, 212, pp. 324-333.

2.1 Introduction

Current challenges, such as climate change and resource scarcity (United Nations, 2017), are expedited by consumption and development patterns. The population and affluence predicted for 2050, would require three planets if current consumption practices are extrapolated (United Nations, 2020). To counter this, it is no longer sufficient for companies to maintain the status quo through incremental business model changes - business practices need to change to sustain companies in the long term and to meet consumers' expectations of conducting business more sustainably (Porter and Kramer, 2011).

The circular economy (CE) is an increasingly popular approach to create sustainable business. The aim of a CE is to attain a sustainable society and economy by avoiding and minimizing resource consumption through multiple product and material loops (EMF, 2015). However, there are many different definitions of the CE (Kirchherr et al., 2017) and a common understanding of what is considered a circular business models is only gradually emerging (e.g., Lewandowski, 2016; Bocken et al., 2016). This may be due to the different concepts united under the term CE (Blomsma and Brennan, 2017) and a manifold of different 'circular' business cases in practice (Guldmann, 2016). The CE field is an emerging research field, and so far, the focus has widely been on materials and the company side of circularity (Guldmann, 2016; Whalen, 2017).

Sustainable consumption (SC) patterns are necessary to realise a sustainable society and economy (Druckman and Jackson, 2010). SC entails satisfying consumer needs while

reducing negative impacts caused during material extraction, production and consumption (Mont and Plepys, 2008; Cooper, 2013). In the CE, companies are potential enablers of SC through changing production processes and consumption patterns by satisfying consumer needs in new ways, through new business models (Bocken, 2017). In the last decades, some forms of sustainability-focused companies have emerged. An example is the 'Benefit Corporation', a specific type of company certified to purposely generate positive impact for stakeholders, the environment and society as part of its corporate structure (B Lab, 2018).

We applied a Delphi-inspired approach (Dalkey and Helmer, 1963) with expert interviews to explore how business models and their elements can lead to SC in the CE. During the first round of expert interviews, we identified relevant business model elements that experts combined to business models for sustainable consumption in the clothing industry in the second interview round. This study represents a step towards exploring the role of business models for SC in the transition to the CE. Contributing to the literature by combining the streams of sustainable business models (e.g., Boons and Lüdeke-Freund, 2013; Bocken et al., 2014) and SC (e.g., Mont and Plepys, 2008; Cooper, 2013) in the CE context, and supporting practitioners by providing a framework to develop and discuss business models for SC.

2.2 Background

2.2.1 Inducing sustainable consumption

Consumption in developed countries is dominated by ever shorter product use and lifetimes, catalysed by a throwaway culture (Cooper, 2013). In order to achieve the goal of the CE, a sustainable society and economy, this trend needs to be reversed - SC is needed (Druckman and Jackson, 2010; Bocken et al., 2016). The United Nations grasp SC and production as "doing more and better with less" (United Nations, 2020). The literature presents definitions of SC emphasizing impact reduction or an absolute reduction of consumption (Mont and Plepys, 2008), or focus on simultaneously achieving societal well-being and resource efficiency (Tukker et al., 2006). Integrating these definitions, this paper defines SC as shaping and satisfying consumer needs to continuously reduce negative impacts of consumption on the environment and the wider society. SC thus includes sustainable use and requires sustainable production.

For a CE, different options to induce SC in the consumer market have been suggested. These options include marketing and communication-based approaches (Chamberlin and Boks, 2018), changing product design to extend use life (Cooper, 2013; Bakker et al., 2014a) or to stimulate sustainable consumption patterns (Wever et al., 2008). Further options are the recovery and reuse of materials and components at the end of

product life (EMF, 2017) and business model-based approaches, such as product-service systems (PSS) (Tukker, 2004). PSS are believed to decouple raw material input from firm profits through dematerialization of consumption, thereby potentially decreasing negative impacts (Manzini and Vezzoli, 2003). However, strategies for sustainability focused on PSS or design have so far not achieved the aspired sustainability improvements (Tukker et al., 2006).

Some scholars believe that increased consumption equals higher well-being whereas others deem current consumption patterns "environmentally and psychologically damaging" (Jackson, 2005, p. 19). Lorek and Spangenberg (2014) suggested that market and technology-based SC approaches lead to weak sustainable consumption and that approaches challenging consumption levels, consumption patterns and the market size lead to strong sustainable consumption. Bocken and Short (2016) also saw a need to reduce overall consumption levels and advocated sufficiency as a strategy for SC. They argued that reducing and avoiding consumption offers the largest potential for sustainability. Druckman and Jackson (2010) explored sufficiency earlier through consumer-focused 'reduced consumption scenarios'. The need for SC has been recognised in academia but has not been widely

implemented in practice (Mont and Plepys, 2008). One of the challenges for companies is achieving consumer acceptance of sustainable offerings, such as second-hand or remanufactured products (Edbring et al., 2016; Mugge et al., 2017). Overall, the role of companies in achieving SC has been underexplored (Michaelis, 2003; Bocken, 2017) even though companies could become key actors in reducing production and consumption side impacts.

2.2.2 Circular business models

Business model innovation is understood as a holistic approach to achieve change in companies (Osterwalder et al., 2005; Boons and Lüdeke-Freund, 2013). Osterwalder et al. (2005, p. 3) defined business models as "conceptualization of the way a company does business" in order to "identify the elements and relationships that describe the business a company does". Bocken et al. (2014) identified circular business models ("create value from waste", p. 48) as one archetype of sustainable business models. Circular business strategies have been summarised as "slowing, closing and narrowing" resource loops (Bocken et al., 2016, p. 309). Slowing loops refers to product lifetime extensions and increased utilization and links directly to sustainable consumption. Lewandowski (2016) proposed a business model framework that incorporates circular economy principles and included PSS as a circular business model. PSS are suggested to potentially lead to SC (Mont, 2004a).

In circular business model literature, the general emphasis has been on resource efficiency and business model innovation, implemented through strategies, such as reuse, repair, and remanufacture (Bocken et al., 2016; Nußholz, 2017). Circular business models are versatile and tailored to the context and capabilities of the companies (Guldmann, 2016), and often different circular (and linear) business models operate in parallel (Whalen, 2017). A business model can be considered 'fully' circular when upstream and downstream activities are 'circular' (Urbinati et al., 2017). Urbinati et al. (2017) focused on the production side; they see consumers as passive actors who are merely provided with circular offerings and can potentially be informed about their benefits. Similarly, Whalen (2017) and Guldmann (2016) who both reviewed CE business cases, did not explicitly take the consumption side into account.

2.2.3 Circular business models for sustainable consumption

The CE has increasingly gained attention for its potential to tackle overconsumption and early disposal (Murray et al., 2017), thereby minimizing wasted resources. The right circular business model can help a company achieve economic and environmental sustainability simultaneously (Murray et al., 2017). Edbring et al. (2016) and Mugge et al. (2017) found that consumer acceptance of circular offerings, such as second-hand or remanufactured products, differs greatly between products and customer segments. Bringing together business models and sufficiency, Bocken and Short (2016) proposed 'sufficiency-driven business models' through which companies actively aim to decrease consumption levels. Drawing on prior business model literature (Osterwalder et al., 2005; Richardson, 2008) Bocken and Short (2016) developed a business model framework that includes sustainability aspects. Their sustainable business model framework contains business model elements, such as product/service, customer segments and relationships, and growth strategy/ethos (see Figure 3). These elements can be used to describe how a business model offers, creates and captures value for a company and other stakeholders. This framework depicts elements of a sustainable business model but does neither consider the transition to the CE as context nor determine business model elements that influence the sustainability of consumption.

As outlined in the previous sections, SC is needed in the CE but often not explicitly addressed, and guidance is lacking on how to incorporate CE principles and SC simultaneously. Changes to business models can potentially improve the sustainability of the production side and the consumption side, but it has not been studied how companies' business models could be shaped to lead to SC. This study builds on Bocken and Short's (2016) sustainable business model framework.

To explore how business models can help achieve SC in the transition to the CE the following research questions are addressed:

1. What future business models can help achieve sustainable consumption in the transition to the circular economy?
2. Which business model elements are most relevant for sustainable consumption?

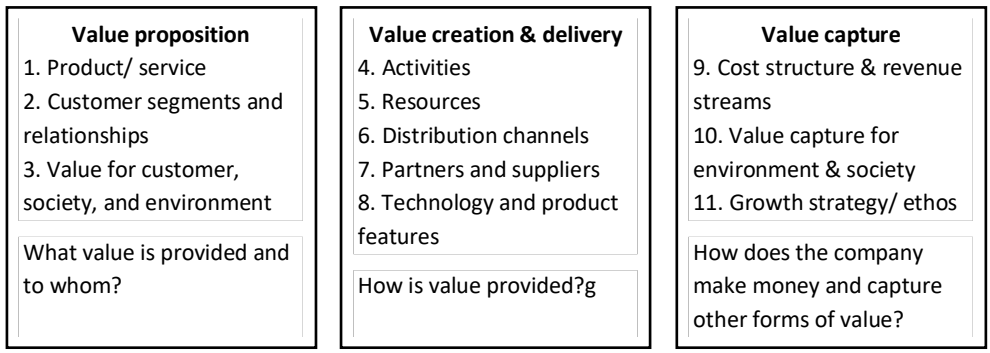

Figure 3: Sustainable business model framework with business model elements (Bocken and Short, 2016, based on Osterwalder et al., 2005 and Richardson, 2008).

2.3 Method

This study applied an iterative, two-round interview set-up with experts that is strongly inspired by the Delphi method. In the following sections, the application of this method is described.

2.3.1 Delphi-inspired expert study

The research design was inspired by the Delphi method which was developed by the RAND Corporation. The Delphi method is understood to facilitate iterative group communication processes (Hsu and Sandford, 2007), and aims to either reach consensus or nuanced insights (Skulmoski et al., 2007), and enables an exchange of experts in different geographical locations (Rowe and Wright, 1999). The Delphi method can help forecast the development of a specific topic through several rounds of questionnaires with controlled, intermittent feedback (Dalkey and Helmer, 1963). The strength of this method is the objective exploration of issues that concern the future and require personal judgment (Mulder et al., 1996).

A Delphi-inspired approach was selected as it supports the exploratory nature of this study (Skulmoski et al., 2007). Van Dijk (1990) compared the application of questionnaires, group interviews and individual interviews in Delphi studies and concluded that individual interviews have lower drop-out rates, increased involvement and improved quality of answers compared to the other data collection methods.

Already in the early days of the Delphi method, the RAND cooperation used interviews alongside questionnaires to clarify aspects and to enrich the data (Dalkey and Helmer, 1963). Following these arguments, we chose a semi-structured interview format to gain in-depth insights (Bryman, and Bell, 2015). This format also allows for follow-up questions and clarifications when necessary to ensure that all diverse experts in the sample interpreted the questions similarly (Bryman and Bell,

2015). We conducted two rounds of individual interviews between April and August 2017. Based on the themes we identified in the first round we developed a framework that was fed back to the experts. During the second interview, experts used the framework to develop future business models. Table 1 provides details of the applied methodology and the outcomes of each step.

Table 1: Overview of methodological steps, process and outcomes.

	Purpose	Process	Outcome
Expert selection	Creating a panel of CE and SC experts	Identification via publications, CE case studies, CE related job, then snowball technique, contacted 32 experts	Panel of 22 experts
Interview round 1	Exploratory, discover most relevant business model elements for SC	Semi-structured interviews based on the 11 business model elements	22 interviews provided input for feedback and interview round 2
Analysis round 1	Develop feedback and interview 2 set-up	Coding of interview transcripts for SC	4 business model elements emerged that were developed into a SC business model framework
Feedback	Anonymous exchange of arguments between experts	1 week before the second interview a summary of the round 1 results was sent	Experts could reflect and develop their opinions
Interview round 2	Determine which combinations of business model elements experts deem most promising to achieve SC in the clothing industry	Semi-structured interviews, reaction to framework and questions regarding business models for clothing industry in the present and the future	15 interviews and 23 business model options for the clothing industry based on SC business model framework

2.3.2 Selection of experts

We assembled a panel with core expertise in the relevant domains and purposefully engaged experts from different sectors (see Table 2) to capture and integrate multiple actors and disciplines and hence perspectives, required to achieve a holistic view of CE (Murray et al., 2017). The panel comprised experts from academia, industry and policy and with expertise in different CE concepts, for example, Cradle to Cradle (McDonough and Braungart, 2002) and The Performance Economy (Stahel, 2010). This diverse panel enabled the exploration of future business models for SC in the CE despite different definitions of the CE (Kirchherr et al., 2017).

Table 2: Sector and expertise of panel experts ('✓' indicates participation in the interview round).

#	Interviewee code	Country	Expertise	Round 1	Round 2
1	Academic 1	Austria	SC	✓	✓
2	Academic 2	Finland	CE & SC	✓	✓
3	Academic 3	Netherlands	CE	✓	✓
4	Academic 4	Netherlands	CE & SC	✓	✓
5	Academic 5	UK	CE & SC	✓	✓
6	Academic 6	Norway	CE & SC	✓	✓
7	Academic 7	Sweden	CE & SC	✓	✓
8	Academic 8	Sweden	SC	✓	
9	Academic 9	Netherlands	SC	✓	✓
10	Academic 10	Switzerland	CE	✓	
11	Practitioner 1	Norway	CE	✓	
12	Practitioner 2	US	SC	✓	✓
13	Practitioner 3	UK	CE	✓	✓
14	Practitioner 4	Netherlands	CE	✓	
15	Practitioner 5	Belgium	CE	✓	
16	Practitioner 6	UK	CE	✓	✓
17	Practitioner 7	Netherlands	CE	✓	✓
18	Practitioner 8	Sweden	CE	✓	✓
19	Practitioner 9	Netherlands	CE	✓	
20	Practitioner 10	Netherlands	CE	✓	✓
21	Practitioner 11	Netherlands	CE	✓	
22	Civil servant 1	Belgium	CE	✓	✓

Identifying the right experts is important as this directly influences the quality of a Delphi study (Hsu and Sandford, 2007; Skulmoski et al., 2007). Experts on either CE, SC, or both fields were identified via known CE business cases, involvement in relevant

consulting or policy development, and related academic publications. Subsequently, the panel was extended using the snowball sampling technique (Wohlin, 2014). Experts from industry worked for example in the textile, FMCG, recycling, and manufacturing sectors; and were acting as CEO, designer, consultant, and sustainability director. This panel facilitated the exchange between theory, practice, and policy.

2.3.3 First interview

The first interview consisted of three parts; first, we explored experts' understanding of CE and SC. Second, experts provided their opinion on how elements of the sustainable business model (Figure 3) should change in the transition to a CE in order to achieve SC. Third, they formulated the implications of a CE for consumers (see Table 3 for example questions). The interviews were conducted with the 22 experts individually; either in person, via Skype or telephone, and lasted around one hour. The data from the interviews were coded in NVivo, first according to the questions, then by the specific content to discover themes (Ryan and Bernard, 2003). Four themes were discussed by all experts and contained a variety of different opinions (see Table 4 for coding examples). Based on these themes, the set-up of the second interview was developed.

Table 3: Overview interview 1 set-up and exemplary questions.

	General topic	**Exemplary question (shortened)**
Part 1	Understanding CE and SC	How would you define circular economy and sustainable consumption in one sentence each?
Part 2	Business model elements for SC in transition to CE	How should companies shape their value proposition when implementing circularity and sustainable consumption?
Part 3	Consumers in the CE	Imagine a truly circular economy – how would consumption change? Why?

Table 4: Coding example for the business model element Resource strategy.

Content groups	**Exemplary quotes**
Substitution of non-sustainable materials	"80% of our materials [are] either bio-based or recycled […] everything else is either a virgin plastic material or a petrol-based chemical and we are trying to reduce that. We want all of our materials to be either bio-degradable or recyclable." (Practitioner 2)
Efficiency improvements	"we're […] minimizing resource [use], certainly using them more efficiently and reducing impact that way" (Practitioner 3) "you're also using the detergent more efficiently, you're consuming less energy" (Academic 4)

Cycling of materials	"products […] are perpetually recycled" (Practitioner 10) "use all the waste materials as the whole materials for industrial production for the second round" (Academic 2)
Cycling of products and materials	"reuse of the product and recycling [of] materials" (Academic 2) "fleet of assets and then letting customers use that fleet" (Practitioner 6)

2.3.4 Second interview

The aim of the second round was to seek consensus on the four themes (i.e. business model elements) and to integrate options of these into future business models for SC in the clothing industry. The four business model elements were used to develop a framework (Fig. 2) that provides an overview of suggested options for each element and enables mapping of business models for SC. One week prior to the second interview experts received feedback on the first round, including the framework, and one day before the interview the interview structure.

In the second interview, the findings of the first interview were first summarised and agreed upon. This was followed by an explanation of the SC business model framework with an example (Fig. 2). During the first round, it had become clear that discussing business models in abstract terms was difficult and that experts extrapolated the present when asked about the future. The second interview was set-up to follow this thinking process; business models for a specific industry were discussed, first for the present and then for the future. Using the framework experts described the most promising combinations of the four business model elements to achieve sustainability improvements and consumer acceptance for a company in the clothing industry. The clothing industry was selected as current production and consumption practices are highly unsustainable (WRAP, 2012). After mapping future business models, experts were asked to criticise and question the framework.

2.4 Results

2.4.1 Results first interview round

The first round of interviews started with the experts' understanding of CE and SC. The majority of experts showed a shared understanding of CE as an economic system within which resources are cycled to achieve economic and environmental benefits. Most experts agreed that a truly circular economy should lead to SC. However, several experts were not convinced that SC would be accomplished through the implementation of CE. These experts either had a critical view on the current implementation of circular

business models in practice, questioned the sustainability of the CE concept, or questioned if consumption could ever be sustainable.

Experts then described future specifications of the business model elements in order to achieve sustainable consumption in the circular economy and implications for consumers. The analyses of the interviews revealed four themes that represent business model elements that were mentioned repeatedly but that experts envisaged differently. These four business model elements are Resource strategy, Revenue model, Consumer effort, and Objective for consumption level. The two business model elements Resource strategy and Revenue model focus on the production side of a company whereas the elements Consumer effort and Objective for consumption level bring in the consumption side. These four business model elements are explained in the following sections.

Resource strategy

Preventing the waste of resources and excessive virgin material extraction is central to the CE concept as these processes require energy, often resulting in pollution, and increasing competition over scarce materials (Bakker et al., 2014b; Zink and Geyer, 2017). Hence, an appropriate resource strategy as input in offerings is highly important to enable SC. The strategies suggested by experts are explained in more detail in the following.

Substitution of non-sustainable materials[1]: Replacement of materials and processes by (more) sustainable ones. Practitioner 2 explained the resource strategy in his company as follows: "all of our materials are either from bio-based or recycled sources, and all of the packaging we make and all the ingredients for our products are either recyclable or bio-degradable so that you can tie into something like the carbon cycle to renew the materials, that is fundamental in our design thinking."

Efficiency improvements to minimise waste and negative impacts: Interviewees described process optimization that leads to a decrease in negative environmental impact but not necessarily to circularity; for example, through strategies, such as decreasing raw material use and waste per product and down-cycling of waste. Though this is not truly circular, it is a strategy that was mentioned several times for the transition phase to a circular economy. In the company where Practitioner 3 works, they

[1] Whether a material can be considered sustainable or non-sustainable depends on the context it is applied in. The same material might be sustainable in one context but not in another.

are “minimizing resource [use], certainly using them more efficiently and reducing impact that way”.

Cycling of materials: Interviewees described this strategy as a way to reduce the need for virgin raw materials; products are collected after their end-of-life, and the materials are reused for new products. Practitioner 9 envisaged that “resources will be in a common pool so that they can be used in different types of products by anyone, but they will have to return the resources to that pool after a certain amount of time or put them back into resource circulation”.

Cycling of products and materials: This resource strategy incorporates the same ideas as the previous resource strategy but aims to preserve value through “reuse of the product and recycling [of] materials” (Academic 2). For example, second-hand sales, remanufacturing, refurbishing and take-back schemes can facilitate this. Practitioner 2 suggested to “design the products for either collection and recycling or for multiple uses” and explains that “it is incumbent on industry in cooperation with government to set up a very convenient recycling infrastructure so there is no question in an individuals' mind what can and must be done with substances after it's used once and things simply don't get thrown away.”

Revenue model

The revenue model defines how companies monetise their offerings, how consumers can obtain the desired functionality, and who is responsible for means that provide this functionality (Manzini and Vezzoli, 2003). Experts suggested revenue models that are closely related to Tukker's (2004) classification of PSS.

Experts mentioned a range of different revenue models from products to services. Experts suggested product-oriented (Product related services or advice, Multiple subsequent owners), use-oriented (Renting, Leasing, Subscription) and result-oriented (Pay per service unit, Functional result) revenue models. The majority of interviewed experts anticipated a decrease in consumer-owned products. Practitioner 6 stated: “Ultimately, you will see a move away from ownership of a lot of things. I wouldn't necessarily need to own a number of things as long as I have access to them”. Academic 1 explained why there would be a shift towards services; “I think it's easier to keep products in a good state when you don't sell them but you lend them or lease them. The Multiple subsequent owners revenue model refers to companies monetising long-life products through second-hand sales, refurbishment or remanufacturing. Practitioner 6 suggested that “there's this whole aftermarket creating value, why am I [as manufacturer] not competing in that market somehow?” The Subscription revenue model allows consumers to access offerings when needed for a fixed, regular fee. Some

experts envisioned limits for access-based consumption - Practitioner 3 stated that there “is always going to be an element of ownership for certain things”.

Consumer effort

For a potentially more sustainable offering to achieve sustainability gains it needs to gain consumer acceptance and replace less sustainable alternatives (Zink and Geyer, 2017). Further, for consumers to consume sustainably, actions such as returning or repairing products might be required (Wastling et al., 2018). The consumer effort required for a new, sustainable offering compared to the effort required to consume current standard offerings determines whether a product is more or less convenient.

Interviewees disagreed on the role of consumers in achieving SC. Views ranged from entirely consumer-driven SC, through for example informal sharing, to completely company-driven SC with no changes to the role of consumers. Active roles of consumers were mentioned, for example fixing devices, returning products, using products longer, maintaining them and even changing lifestyles. Academic 9 believed that “we [the consumers] will be more considerate about which product we buy”, and Academic 10 stated that “users will have a stewardship relationship with the goods they own”. Academic 6 emphasised the importance of benefits that make potentially higher effort worthwhile: “I might be motivated to return them for recycling or refurbishing if something is in it for me.” The other end of the spectrum was described as companies providing sustainable products or services that are convenient for the consumer but require no higher effort or involvement than the equivalent current consumption practices. Academic 7 stated, “I don't think it is reasonable to rely on people [...] to [only] buy from this producer and then you have to drive whatever kilometres to leave this product at this recycling station or at this repair shop. It has to be convenient.” Practitioner 9 even suggested that “if you provide people [with] sustainable things to consume, then the consumption will be sustainable”. Practitioner 11 concurred and explained: “It doesn't necessarily mean that if you do something circular as a supplier or manufacturer that you will change consumption. You can also do it in a way that the people don't even realise it.” Academic 3 expressed that both ends of the spectrum need to be addressed; “I think there are people who don't want to become active; they should be enabled as well.”

Objective for consumption level

The majority of interviewed experts deemed a decrease in consumption levels, also referred to as sufficiency, necessary in order to achieve SC and a CE. A company can actively try to influence consumption levels, for example, through business models that involve shared, long-lasting or upgradable products, increasing their lifetimes or use intensity, thereby decreasing overall consumption levels (Bocken et al., 2016).

Experts talked about companies aiming to change consumer lifestyles and consumption levels: “you don't want to be encouraging rampant consumption” (Practitioner 9) but instead support “reuse, good maintenance, prolonged use [...] to keep things longer in the system” (Academic 6). Several experts talked about the decoupling of consumption and raw material use for example through non-ownership models. Thus, consumption levels could remain stable while the material input decreases. Practitioner 7 believed that “you don't have to do less, you can even do more, but it is all about being smart in how you create it - how can you gain value or keep it within the loop?” This expert anticipated that cycling of materials eliminates the need to reduce overall consumption.

2.4.2 Sustainable consumption business model framework

During the first interview round, the four themes Resource strategy, Revenue model, Objective for consumption level and Consumer effort were discussed by all experts, but they did not agree on the specific characteristics. These four themes are business model elements. Based on these, Figure 4 was developed to visualise the breadth of options suggested by experts. The framework for business models for SC provides an overview of opportunities that can potentially lead to more SC in the transition to the CE. It can be used to map existing businesses and to explore opportunities for future business models for SC. Within this framework, experts combined options of the four business model elements to create business models for SC during the second interview. For a detailed explanation of the business model elements in this framework, please refer to the previous sections. The use and meaning of the figure are explained using a leasing jacket as an example (see Figure 4). An example from the clothing industry was selected because current clothing consumption practices are unsustainable (WRAP, 2012) but different business models are available and imaginable (Armstrong et al., 2015) and because the second interview round focused on the clothing industry.

Many wardrobes contain a large percentage of clothes that are rarely or never used. These underused clothes represent wasted resources. Leasing models for everyday clothes and rental models for special occasion wear could reduce the amount of idle clothing in wardrobes. For example, a consumer might lease a jacket (a). Paying for the jacket on a monthly basis will ensure that the jacket is sent back once it is no longer needed or desired. This leads to a reduction in consumption as consumers can change the style of jacket from year to year while the previous jacket is used by another consumer thereby decreasing consumption (b). The company provides jackets that are durable, easy to repair and recyclable so that they can be cycled from one consumer to the next for as long as possible. In this way, the product and materials are cycled (c). The jacket is professionally cleaned and repaired after each consumer, can be selected online, and is posted to an address or pick-up location convenient for the consumer and hence requires less effort than traditional jacket shopping and owning (d).

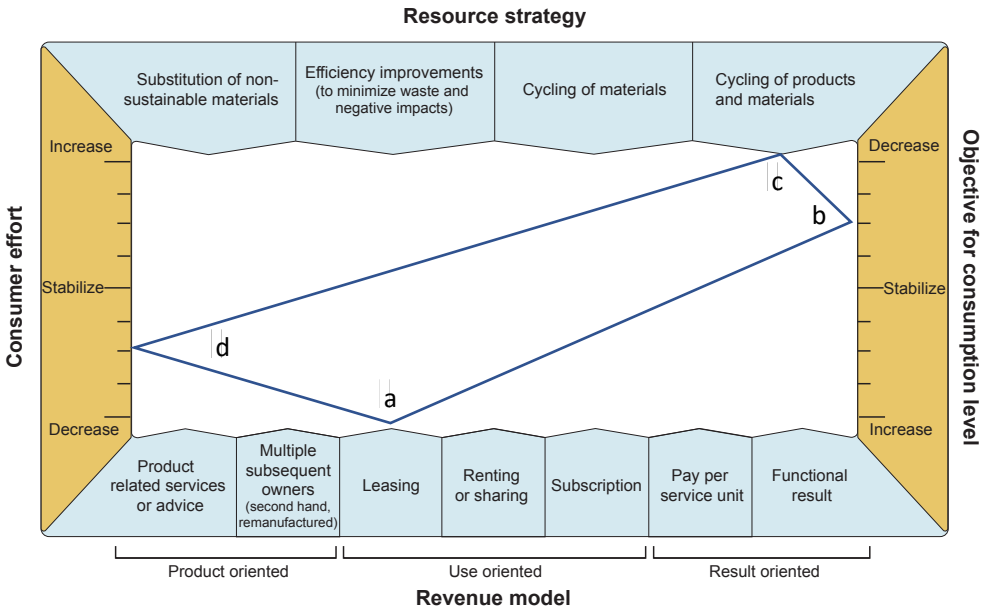

Figure 4: Business model framework for SC mapping the four business model elements (labelled a-d) for the example of leasing clothes.

The two consumer-focused business model elements (Consumer effort and the Objective for consumption level) are defined in relation to current standard consumption practices and by their extremes. The line midway (Stabilise) indicates that the Consumer effort or the Objective for consumption level respectively, stay the same as they are with current standard consumption practices. The extremes of these elements (high/low and decrease/increase) indicate a significant change. In the case of the Objective for consumption level element, a mere substitution of another company's product at its end of life is not considered a decrease.

2.4.3 Results second interview round

The aim of the second interview round was to uncover promising business models for SC. The focus was on the clothing industry because the first interview round showed that it was difficult for experts to talk about business models in abstract terms. Interviewees envisaged and mapped one or two business models for the present and the future in the provided framework. Figure 5 visualises the percentage of experts that selected the different options per business model element; experts could select a maximum of two options per business model element. In Table 5 the selected combinations of the four business model elements are summarised.

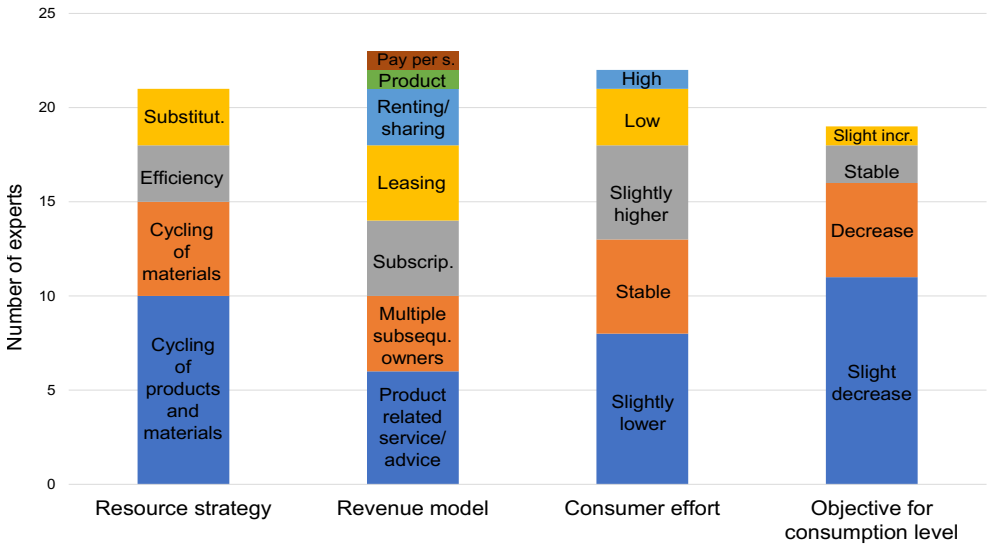

Figure 5: Number of experts who selected the different options in the framework for future clothing business models (colours used to separate the different options).

Table 5: The numbers indicate how many of the 23 suggested business models combine the different Revenue model options with the different options for Resource strategy, Consumer effort, and Objective for consumption level for envisaged future clothing companies.

Resource strategy / Revenue model	Substitut. non-sustainable materials	Efficiency	Cycling of materials	Cycling of products & materials	Consumer effort			Objective for consumption level		
					Decr.	Stable	Incr.	Decr.	Stable	Incr.
Product				1			1		1	
Product-relat. services		2	3	1	3	1	2	6		
Multiple subs. owners	1			3	2	1	1	4		
Leasing		1	1	2	2	1	1	2	1	1
Renting or Sharing	1		1	1	1	1	1	2	1	
Subscription	1			3	3	1		4		
Pay per serv.				1	1			1		
Funct. result										
Total	3	3	5	12	12	5	6	19	3	1

During the second interview, experts indicated that they deem Cycling of products and materials and Product related services/advice highly promising as resource strategy and revenue model respectively. Most experts described business models to be implemented now as requiring higher consumer effort and only serving a niche segment. Experts explained that the future business models would serve a larger share of the market as they will be more convenient compared to current standard

consumption practices. They explained this decrease of consumer effort with the need to first set-up the infrastructure and the necessity for behaviour change now that will be the norm in the future. Most experts agreed that a low consumer effort, thus convenience, would be desirable as this can lower barriers for consumers resulting in wider adoption and

larger sustainability improvements. Some experts described a consumer segment that is willing to accept convenience trade-offs for higher sustainability gains. Most experts saw this segment as a small share of the population and hence favoured convenient solutions.

The suggested business models were grouped in three categories according to their revenue model; these groups are product oriented (Product related services/advice, Multiple subsequent owners), use oriented (Leasing, Renting or Sharing, Subscription) and result oriented revenue models (Pay per service unit, Functional result). A combination of Use oriented revenue models with Cycling of products and materials as resource strategy was proposed by six of the 16 interviewees of the second interview round (Table 5). However, 50% of suggested future business models are product oriented and imply that ownership will still be important. Experts believed that use-oriented models support the cycling of materials and products, thereby reducing virgin material inputs.

The comparison of the suggested future business models for the clothing industry did not reveal one or a few preferred business models. Instead, a range of business models emerged, and three of these are exemplarily mapped in Figure 6. Firstly, despite not reaching an overall consensus, one combination of options from the four business model elements was suggested by three experts independently (Academic 7, Practitioner 2 and Civil servant 1). This business model is mapped with a thick line in Figure 6. The experts proposed the combination of a subscription revenue model with the resource strategy of Cycling materials and products, a lower effort for the consumer and the objective to reduce consumption levels. Experts' suggestions regarding the vertical business model elements varied slightly, but all indicated a decrease in Consumer effort and Consumption levels. The experts explained that they expect these elements to reinforce each other. All three experts described this business model as aiming for intensified use of the garments. They argued that a clothing subscription could decrease the amount of idle clothes as consumers would return no-longer-used items that subsequently can be sent to another consumer, thereby decreasing the overall consumption level of clothes. Civil servant 1 stated that the non-ownership character of a subscription model would support the cycling of products and materials by taking the responsibility for disposal away from consumers. The expert also envisaged that subscription models would entail convenient return systems through

then established reverse logistics processes that would reduce consumers' efforts to consume sustainably.

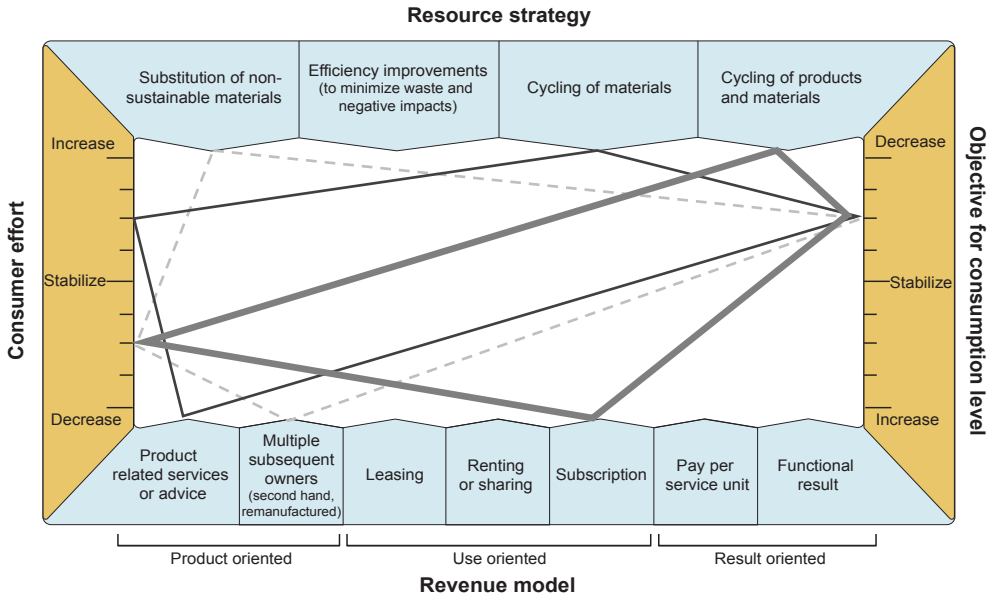

Figure 6: Business model framework for SC with three examples of proposed future business models.

Practitioner 6 suggested the dotted lined shape, which represents a business model that is built around the idea of using future biodegradable materials. The consumer effort to consume sustainably was described as slightly lower than standard practices as preowned garments could be sold through conventional channels and would be sustainable by design. The interviewee described the garments as high-quality and long-lasting so that they could lead to decreased consumption levels.

Academic 7 proposed the thin lined shape, which represents the business model of an online made-to-fit clothing company. This company creates a range of different designs that are selected by consumers on a website and then realised locally, for example in 3D print workshops. The interviewee suggested that this offers opportunities for personalization and would thereby better fit the shape and taste of the consumer and potentially be used for longer, hence decreasing consumption levels. This process would also require more time and effort from the consumer than traditional shopping for fast-fashion.

2.4.4 Reflection on the proposed business model framework

The SC business model framework was discussed with all experts to develop it further. Some interviewees mentioned that social consideration should be included in the

resource strategies, others noted that the framework could include the role of design in achieving SC more explicitly. The four business model elements required some explanation and they can be interdependent. For example, the choice of revenue model can directly influence the consumer effort and require a specific resource strategy. Some experts expected that the emerging shape inside the framework indicates the level of SC that the developed business model achieves. Based on the wide consensus on the 'decrease' side on the Objective for consumption level this element could be changed, for instance, by providing different levels of decrease that might depend on the industry or even the specific offering (e.g., use frequency, replacement frequency). Overall, the interviewees found the framework useful to map current businesses and to think about future business models for SC.

2.5 Discussion and conclusions

In this study, we applied a two-round, Delphi-inspired approach through interviews. During the first interview round, based on Bocken and Short's (2016) sustainable business model framework, four business model elements that are important for SC were identified; namely Resource strategy, Revenue model, Consumer effort, and Objective for consumption level. The framework for SC business models comprises these elements and was used by experts to develop SC business models during the second interview round. A variety of different SC business models for the clothing industry emerged.

2.5.1 Discussion

This paper proposes a business model framework for SC that includes production and consumption side aspects of a business model that can help achieve SC. With this, we propose a step towards Mont and Plepys (2008, p. 536) who voiced a need for strategies that "target both the supply and demand sides". This research highlights the importance of considering the consumer who is often neglected in CE discussions that largely focus on material and product flows (Edbring et al., 2016; Murray et al., 2017). Further, it demonstrated that PSS (Manzini and Vezzoli, 2003; Tukker, 2004) could potentially become more sustainable if companies that implement them change the Resource strategy, Consumer effort, and Objective for consumption level of their business models with SC in mind.

This research suggests that a wide range of different business models for SC could be promising in terms of sustainability and consumer acceptance. This confirms findings of Mugge et al. (2017) who identified several customer segments with different requirements for refurbished smartphone offerings in their research and research conducted by Edbring et al. (2016) who discovered that different types of furniture

require different SC strategies. It appears that the finding of the sustainability potential of coexisting, diverse offerings is applicable across different industries.

Concurring with Bocken and Short (2016) the interviewed experts expressed that SC business models should decrease consumption levels. The business model elements identified in this study link to four business elements from Bocken and Short's (2016) framework; namely to Customer segments and relationships, Resources, Cost structure & revenue streams, and Growth strategy/ethos. Building on their framework and the first round of interviews we developed a framework for SC business model that allows focussing specifically on improving the sustainability of consumption in the CE context. It might be beneficial to use both frameworks in parallel to improve the sustainability of consumption whilst not losing track of other important business model elements.

We expected that interviewees, due to their CE and SC expertise, would describe visionary business models that could potentially lead to strong sustainable consumption. However, the proposed business models aim to slightly decrease consumption levels while being convenient for consumers, thus, relating to weak sustainable consumption (Lorek and Spangenberg, 2014). This shows that radical change to businesses, which could lead to strong sustainable consumption, is difficult to imagine even for experts in the field. This could originate in the assumption that striving for strong sustainable consumption traditional contradicts growth objectives. However, Bocken and Short (2016) and Wells (2018) have presented some best practice examples.

In recent years, most studies applying the Delphi method used questionnaires to gather opinions but also interviews have been suggested and used (Van Dijk, 1990; Allwood et al., 2008). To support the exploratory nature of this study and enable the integration of different knowledge domains we designed a methodology based on principles of the Delphi method; conducting several interview rounds, intermittent feedback and preserving the anonymity of experts. The applied Delphi-inspired method is based on two rounds of semi-structured interviews, the second round being supported by a framework based on the results of the first interview round. The use of this methodology led to rich insights into this complex topic and a solution space for business models for sustainable consumption in the circular economy.

The applied qualitative methodology entails some limitations; the study is based on the subjective opinions of experts who developed business models that match their vision of a future circular economy. The use of a relatively small sample, the subjective nature of the data and a focus on one industry only (in the second round), imply that not all findings are applicable to other industries. However, high-level findings, such as the benefits of a variety of business models, the importance of consumer effort and

consumption reduction, can probably be generalised. Some industries might require major technological innovations to achieve SC and to become circular.

In this study, we focused on the business to consumer market as products and services, such as clothing, were more tangible for participants. However, our framework is likely to be also applicable for B2B business models; for example, the effort a firm or an end-user at a firm has to invest to use a product or service is at least as relevant for adoption as it is for consumers. This framework and possible adjustments thereof for the business to business context could be explored in the future. Further, financial aspects of business models could not be considered as these would be highly context-dependent and hypothetical. Future research could explore financial aspects. It could also investigate the applicability of the proposed framework to different industries and test the viability of proposed business models in practice. Further research could also evaluate actual sustainability gains and potential changes to consumption patterns through business models developed within the proposed framework, which could be mitigated by rebound effects (Zink and Geyer, 2017). Further, it would be interesting to build on this study and explore business opportunities enabling strong sustainable consumption (Lorek and Spangenberg, 2014).

2.5.2 Conclusions

This research aimed to reveal potential business models for SC in the context of the CE transition. To date, CE and SC have mostly been studied separately. We sought to combine these topics by developing future SC business models for the CE transition. Based on our findings we developed a business model framework that can be used by practitioners and academics alike to map current offerings, and to develop future business models that incorporate SC. This framework can support SC-focused discussions of business models, as it highlights a range of options to improve SC. During the second interview round, experts mapped a wide variety of business models for the clothing industry on the four business model elements in the framework and outlined different customer segments and contexts of use.

This study suggests that a variety of business models is most promising to achieve SC in the transition to the CE as they allow consumers to choose the offering that best matches their personal needs and preferences. Sustainable offerings that require little effort of consumers would probably be adopted by more people. Combining a convenient offering with a matching revenue model, and an objective to decrease consumption levels along with a matching resource strategy, can increase SC levels. The findings of this research confirm that changes to business models are needed to transform current unsustainable consumption patterns (Bocken, 2017) and offers a framework to develop business models for SC.

We explored SC business models in the context of the CE transition, thereby contributing to existing literature of these fields (e.g., Mont and Plepys, 2008; Boons and Lüdeke-Freund, 2013), and to practice by providing a framework for the analysis and development of business models for SC. This study shows that SC can be integrated into business models and provides a framework that can support doing this. Implementing SC business models to stimulate SC on the production and consumption side is an important step towards a more sustainable society.

Chapter 3
Consumer adoption of access-based PSS

This chapter is based on: Tunn, V.S.C., Bocken, N.M.P., van den Hende, E.A., Schoormans, J.P.L., in Press. Diffusion of access-based product-service systems: Adoption barriers and how they are addressed in practice. In: PLATE Product Lifetimes And The Environment 2019 – Conference Proceedings. N.F. Nissen and M. Jaeger-Erben (Eds.). TU Berlin University Press.

3.1 Introduction

During the last two decades, product-service systems have been proposed as circular and sustainable business models (Mont, 2002a; Stahel, 2010; Tukker, 2015, Vermunt et al., 2019). These business models combine product, service, and infrastructure elements to satisfy consumer needs (Mont, 2002a). For example, access-based product-service systems (AB-PSS) allow users to take advantage of products' functionalities for a fee, without owning them. This could disincentivise planned obsolescence and reduce idle products (Tukker, 2004; Bocken et al., 2016; Den Hollander, 2018), thereby extending product lifetimes and increasing product utilisation. The implementation of AB-PSS in organisations changes the way they conduct business and must be understood as business model innovation (Lewandowski, 2016; Bocken et al., 2016). Many innovative business models such as AB-PSS are emerging; however, some are more readily adopted by consumers than others (Edbring et al., 2016). These business models seem to evoke more resistance than innovative products that are directly sold to consumers (Mont, 2002b; Poppelaars et al., 2018; Cherry and Pidgeon, 2018).

Until today, AB-PSS are a niche mode of consumption. The aim of this study is to outline why consumers adopt or reject AB-PSS. We review adoption barriers in literature and extract ways to address them from widely adopted mobility AB-PSS through interviews. We then employ innovation diffusion theory to generate further insights into consumers adoption of AB-PSS that can guide designers to improve adoption.

3.2 Background

3.2.1 Consumer adoption of AB-PSS

In 2003 Mont and Plepys (2003) indicated that product-service systems have been successfully applied in the business-to-business context but have been less successful in consumer markets. In recent years, AB-PSS have been tested and implemented for many consumer products and mobility AB-PSS such as bicycle and car sharing schemes have been mushrooming in many cities. Studies have analysed the rental of high-quality baby products such as prams (ResCoM, 2019), and infant car seats (Catulli et al., 2017a). These propositions are seen as financially beneficial by consumers due to the temporary need for the products. Recently, companies have increasingly started offering AB-PSS for products that consumers use for a longer time. For example, jeans and headphones can be accessed for several months or even years through AB-PSS (Weiguny, 2018; Gerrard Street, 2019). Consumers adopt the headphone AB-PSS because the included repair and replacement services eliminate the financial risk of headphones breaking after the warranty expires. The company MUD jeans is known for its jeans AB-PSS, yet only 25% of their jeans are used through their AB-PSS and 75% are still bought by consumers (Weiguny, 2018). This example shows that we need to better understand what consumers value in AB-PSS and why they adopt or reject them.

3.2.2 AB-PSS and adoption innovation diffusion models

Innovation diffusion models aim to explain the level of adoption of innovations in the market. Many innovations fail and never achieve wide market diffusion (Moore, 1991; Hall & Vredenburg, 2003; Feola & Nunes, 2014). Hall and Vredenburg (2003) argue that sustainable innovations face barriers additional to the general barriers that innovations entering the market encounter because of contradicting demands from a multitude of stakeholders. Rogers (1995) developed a seminal model to explain the diffusion of innovations in the 1960s. He reasoned that the diffusion of innovations is influenced by five innovation attributes, namely the Relative advantage, Compatibility with existing values, practices and habits, Complexity, Trialability, and Observability.

The early innovation management literature focused on product innovations but soon the models were also applied to services (Schrader, 1999; Mont & Plepys, 2003; Rexfelt & Hiort af Ornäs, 2009). Schrader (1999) applied Rogers' (1995) innovation attributes to outline consumers' perceived advantages and disadvantages of communal washing machines and car sharing. Rexfelt and Hiort af Ornäs (2009) also refer to Rogers' (1995) innovation attributes and conclude that many comments of the participants relate to them. Mont and Plepys (2003) briefly discuss the applicability of Rogers' (1995) framework to product-service systems. However, it appears that no study has

systematically applied these attributes to analyse consumer adoption of AB-PSS. Therefore, it is still unclear how AB-PSS adoption differs from the diffusion of product innovations. In this paper, we aim to elucidate this by addressing the following research questions:

1. What adoption barriers do AB-PSS face in the consumer market?
2. What can we learn from innovation diffusion literature about AB-PSS adoption?
3. How can AB-PSS achieve wider adoption in the consumer market?

3.3 Method

This study aims to provide insights to improve the consumer adoption of AB-PSS. We identify adoption barriers through a literature review as there is an extensive body of literature. We complement these barriers with insights into how these barriers are addressed in practice. We decided to study mobility AB-PSS that are widely adopted in practice, because previous literature has largely studied hypothetical AB-PSS (e.g., Rexfelt & Hiort af Ornäs, 2009; Catulli et al., 2013; Armstrong et al., 2015) or AB-PSS that are not (yet) widely adopted (e.g., Catulli et al., 2017a; Pedersen & Netter, 2015).

We revealed barriers to consumer adoption of AB-PSS through a systematic literature review. We included the following keywords, their synonyms, and related concepts in the search query: product-service system, consumer, and adoption. The search query was run in SCOPUS on 26/06/2018 and resulted in 112 unique publications. We only included publications in our analysis that cover

Business to Consumer AB-PSS involving tangible products. Further, we only used papers that address factors influencing the adoption or acceptance of AB-PSS. This led to an initial set of 18 publications. Publications were added using the snowballing technique (Wohlin, 2014) resulting in a total set of 34 publications. We identified nearly 200 AB-PSS adoption barriers. Multiple authors mentioned the same barriers and phrased them slightly differently. During two discussion and clustering sessions, three researchers condensed these to 17 barriers.

We employed eight semi-structured interviews with four mobility AB-PSS experts and four users to explore how adoption barriers are addressed in practice. Mobility AB-PSS can be considered successful in terms of consumer adoption; they are very common in the Netherlands and adopted by a significant share of consumers. These AB-PSS have the potential to reduce car use and encourage the use of public transport, thereby benefitting sustainability. The interviewed experts work in positions such as Marketeer and Innovation officer at mobility AB-PSS providers (e.g., bicycle or scooter sharing). The interviewed users have tried at least one mobility AB-PSS. The interviews were

conducted in person, recorded, transcribed and coded, resulting in 20 aspects that influence mobility AB-PSS adoption in practice (Ryan & Bernard, 2003).

Finally, the AB-PSS adoption barriers and the insights from practice were clustered according to Rogers' (1995) innovation attributes. In this way, we determined whether they relate to innovation diffusion theory or are specific to AB-PSS.

3.4 Results

All identified barriers and ways in which they are addressed in practice could be clustered according to Rogers' (1995) innovation attributes. Most findings relate to the Relative advantage which comprises benefits that consumers perceive AB-PSS to have or lack compared to other modes of consumption, such as ownership.

3.4.1 Review of barriers to consumer adoption of AB-PSS

During the literature review, AB-PSS adoption barriers were extracted. Not all papers used the term adoption barriers, some described acceptance barriers, consumer satisfaction, or factors for (non-) acceptance of AB-PSS. We provide the clustered barriers in Table 6 with exemplary quotes from literature. The table with all references is available upon request.

Table 6: AB-PSS consumer adoption barriers identified in literature.

Barriers	**Exemplary quotes from the literature**
	Relative advantage
Functional aspects	
Quality of product	"Consumers were concerned not only about whether the products were hygienic and in good condition, they also wanted them to be "shiny and new" " (Catulli, 2012, p. 787)
Specific product characteristics	"People have less positive attitudes towards using second-hand products made of soft materials like upholstery and fabrics than products made of hard materials, such as wood and metal." (Edbring et al., 2016, p. 13)
Additional effort required	"For many people, renting and especially sharing are associated with […] excessive costs of organising private life." (Mont, 2004a, p. 149)
Intangible aspects	
Lack of trust in others	"Lack of trust is often seen as a barrier for collaborative consumption" (Edbring et al., 2016, p. 12)
Desire to own	"Respondents saw the renting or leasing of such products associated with a social "stigma", a solution for poorer consumers." (Catulli, 2012, p. 787)

Lack of hedonic value	"We found that in contrast to the hedonic experiences with cars […], these experiences were not common in our data, as functionality is privileged in our context." (Bardhi & Eckhardt, 2012, p. 890)
Lack of intangible benefits	"So one can only substitute those goods with which consumers have a functional rather than an emotional relationship" (Schrader 1999, p. 113)
Financial aspects	
Financial barriers, e.g., perception of high cost	"Products that are used over a long period of time are not seen as suitable for renting, since the cost of renting might be higher than purchasing new furniture." (Edbring et al., 2016, p. 13)
Perceived risks	
Availability	"On the other hand, car pay-per-use adopters were inconvenienced due to product unavailability or the limited working area of car2go." (Poppelaars et al., 2018, p. 11)
Contamination and safety	"Access schemes and growing second-hand markets present consumers with objects with 'contamination' from previous use." (Baxter & Childs, 2017, pp. 391-392)
Having to treat the product carefully	"The majority of consumers feels a *greater need for carefully* handling the product in case of access as compared to ownership." (Baumeister & Wangenheim, 2014, p. 27)
Compatibility	
Lack of flexibility	"One has to make a deliberate decision to gain access to the use of a car, to plan car use and to make a reservation in advance." (Meijkamp, 1998, p. 241)
Change required	"Consumers also seem to more easily adopt a business model that does not require a dramatic change in their practices." (Antikainen et al. 2015, p. 13)
Complexity	
Complexity of offer	"It was not entirely transparent to participants what the real advantages would be, in light of their historical consumption habits." (Armstrong et al., 2015, p. 37)
Trialability	
Relevance of service	"One pattern across the different PSS was participants associating them with package-deals. In their view, added services were rarely relevant and often used to "scam" the customers for more money." (Rexfelt & Hiort af Ornäs, 2009, p. 679)
Reluctance to commit	"The participants did not want to commit to paying fixed costs" (Rexfelt & Hiort af Ornäs, 2009, p. 679)
Observability	
Lack of awareness or understanding	"The missing or at least limited observability of 'intangible' services is often mentioned as an obstacle to their diffusion […] Service companies therefore try to make their offers as visible as possible" (Schrader, 1999, p. 117)

3.4.2 How are consumer adoption barriers addressed in practice?

The interviews revealed how successful mobility AB-PSS address adoption barriers and which barriers consumers perceive. Consumers value the convenience and flexibility that mobility AB-PSS provide. For example, convenience is frequently mentioned in literature; the interviews showed that some consumers find it convenient not to be responsible for repairs whereas others appreciated easy obtainment of the bicycles. An overview of the ways in which mobility AB-PSS address adoption barriers is provided in Table 7.

Table 7: Summary of how adoption barriers are perceived and addressed in mobility AB-PSS with quotes from semi-structured interviews (translated from Dutch).

Barriers	**Exemplary quotes from the interviews**
	Relative advantage
Product quality	U1: "For me, both [shared] bikes are pretty good and robust."
Effort savings	U2: "I just decided to go for it because it [the bicycle] looked as if it would always function smoothly, and if it would not, you could just give them a call or send them an app and then they simply fix it."
Time savings	U1: "The connection between the tram timetables or other public transport is poor, or it [cycling] is faster, because I do not have to wait for a bus to arrive."
Relieves burdens of ownership	U3: "Then I had to choose between a second-hand bike and a [leasing bike]. A big advantage of [the leasing bike company] is that you directly get a new bicycle if it gets stolen or if something breaks down they fix it quickly."
Financial benefits	E3: "The costs are 30 cent per minute, so it is very clear what you pay and there are no hidden costs."
Perceived control	U1: "Well, with a bus you never know whether it actually will arrive or maybe it has a delay. Thus, you have a bicycle now or very likely a bus, but not totally likely."
Temporary need	U3: "With [the leasing bike] I have the feeling that it can be a short-term solution for a month if you would want to change to another bicycle after that."
Provision of intangible benefits	U4: "Yeah, the [shared bike] looks silly. Yes, it really looks touristy."
	Compatibility
Flexibility	U1: "If you consider it from a relocating yourself perspective, at any moment you can say: „well, I am going to the other side of town" and the bicycle is within reach to do that now and you instantly go there."

Low level altering consumers' habits	U3: "I am used to cycling with gears, I personally consider that very pleasant."
Past experiences	U3: "I had thought about the possibility of it [the bicycle] getting stolen because of past experiences, but then I figured that a double lock would do the job."
Accessibility service providers	U1: "There is no service point or anything, and that I consider a disadvantage of [the bike sharing company], as you do not have a single point of contact anywhere."
	Complexity
Ease of use	U2: "I would like to add something that is really annoying me with [the leasing bike]. There are so many [similar looking leasing bikes] at Amsterdam Central Station that you really need to try three locks of three different bicycles before you find yours. Yeah, that is really crappy."
Archetypical product	E1: "The bicycle that we supply, the Dutch original bicycle, is a highly recognisable product for students. Everyone got that "granny" roadster bicycle model."
Low price complexity	U3: "After twelve months this number became the monthly fee and after twenty-four months this number became the monthly fee, so it goes down the longer you have it [the lease product], while with [the leasing bike] the fee stays the same."
	Trialability
Context of use	U4: "I did not use the bicycle but public transport instead when it was raining cats and dogs."
Accessibility of products	U1: "Until a while ago, I used public transport and walked the final part, yet with the presence of so many types of bikeshares I am more aware of it that that possibility exists too and I use it more often."
Low level of commitment	U1: "The "public transport" bicycle [available at several train stations] is a product for a day, for which you are only responsible that day."
	Observability
Recognisable design	U3: "[The leasing bikes] I see all the time, and they stand out very much, which is very clever. Yeah, I see them every day when I arrive at my apartment."
Word of mouth	E4: "70%-90% had heard of [the leasing bike company] by word of mouth, either from someone working [there] or from a friend or family member with [leasing bike] experience, and that made them look into it."

3.5 Discussion and conclusions

This paper provides an up-to-date, structured overview of AB-PSS adoption barriers and how they are addressed in practice, based on a synthesis of 34 articles and insights from eight interviews. We clustered these findings according to Rogers' (1995) innovation

attributes. The results show that many of the identified barriers are addressed in mobility AB-PSS. For example, the barrier Additional effort required has been addressed in one mobility AB-PSS by providing convenient maintenance and repair services thereby relieving burdens of ownership. This study facilitates the understanding of the current state of AB-PSS adoption in the consumer market and how they could achieve wider diffusion.

Furthermore, we found that consumers compare AB-PSS with standard consumption practices. Our findings correspond with Schrader's (1999) observation that consumers assess the relative advantage of AB-PSS and compare it with the available alternatives (e.g., purchasing the product). The relative advantage of AB-PSS consists of functional, intangible and financial aspects, and perceived risks. For example, consumers consider the quality of the product, how easy it is to obtain access, whether they perceive the AB-PSS as financially advantageous, and whether it can provide the desired hedonic and emotional value. It appears that the success of the analysed mobility AB-PSS is largely based on the convenience they provide.

AB-PSS adoption is influenced by the same innovation attributes as the diffusion of product innovations. The large number of identified adoption barriers and ways to address them mirrors the complexity of AB-PSS (e.g., Mont, 2002b; Rexfelt & Hiort af Ornäs, 2009; Armstrong et al., 2015). The bundling of product, service, and infrastructure elements (Mont, 2002a) makes them inherently complex. Any one of these elements can cause a consumer to reject an AB-PSS. Though most of the identified AB-PSS adoption barriers and ways to address them relate to the Relative advantage, some relate to the other innovation attributes. Compatibility describes how much or little consumers need to change in order to use the AB-PSS and Complexity how easy it is to use and understand. Trialability and Observability both comprise strategies that make AB-PSS consumption visible and reduce the perceived risks of adopting AB-PSS. To achieve wider adoption, AB-PSS need to provide a relative advantage to consumers, be visible in the consumptionscape, and allow for trial periods to build knowledge and trust. They should provide relevant benefits that make consumers perceive them as preferable over alternative offerings.

This study builds on previous research (e.g., Schrader 1999, Mont, 2002b; Poppelaars et al., 2018) and contributes to the understanding of AB-PSS adoption in the consumer market. We show that while AB-PSS adoption can be described with the same attributes as the diffusion of product innovations, it is inherently more complex. The findings can help AB-PSS designers to understand the complexity of AB-PSS implementation in the consumer market and the benefits that consumers value. Adoption barriers are likely to vary depending on the product placed in an AB-PSS (Schrader, 1999; Catulli, 2012; Edbring et al., 2016), we suggest to use our findings as an inspiration for AB-PSS

development while designing them for the specific context, and with sustainability in mind (Kjaer et al., 2019). We concur with (Rexfelt and Hiort Af Ornäs, 2009, p. 678) who stated *"As consumer acceptance of PSS is complex and case specific, there is a need for methods and tools which are easy to adapt to each individual project of designing PSS"* and see a need for further research to translate these findings into actionable AB-PSS design guidelines and to test them in practice.

Chapter 4
Factors determining AB-PSS adoption barriers

This chapter is based on: Tunn, V.S.C., Bocken, N.M.P., van den Hende, E.A., Schoormans, J.P.L., under review. Consumer adoption of access-based product-service systems: The influence of duration of use and type of product. Business Strategy and the Environment.

4.1 Introduction

Sustainability challenges such as climate change, plastic pollution, and declining biodiversity are increasingly pressing. Predictions suggest that the effects of negative human-induced impact on the planet will become irreversible soon without urgent business and policy response (IPCC, 2018). The circular economy promises sustainable production and consumption practices through the cycling of products, components, and materials (EMF, 2013). Several scholars translated circular economy principles into business models that simultaneously achieve economic and environmental benefits (e.g., Lewandowski, 2016; Bocken et al., 2016; Tunn et al., 2019a) or analysed pathways towards sustainable and circular business models (e.g., Perey et al., 2018; Schaltegger et al., 2012; Zucchella and Previtali, 2019).

Product-service systems (PSS) are business models that have attracted interest for satisfying consumer needs through bundles of products and services, thereby potentially decoupling need satisfaction from resource consumption (Bocken et al., 2016; Stahel, 2010; Tietze and Hansen, 2013; Tukker, 2015). One category of PSS, access-based product-service systems (AB-PSS), have the potential to deliver this by providing products that consumers can access through rental, leasing, or sharing services. AB-PSS are business models at the intersection of the circular economy and the sharing economy debates. They have been hailed for their potential to achieve greater levels of sustainability in a business context (Tukker, 2004) whether this broader context is a future circular economy (Lewandowski, 2016; Tukker, 2015) or sharing economy (Boons & Bocken, 2018). The circular economy will be used as a context for

the present study, as a paradigm which has received increasing policy and business support as a driver for environmental and economic prosperity (Geissdoerfer et al., 2017; Ghisellini et al., 2016) in contrast to the sharing economy concept which is more contested and less institutionalised (Curtis & Lehner, 2019).

A lack of consumer adoption is a major challenge for organisations to realise the sustainability potential of AB-PSS and thereby transition towards the circular economy (Tukker, 2015). Indeed, despite success in the business-to-business context, adoption of AB-PSS in the business-to-consumer context is lagging (Vogtlander et al., 2017). Reasons for consumers to adopt AB-PSS have been studied extensively in case studies, reviews, and conceptual papers (e.g., Armstrong et al., 2016; Edbring et al., 2016; Lamberton and Rose, 2012; Rexfelt and Hiort af Ornäs, 2009; Tunn et al., 2020). Despite over two decades of research, the importance of adoption barriers to consumers remains little understood. More knowledge on consumer adoption barriers can help support AB-PSS pursuing organisations to design out potential barriers.

With this study, we contribute a quantitative analysis of AB-PSS adoption from a consumer perspective and determine factors influencing the importance of AB-PSS adoption barriers. This research aims to explore which adoption barriers are important and in what circumstances to identify the barriers that are crucial for the adoption of specific AB-PSS. More specifically, this study aims to reveal how the duration of use of a specific product by a consumer through an AB-PSS, and the type of product impact the importance of AB-PSS adoption barriers in consumers' decision-making processes. Through conjoint experiments, we simulate the choice among several AB-PSS configurations to elicit consumers' preferences and to thereby determine the importance of the adoption barriers in different AB-PSS.

4.2 Background

In this section, barriers and key concepts related to consumer adoption of AB-PSS are presented. First, an overview of AB-PSS adoption barriers found in literature is provided. Then the duration of use and the type of product are introduced as two factors that are likely to moderate the importance of AB-PSS adoption barriers. To this end, the differences between AB-PSS that allow consumers to use products for a short time and those AB-PSS that allow consumers to use products for a long time are presented. Thereafter, the differences in consumer perception of AB-PSS involving bicycles and clothing are outlined. Finally, we present the conceptual model of this study.

4.2.1 Barriers to consumer adoption of AB-PSS

Plenty of research has been conducted to better understand consumer adoption of AB-PSS and many adoption barriers have been identified. In a previous study, the authors

have reviewed consumer barriers to the adoption of AB-PSS in the literature (Tunn et al., 2020). Next, they clustered the adoption barriers according to the five innovation attributes of Rogers (1995) innovation diffusion model, namely relative advantage, compatibility, complexity, trialability, and observability. Tunn et al. (2020) found that many of these barriers relate to the perceived relative advantage of AB-PSS compared to the available alternatives. The present research uses the adoption barriers identified by Tunn et al. (2020) as the starting point. While reviewing the identified AB-PSS adoption barriers it became clear that the adoption barriers relate to different consumption phases, or the AB-PSS concept itself. We clustered the barriers in four barrier categories that are explained in the following and presented in Table 8.

Table 8: Barriers to consumer adoption of AB-PSS from literature (Adapted from Tunn et al., 2020).

Barrier	Description	References
Touchpoint-related barriers		
Effort to access product	Additional or undesirable activities required in order to select offer and to obtain access to products via AB-PSS.	Meijkamp, 1998; Tukker, 2004; Catulli, 2012; Fishman et al., 2014; Baumeister & Wangenheim, 2014; Pedersen & Netter, 2015; Hazée et al., 2017; Camacho-Otero et al., 2017
Contamination	Concerns or negative perception of product due to prior use by other consumers.	Bardhi & Eckhardt, 2012; Hazée et al., 2017; Durgee & O'Connor, 1995; Catulli, 2012; Vezzoli et al., 2015; Armstrong et al., 2015; Edbring et al., 2016; Baxter & Childs, 2017; Lidenhammar, 2015; Camacho-Otero et al., 2017
Concerns about product availability	Products are available and can be accessed when they are needed.	Mont, 2004; Rexfelt & af Ornäs, 2009; Lamberton & Rose, 2012; Catulli, 2012; Baumeister & Wangenheim, 2014; Camacho-Otero et al., 2017
Lack of flexibility	The need to plan in order to ensure access to a product when needed.	Meijkamp, 1998; Schrader, 1999; Littig, 2000; Mont, 2004; Rexfelt & af Ornäs, 2009; Baumeister & Wangenheim, 2014; Vezzoli et al., 2015; Tukker, 2015; Poppelaars et al., 2018
Touchpoint- and use-related barriers		
Lack of trust in others	Lack of trust in the provider and other users leads to uncertainties regarding quality and outcome of using the AB-PSS.	Rexfelt & af Ornäs, 2009; Lamberton & Rose, 2012; Catulli, 2012; Bardhi & Eckhardt, 2012; Catulli, 2012; Armstrong et al., 2015; Catulli et al., 2017a; Catulli et al., 2017b; Hazée et al., 2017; Poppelaars et al., 2018; Cherry & Pidgeon, 2018
Change required	Implications AB-PSS adoption has for everyday life and behaviour.	Mont, 2004; Rexfelt & af Ornäs, 2009; Mylan, 2014; Vezzoli et al., 2015; Antikainen et al., 2015; Camacho-Otero et al., 2017; Santamaria et al., 2016

Use-related barriers		
Quality of product	Concerns regarding low quality product either because of low end brands or because of increased utilisation.	Durgee & O'Connor, 1995; Mont, 2002b; Mont, 2004; Catulli, 2012; Lidenhammar, 2015; Camacho-Otero et al., 2017
Specific product characteristics	Characteristics that make a product more or less suitable for access, for example their material, the importance of fashion, or their monetary value.	Schrader, 1999; Tukker, 2015; Antikainen, 2015; Edbring et al., 2016; Poppelaars et al. 2018
Effort to use product	Learning to operate the products placed in AB-PSS, taking additional care during use, cleaning and maintaining them.	Rexfelt & af Ornäs, 2009; Lamberton & Rose, 2012; Mylan et al., 2014; Baumeister & Wangenheim, 2014; Catulli et al., 2017; Poppelaars et al., 2018
Lack of intangible value	Limited use time of products, no or little signalling of personality and status, or lack of positive associations and enjoyment.	Littig, 2000; Mont, 2002a; Mont, 2004; Catulli, 2012; Bardhi & Eckhardt, 2012; Catulli et al., 2013; Baumeister & Wangenheim, 2014; Armstrong et al., 2015; Tukker, 2015; Vezzoli et al., 2015; Edbring et al., 2016; Santamaria et al., 2016; Camacho-Otero et al., 2017; Cherry & Pidgeon, 2018
Concept-related barriers		
Lack of ownership	External or internal negative feelings because of not owning the product such as lower social status, embarrassment and feeling of insecurity.	Littig, 2000; Mont, 2002a; Rexfelt & af Ornäs, 2009; Bardhi & Eckhardt, 2012; Baumeister & Wangenheim, 2014; Tukker, 2015; Armstrong et al., 2015; Cherry & Pidgeon, 2018
Complexity	Consideration of value product and service components rather than just a product.	Schrader, 1999; Mont, 2002b; Rexfelt & af Ornäs, 2009; Lamberton & Rose, 2012; Catulli, 2012; Vezzoli et al., 2015; Armstrong et al., 2015; Hazée et al., 2017; Poppelaars et al., 2018
Reluctance to commit	Reluctance to enter into contractual commitment or regular payments.	Rexfelt and Ornäs, 2009; Catulli et al., 2013; Lidenhammar, 2015; Poppelaars et al. 2018
Financial aspects	Perception of high price or lack of financial advantage.	Durgee & O'Connor, 1995; Schrader, 1999; Mont, 2002b; Rexfelt & af Ornäs, 2009; Catulli, 2012; Baumeister & Wangenheim 2014, Vezzoli et al., 2015; Armstrong et al., 2015; Edbring et al., 2016; Poppelaars et al. 2018

First, some barriers relate to the touchpoints with AB-PSS providers; touchpoints "form the link between the service provider and the customer, and in this way, touchpoints are central to the customer experience" (Clatworthy, 2011, p. 16). One touchpoint-related barrier is contamination as consumers usually access products previously used by others through AB-PSS (e.g., Baxter and Childs, 2017; Hazée et al., 2019). Second, other barriers relate to the use phase of products in AB-PSS. For example, some

consumers doubt the quality of the products and anticipate a decreased use experience in AB-PSS compared to ownership (e.g., Camacho-Otero et al., 2017; Durgee and O'Connor, 1995). Third, some barriers link to the concept of AB-PSS such as the lack of ownership. Fourth and final, some barriers relate to the touchpoints and the use. Some consumers lack trust others, they fear that AB-PSS providers or other AB-PSS users might inhibit them from accessing products or from having a positive use experience (e.g., Bardhi and Eckhardt, 2012; Rexfelt and af Ornäs, 2009). While a large number of AB-PSS adoption barriers has been identified in literature, it is less clear what factors determine the importance of these barriers in specific AB-PSS.

4.2.2 Importance of the duration of use of accessed products

AB-PSS comprise services that provide consumers with different durations of product use. Indeed, Bardhi and Eckhardt (2012) already proposed temporality as one dimension of AB-PSS; temporality refers to the duration of use of one product and the use frequency of the service. Products accessed through sharing or renting services are usually used for a short time, ranging from less than one hour for shared bicycles to several weeks for a rental car during vacation, for instance. Leasing services generally provide products for a longer time. For example, car leasing contracts typically last two years or longer.

Adapting Bardhi and Eckhardt's (2012) terminology, we use duration of use to refer to the time during which one consumer obtains exclusive access to a product through an AB-PSS. The duration of use indicates the length of the use phase, it starts when an AB-PSS user obtains access to a product from the AB-PSS provider and ends when the consumer releases the product so that it becomes available for others to use. Belk (2014) also differentiated short-term renting, from long-term renting and leasing, arguing that they lead to different consumer-product relationships and several researchers found that attitudes were more positive towards short-term use AB-PSS than towards long-term use AB-PSS (Edbring et al., 2016; Durgee and O'Connor, 1995; Lidenhammar, 2015). Bicycle sharing is such a short-term use AB-PSS; consumers typically find a bicycle when they need it, obtain access (e.g., through a smartphone application), and use it for anything between 10 minutes and a whole day. Then they release the bicycle for other consumers to use (Fishman et al., 2013).

The main difference between short-term and long-term use AB-PSS lies in the frequency of consumer-provider touchpoints and the length of the use phases. Short-term use AB-PSS have frequent touchpoints and short use phases, whereas it is exactly the opposite for long-term use AB-PSS; these typically have few consumer-provider touchpoints and long use phases. Hence, touchpoint-related barriers are likely to be more important for consumers in short-term use AB-PSS and the use-related barriers in long-term use AB-

PSS. Consumers' commitment also differs between these AB-PSS; their commitment is generally lower in short-term use AB-PSS as the use of a product and the AB-PSS can be immediately ended any given moment. In contrast, the consumers' commitment is higher in long-term use AB-PSS as these usually require bilateral contracts and regular payments. A summary of the differences between long-term use AB-PSS and short-term use AB-PSS is provided in Table 9.

Table 9: Differences between short-term use AB-PSS and long-term use AB-PSS.

Differences	**Short-term use AB-PSS**	**Long-term use AB-PSS**
Duration of product use	Short use phases: A few minutes up to a few weeks	Long use phases: Several months or even years
Touchpoints with provider	Frequent touchpoints with AB-PSS provider	Infrequent touchpoints with AB-PSS provider
Number of users	Many users use the products sequentially	A few users use the products sequentially
Sustainability potential	Increased utilisation and decreased idle times (Tukker, 2004)	Extended product lifetimes because of product redesign, professional maintenance and repair (Tukker, 2004)

Short-term AB-PSS are characterised by a limited duration of use of one product and frequent touchpoints with the providing organisation. These touchpoints can be physical or digital service encounters. Hence, touchpoint-related barriers are very important to consumers in short-term use AB-PSS. We hypothesise that duration of use moderates the effect of touchpoint-related adoption barriers on consumer AB-PSS preference (the selection of the barriers is described in section 3.1.1). More specifically:

> **H1a:** Effort to access has a larger effect on consumer preference for short-term use AB-PSS than for long-term use AB-PSS.
>
> **H1b:** Contamination has a larger effect on consumer preference for short-term use AB-PSS than for long-term use AB-PSS.

Long-term use is characterised by an extended period of use during which the consumer interacts with the same product (Tukker, 2004). Touchpoints with the AB-PSS provider are thus infrequent and limited to the initial information seeking, contract signing and product pick-up, potential maintenance and repair during the use. Eventually, after several months or even years, consumers terminate the contract and return the bicycle that is then passed on to another user. We hypothesise that duration of use moderates the effect of use-related adoption barriers on consumer AB-PSS preference. More specifically:

H2a: Product quality has a larger effect on consumer preference for long-term use AB-PSS than for short-term use AB-PSS.

H2b: Product characteristic has a larger effect on consumer preference for long-term use AB-PSS than for short-term use AB-PSS.

4.2.3 Different consumer perceptions of bicycle AB-PSS and clothing AB-PSS

Some studies have shown that AB-PSS adoption barriers depend on the products placed in AB-PSS. Bardhi and Eckhardt (2012) proposed that AB-PSS can be differentiated by whether physical or digital products are accessed, and whether the products are functional or experiential. It is thus more likely that consumers access functional products than products with emotional value (Schrader, 1999). This is elaborated on by Baumeister and Wangenheim (2014), who argue that AB-PSS should be described by their typical purchase price, durability, visibility of consumption, and main consumption goal. They also advise researchers to study at least two AB-PSS involving different products to generate generalisable findings.

In this research, we study clothing and bicycles. Bicycles are typically more expensive and durable than clothing items. The visibility of clothing use is higher than that of bicycle use as they are typically worn for several hours. Consumption goals of clothing typically include intangible benefits such as expression of one's identity, and status (Armstrong et al., 2016) beyond the functional value of providing coverage, protection, and warmth. On the other hand, the main consumption goal of consumers using city bicycles in the Netherlands is functional; getting from one location to another. Research has suggested that AB-PSS involving products that provide intangible benefits are likely to face consumer resistance (Armstrong et al., 2016; Catulli et al., 2017b; Cherry and Pidgeon, 2018; Schrader, 1999).

Contamination has been mentioned as an adoption barrier for shared mobility (Bardhi and Eckhardt, 2012; Hazée et al., 2017) and clothing AB-PSS (Armstrong et al., 2015). However, contamination is likely to be more prominent for clothing than for bicycles because clothes are close to the body (Hazée et al., 2019) and contaminations cues are more visible for clothing (Argo et al., 2006). The material properties of products also influence consumers' perception of contamination (Edbring et al., 2016); products made from soft materials such as clothing are more susceptible to lead to perceived contamination than products made from hard materials such as bicycles. Previous research has found that some consumers find clothing too personal to rent (Antikainen et al., 2015) and that consumers would never rent undergarments (Armstrong et al., 2016).

The effort to access the products is likely to be a more important adoption barrier for bicycles than for clothing. Consumers have a low threshold regarding the distance they are willing to walk to reach shared bicycles (Fishman et al., 2014). A higher effort to reach and access shared bicycles directly decreases the functional value of the shared bicycles. While a long distance to reach rental clothing impacts the convenience of the AB-PSS (Pedersen and Netter, 2015) it is not crucial for reaching the main consumption goals. Yet, the importance of the effort to access has not been quantitatively compared across AB-PSS involving different products.

The extant literature provides insights for hypotheses development for the relationship between product type and two touchpoint-related adoption barriers: contamination and effort to access. However, for product quality and product characteristics (use related barriers) and trust (touchpoint and use-related barrier), extant literature did not provide insights for a priori expectations. Nevertheless, there is also no reason for product type moderation effects to be absent for AB-PSS preferences resulting from use-related adoption barriers. Thus, we figured that formally testing the product type moderation for specific touchpoint-related barriers, while exploring the product type moderation for the other barriers would sufficiently demonstrate the effect of the type of product. We hypothesise that type of product moderates the effect of touchpoint-related adoption barriers on consumer AB-PSS preference. More specifically:

> **H3a:** Effort to access has a larger effect on consumer preference for bicycle AB-PSS than for clothing AB-PSS.
>
> **H3b:** Contamination has a larger effect on consumer preference for clothing AB-PSS than for bicycle AB-PSS.

4.2.4 Research gap and conceptual model

Despite two decades of research, it is still unclear which adoption barriers are important and in what circumstances AB-PSS adoption barriers are important to consumers. This might impede the widespread uptake of such models which have the potential to contribute to a future circular economy (Tukker, 2015). There is an urgent need to understand this to improve consumer adoption of AB-PSS. Besides, the context of AB-PSS has changed over the last decade due to digitalisation, but this seemingly has not been considered in AB-PSS research so far. Prior studies of AB-PSS largely investigated single product categories and did not compare short-term use and long-term use AB-PSS. Furthermore, current literature mainly provides qualitative insights, that require further quantitative testing. Recently, Poppelaars et al. (2018) researched car sharing (short-term use) and smartphone leasing (long-term use). They investigated both AB-PSS qualitatively but did not mention the duration of use as a key difference. This study is set in the era of digitalisation and provides and tests a model that elucidates the

differences in the importance of AB-PSS adoption barriers among AB-PSS by identifying the duration of use and the type of product as moderating variables.

The present study compares the importance of five adoption barriers across hypothetical short-term use AB-PSS and long-term use AB-PSS for bicycles and clothing. Testing multiple AB-PSS for different product types quantitatively answers the call for more generalisability of AB-PSS research (Baumeister and Wangenheim, 2014). While previous qualitative research largely focused on identifying AB-PSS adoption barriers, the quantitative design of our study enables us to determine the importance of specific barriers for consumer AB-PSS preference that can aid the better design of such services in the future. Based on the literature discussed in the previous sections, we developed a conceptual model that visualises how we expect duration of use and type of product to moderate the effect of touchpoint-related and use-related barriers on consumers' AB-PSS preference (Figure 7).

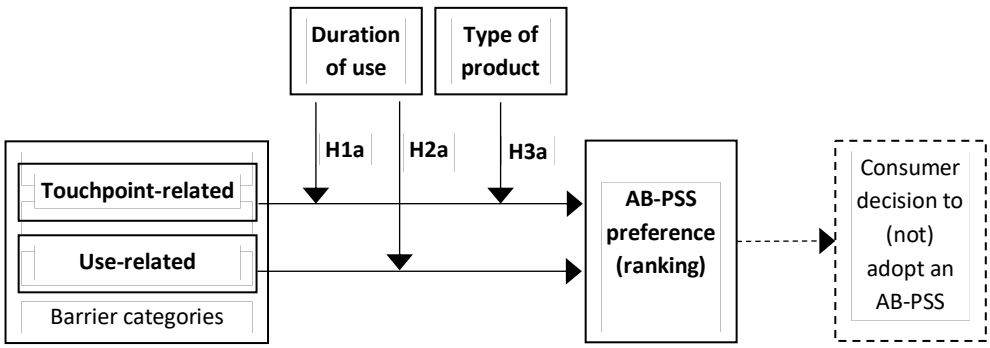

Figure 7: Conceptual model of duration of use and type of product moderating the effects of the touchpoint/use-related AB-PSS adoption barriers on consumers' AB-PSS preference.

4.3 Method

We conducted four conjoint experiments of hypothetical short-term and long-term use AB-PSS for bicycles and clothing to test the hypotheses. Conjoint experiments were chosen as these simulate the decision between different options that consumers face in the real world. Rao (2014, p. 40) explained that "conjoint methods are intended to "uncover" the underlying preference function of a product in terms of its attributes."

Conjoint experiments have been applied to products and services in different sectors; for example, to optimise health care, and financial services (see Dauda and Lee, 2015; Jan et al., 2000). We conducted four conjoint experiments in parallel and explored the data using conjoint analyses and tested the hypotheses using linear regression. Similarly, Okechuku (1994) compared the results of four separate conjoint analyses with

a between-subjects design to determine differences in attribute importance between consumers from different countries.

Although the studied AB-PSS are hypothetical, comparable offers are available in the Netherlands. Table 10 provides an overview of the methodological steps of this study, upon which the following sections elaborate.

Table 10: Overview of the methodological steps of this research, their purpose, process and outcome.

Step	Purpose	Process	Outcome
1. Design of stimuli	Design of stimuli to test four AB-PSS, this step is crucial to ensure that the results are comparable.	Barrier selection, translation into attributes, and then determining appropriate attribute levels through online surveys (n=74).	Four scenarios with five comparable attributes and two attribute levels.
2. Conjoint experiments	Obtain consumer preferences and thereby the importance values of the levels of the five attributes for each of the four AB-PSS.	Participants (n=47) ranked profiles of two AB-PSS (e.g., bike share and clothing lease) from most to least preferred.	Participants' preference rankings of the AB-PSS profiles and basic demographic information.
3. Conjoint analyses	Reveal the relative importance of adoption barriers to consumers in four different AB-PSS.	Analysis of the rankings of barriers for the four AB-PSS (bike share, bike lease, clothing rental, clothing lease) in SPSS.	Participants' individual part-worth utilities and overall utilities of attributes for the four AB-PSS.
4. Regression analysis	Obtain significance of the results to test the hypotheses.	Regressing rank orders on the dummies for barriers, duration of use, the type of product, and their interactions.	Significant effect of the duration of use, the type of product, their interaction on the importance of AB-PSS adoption barriers.

4.3.1 Design of stimuli

We chose to study bicycle and clothing AB-PSS, as both involve consumer products that are often idling and would thus benefit from AB-PSS. Following Kjaer et al.'s (2019) argumentation, placing these products in AB-PSS could improve sustainability because fewer products would be needed. Further, the mobility and textile industries both cause high environmental impacts (Ivanova et al., 2016; WRAP, 2012). In addition, we sought for the hypothetical AB-PSS to resemble existing ones without naming any making them more believable and imaginable for respondents (Rao, 2014). For example, OV-fiets (www.ns.nl/en/door-to-door/ov-fiets) offers shared bicycles at Dutch train stations and Swapfiets (http://www.swapfiets.nl) provides bicycles for lease. Similar AB-PSS are

available for clothing; LENA the fashion library allows consumers to rent clothes for a day or several days (www.lena-library.com) and MUD jeans (www.mudjeans.eu) offers leasing jeans. Consumers pay a monthly fee for 12 months for the jeans, during this time MUD jeans takes care of repairs, thereafter consumers can choose to keep using the jeans or to swap them in for a new pair. MUD jeans then reuses or recycles the returned jeans depending on the state of the jeans. We focused on outerwear for the clothing AB-PSS, as products close to the skin proliferate consumers' hygiene concerns (Armstrong et al., 2016).

Selection of barriers

We selected a subset of the AB-PSS consumer adoption barriers found in the literature (Tunn et al., 2020) for the main experiments. We decided to focus on the first three AB-PSS adoption barrier categories, as concept-related barriers are either inherent to the AB-PSS, require extensive information of consumers or mindset changes. Three rationales influenced the selection of AB-PSS adoption barriers for this study. First, we aimed to test those barriers that seemed likely to differ among the bicycle and clothing AB-PSS according to literature (see section 2.3). Second, due to developing a conjoint set-up, only a limited number of barriers could be tested; conjoint experiments typically include only a few attributes as the task otherwise gets too complex and lengthy for participants (Rao, 2014). Third, we designed the experiments to test our hypotheses which required comparability across the four AB-PSS. The selection criteria to ensure comparability across the four AB-PSS are presented in Table 11.

Table 11: Ensuring comparability across the four AB-PSS through the conjoint experiments.

Barrier	Relevant barrier for all 4 AB-PSS	Valid attributes for all 4 AB-PSS	Multiple attribute levels
Touchpoint-related barriers			
Effort to access product	Yes	Yes	Yes
Contamination	Yes	Yes	Yes
Concerns about product availability	Yes	Yes	No
Lack of flexibility	Yes	Yes	No
Touchpoint- and use-related barriers			
Lack of trust in others	Yes	Yes	Yes
Change required	Yes	No	-
Use-related barriers			
Quality of product	Yes	Yes	Yes
Specific product characteristics	Yes	Yes	Yes
Effort to use product	Yes	No	-
Lack of intangible value	Yes	Yes	No

By following the aforementioned rationales five AB-PSS adoption barriers were selected. Based on their relevance in literature, the two touchpoint-related barriers Effort to access and Contamination were selected. The Product quality and Product characteristics are the two use-related barriers that were selected because they are relevant to all four AB-PSS and can be translated into attributes with several attribute levels. We included the touchpoint and use-related barrier Trust as a control barrier to test whether it is indeed equally important in short-term and long-term use AB-PSS.

Translation of adoption barriers to AB-PSS attributes

The selected barriers needed to be translated into relevant product or service attributes for all four AB-PSS. The selection of attributes and attribute levels is a crucial step in the design of conjoint experiments (Rao, 2014). We selected attributes that can be varied in severity, have high face validity, and are as similar across the four AB-PSS as possible. For example, attributes for the barrier Contamination were cleaning frequency or cleaning intensity for the bicycle AB-PSS and wear and tear for the clothing AB-PSS.

The barrier Effort to access is represented by the attribute time to reach that refers to the time it takes consumers to obtain the product through an AB-PSS. This follows Fishman et al. (2014) who determined the distance of bicycle-sharing docking stations to potential users' homes and offices as an important adoption barrier. As mentioned above, the attributes for Contamination are cleaning frequency or cleaning intensity for the bicycle AB-PSS, and wear and tear for the clothing AB-PSS.

Lack of trust in others was translated to the source of reviews as Edbring et al. (2016, p. 12) suggested that "creating a clear structure and introducing mechanisms for peer review and feedback can greatly increase trust between people and thereby enable greater sharing of resources." While user reviews are a source of trust building the level of trust in reviews depends on the review platform (Filieri, 2016).

Product quality is represented by the attribute product brand (Rao and Monroe, 1989). The attributes for the barrier Product characteristics are inevitably somewhat dissimilar for clothing and bicycles. For clothing, we chose the attribute comfort because according to Rusinko and Faust (2016) it is an important determinant of consumer perception of fibres and is thus likely to influence garment preference. For bicycles, we chose the number of available gears, because it is an attribute of bicycles that influences cycling comfort. The selected attributes are a combination of categorical and continuous attributes. Although the price is an important factor in consumers' decision making, we intentionally disregarded the price as an attribute as we aimed to determine the importance of the previously mentioned adoption barriers in different AB-PSS in this study rather than economically optimise specific AB-PSS configurations.

Definition of attribute levels

We defined two levels for each of the five attributes of the four AB-PSS. Choosing comparable attribute levels for the variables across the four AB-PSS is detrimental for the results to be comparable (Orme, 2010). The selection of an extreme value for one level of a variable could inflate the importance of that variable in the results (Orme, 2010). We conducted online surveys to determine the attribute levels for the AB-PSS profiles in the main experiment. Seventy-four participants residing in the Netherlands completed these online surveys (age 22 years – 64 years, mean age = 36 years, 54% female). The four surveys included the scenarios that were also used in the main-experiment. Each participant read one of the four AB-PSS scenarios and then evaluated several levels of each attribute in the context of that scenario (3 to 6 levels depending on the attribute). They could indicate how they perceive the different attribute levels on a 4-point scale with 1 (preferred), 2 (still acceptable), 3 (undesirable), and 4 (unacceptable).

Table 12: Barriers from literature and corresponding attributes and levels for the four AB-PSS scenarios (attribute levels are presented: Preferred / Still acceptable).

	Bicycle		**Clothing**	
	Short-term	Long-term	Short-term	Long-term
Barrier	**Effort to access product** (touchpoint-related)			
Attribute	Time to reach	Time to reach	Time to reach	Time to reach
Levels A/B	4 mins / 9 mins	9 mins / 19 mins	4 mins / 9 mins	12 mins / 22 mins
Barrier	**Contamination by others** (touchpoint-related)			
Attribute	Cleaning frequency	Cleaning intensity	Wear and tear	Wear and tear
Levels A/B	Every 4 weeks / Every 8 weeks	Deep cleaning / Basic cleaning	Like new/Minimal wear and tear	Like new/Minimal wear and tear
Barrier	**Lack of trust in provider and service** (touchpoint and use-related)			
Attribute	Source of review	Source of review	Source of review	Source of review
Levels A/B	Independent / Company website	Independent / Company website	Independent / Company website	Independent / Company website
Barrier	**Quality of product** (use-related)			
Attribute	Brand	Brand	Brand	Brand
Levels A/B	High end / Simple mid-range brand	High end / Simple mid-range brand	High end / Simple mid-range brand	High end / Simple mid-range brand
Barrier	**Specific product characteristics** (use-related)			
Attribute	Number of gears	Number of gears	Comfort	Comfort
Levels A/B	7 gears / 1 gear	3 gears / 1 gear	Highly comfortable / Comfortable	Highly comfortable / Comfortable

Averages of consumers' evaluations of the attribute levels were used to select two attribute levels for the AB-PSS profiles. The two attribute levels, level A and level B

should differ in preference without being in themselves a reason for rejection of the AB-PSS. The criteria applied were that the average for level A should be 1-1.5 and the average for level B 2-2.5. Further, the score difference between level A and level B should be as close to 1 as possible to avoid larger/ smaller impacts of one attribute merely being caused by a larger/ smaller difference between the attribute levels. The continuous attributes followed a linear model within the relevant range of values. For some of the continuous attributes, the difference between the levels A and B were too large, by fitting linear regression functions to the results of the survey we calculated the values for an evaluation of 1.25 for level A and 2.25 for level B and rounded them appropriately. The categorical attribute levels were selected based on the averages and their phrasing was slightly adjusted if the differences between levels A and B were significantly smaller or larger than 1. An overview of all attributes and attribute levels is provided in Table 12.

AB-PSS profiles

Levels A and B of the different attributes were combined to create short AB-PSS descriptions. The possible number of combinations would have been too large to present them to participants. We thus applied an orthogonal design with a fractional factorial analysis. This method combined and equally distributes the different attribute levels, reducing the number of combinations (see Appendix B). We obtained eight different combinations of the attribute levels, referred to as AB-PSS profiles. These eight profiles represent eight different configurations of the AB-PSS. We followed this process for all four AB-PSS with the same seed value (2345) resulting in four times eight AB-PSS profiles, with one profile having only level A attributes. Below (Figure 8) we provide an exemplary AB-PSS profile as used in the experiments.

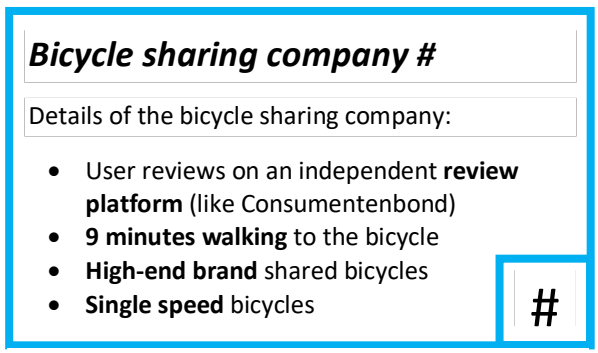

Figure 8: Exemplary AB-PSS profile as used in the experiment.

4.3.2 Participants

The participants of the main experiment were sampled from a consumer household panel of Delft University of Technology (n=47, 26 years – 75 years, mean age = 44 years, 62% female). This sample was culturally homogenous which prevents concerns regarding varying attitudes towards AB-PSS because of cultural differences (Iran et al., 2019). The large majority of participants used smartphones (98%) and 74% of participants had utilised an AB-PSS in the six months before the experiment. We excluded one participant from further analyses because of misinterpretation of the rank order task; only this participant ranked the AB-PSS description with only level A attributes (i.e., attributes all pretested as preferred) as the least preferable clothing AB-PSS and the second-least preferable bicycle AB-PSS.

4.3.3 Procedure

In an individual task, each participant first read a bicycle AB-PSS scenario and then ranked eight bicycle AB-PSS profiles from most preferred to least preferred. This procedure was repeated for the clothing AB-PSS. The scenarios use storytelling techniques, describing a relatable character in a context that clearly depicts the rationale for, and benefits of the AB-PSS (Van den Hende et al., 2012). Stories enabled participants to imagine themselves in the situation of the main character and make decisions in the described situation (Van den Hende and Schoormans, 2012). This storytelling method allowed us to let participants experience the AB-PSS vividly through narrative transportation (Green and Brock, 2000). Thereby, participants could evaluate AB-PSS that were new to them (Van den Hende and Schoormans, 2012). See Appendix A for the four AB-PSS scenarios.

Each participant evaluated an AB-PSS with a short duration of use and an AB-PSS with a long duration of use to minimise cross-over effects. Thus, each participant evaluated two AB-PSS. The preference rank orders were documented with photographs. Thereafter, participants reported demographic information and their AB-PSS experience in a questionnaire. Participants received a small financial compensation for their effort.

4.4 Results

We conducted four separate conjoint analyses to explore the importance of the adoption barriers within the four AB-PSS. We then used linear regression to compare the effects of the adoption barriers across the four AB-PSS to test our hypotheses.

4.4.1 Conjoint analyses for exploration

The conjoined experiments simulated consumer choice in the market, the data were analysed using conjoint analysis to obtain the utilities of the attributes. The four separate conjoint analyses resulted in respondents' part-worth utilities for each attribute level and overall importance values that describe the extent to which the attributes and thus the underlying barriers influence preference for the AB-PSS. Respondents' part-worth utilities are hereafter referred to as utilities. A high utility value for an attribute level indicates high consumer preference for that attribute level. Each attribute in the study was equipped with a "preferred" and a "still acceptable" level (e.g., for time to reach: 4 minutes and 9 minutes). See Figure 9 for the average importance values for all barriers per AB-PSS.

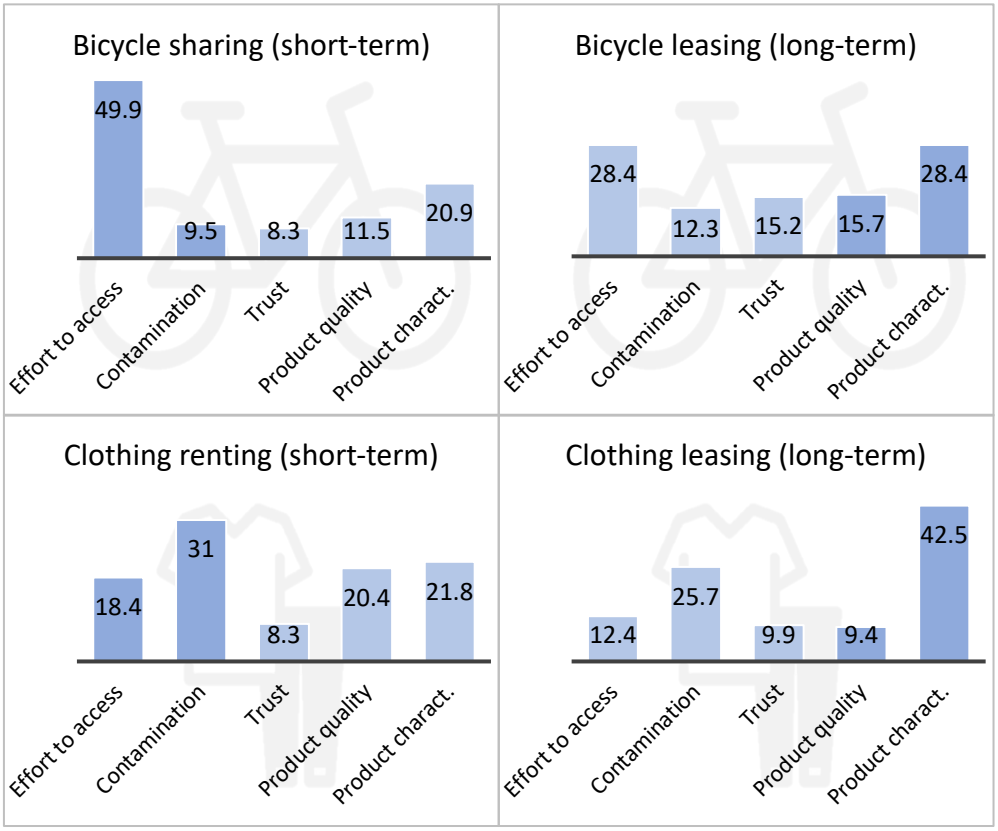

Figure 9: Relative importance (in percent) of the barriers for the four AB-PSS. In the short-term AB-PSS the touchpoint-related barriers are highlighted, in the long-term AB-PSS the use-related barriers are highlighted.

The preference for short-term bicycle AB-PSS (Bicycle sharing) was primarily determined by Effort to access (49.9%). Product characteristics (number of gears) influenced 20.9% of preference and the remaining barriers had less influence (see Figure 9). In the case of long-term bicycle AB-PSS (bicycle leasing), consumer preference was primarily determined by the Effort to access and Product characteristics (number of gears), both obtained importance values of 28.4%. The remaining barriers were less important in determining preference (12.3-15.7%).

For short-term clothing AB-PSS (Clothing renting), consumers found Contamination (wear and tear, 31%) most important. The barriers Effort to access, Product quality, and Product characteristics also had some influence on preference (18.4-21.8%). Consumer preference for long-term clothing AB-PSS (Clothing leasing) was to 42.5% determined by Product characteristics (comfort level). The second-most important determinant of preference for long-term clothing AB-PSS was Contamination (25.7%), the other barriers had only a minor influence (see Figure 9).

Overall, the relative importance of Effort to access seems higher in bicycle AB-PSS and Contamination in clothing AB-PSS. There are also appear to be differences between the short-term and the long-term use AB-PSS; for both short-term use AB-PSS one of the touchpoint-related barriers (Effort to access and Contamination respectively) seems most important in determining preference. Similarly, the use-related barrier Product characteristics appears to be a major determinant of preference for the long-term use AB-PSS. However, in the case of the long-term bicycle AB-PSS the touchpoint-related barrier Effort to access was equally important.

4.4.2 Hypotheses testing

We used linear regression to test the hypotheses. First, we converted the five AB-PSS adoption barriers into dummy variables that signified the “preferred” attribute level A. Hence, we coded level B attributes as 0 (e.g., Level B of Effort to access: the longer time to reach the product) and coded level A attributes as 1 (e.g., Level A of Effort to access: the shorter time to reach the product). The duration of use dummy variable was coded 0 for short-term use (i.e., renting/sharing) and 1 for long-term use (i.e., leasing). Finally, we dummy-coded the type of product as 0 for bicycle AB-PSS and 1 for clothing AB-PSS. Consumer rankings of the eight AB-PSS served as the dependent variable, coded 1 (least preferred AB-PSS), to 8 (most preferred AB-PSS). We included consumer rankings as a measure of consumer preference.

We conducted a linear regression analysis in which the five barriers, duration of use, and product type predicted consumer rankings, as well as the interactions between the five barriers and the duration of use, and the interactions between the five barriers and

the type of product. The results of the linear regression and the outcomes of the hypotheses testing are summarised In Table 13.

Main effects. The main effects of the adoption barriers provide support for the general importance of the selected barriers. Effort to access (β = 3.36, $p < .001$), Contamination (β = .82, $p < .001$), Trust (β = .58, $p < .01$), and Product characteristics (β = 1.40, $p < .001$) are all important for the AB-PSS, while Product quality seems to be unimportant (β = .27, $p > .16$). The β coefficients indicate the influence of the attributes on rankings and thus the importance of the adoption barriers for consumers' AB-PSS preference. Overall, four out of the five barriers that we selected and manipulated were found to have a significant effect on consumer preference.

Duration of use. The moderation effect of duration of use on the effect of the touchpoint-related barriers on consumer preference is significant for Effort to access (β = -.97, $p < .001$). The negative β indicates that Effort to access has a higher influence on consumer preference for short-term AB-PSS than for long term-AB-PSS, supporting H1a. For Contamination the moderation effect has the same direction; however, it does not reach significance (β = -.24, $p > .27$), thus rejecting H1b. This is likely to be the case because Contamination has a high influence on consumer preference for short-term use and long-term use clothing AB-PSS.

The duration of use significantly moderates the effect of the use-related adoption barrier Product quality on consumer preference (β = .75, $p < .001$), supporting H2a. Product quality is thus more important for long-term AB-PSS than for short-term AB-PSS. Duration of use does not have an effect on the relationship of Product characteristics and consumer preference (β = .19, $p > .40$) thus rejecting H2b. This use-related barrier is not significantly more important for long-term AB-PSS than for short-term AB-PSS. This is surprising considering the high relative importance of Product characteristics in long-term use AB-PSS derived through the conjoint analysis.

The touchpoint-related and use-related adoption barrier Trust served as a control barrier in this study, for which we anticipated no moderation effect of the duration of use. Indeed, the duration of use did not moderate the effect of the adoption barrier Trust on consumer preference (β = .37, $p > .09$). While not significant, our analysis suggests a trend; trust seems to potentially have a higher influence on consumer preference for long-term use AB-PSS than short-term use AB-PSS. This could because long-term use AB-PSS generally imply a contractual relationship between consumer and AB-PSS provider whereas short-term AB-PSS are purely transactional and can be terminated by consumers at any moment.

Product type. We hypothesised that product type moderated the effect of touchpoint-related barriers on consumer preference. Effort to access has a larger effect on

consumer preference for bicycle AB-PSS than clothing AB-PSS (β = -1.77, p < .001), supporting H3a. Contamination, on the other hand, has a larger effect on consumer preference for clothing AB-PSS than bicycle AB-PSS (β = 1.35, p < .001), supporting H3b. Product type did not moderate the effect of the adoption barrier Trust on consumer preference (β = -.20, p > .37), in line with expectations. As discussed before, we had no a priori expectations regarding the moderation effect of the type of product on consumer preference of use-related adoption barriers, due to lack of documented effects of these barriers.

Table 13: Effects of duration of use, product type, adoption barriers, and their interactions, on consumers' AB-PSS preference.

Tested effect	**Coefficient β**	**(SE)**		**Hypothesis conclusion**
Main effects				
Duration of use (DoU)	-.05	(.27)		
Product type (PT)	-.23	(.27)		
Effort to access	3.36	(.19)	***	
Contamination	.82	(.19)	***	
Trust	.58	(.19)	**	
Product quality	.27	(.19)		
Product characteristics	1.40	(.19)	***	
Duration of use moderation				
DoU*Effort to access	-.97	(.22)	***	H1a supported
DoU*Contamination	-.24	(.22)		H1b rejected
DoU*Trust	.37	(.22)		
DoU*Product quality	.75	(.22)	**	H2a supported
DoU*Product characteristics	.19	(.22)		H2b rejected
Product type moderation				
PT*Effort to access	-1.77	(.22)	***	H3a supported
PT*Contamination	1.35	(.22)	***	H3b supported
PT*Trust	-.20	(.22)		
PT*Product quality	1.66	(.22)	***	
PT*Product characteristics	-.58	(.22)	**	
Constant	1.29	(.23)	***	

Dummy coding duration of use (DoU): 0 = short-term use, 1 = long-term use
Dummy coding product type (PT): 0 = bicycle, 1 = clothing
Significant results: *p < .05; **p < .01; ***p < .001

Our results indicate that the use-related adoption barrier Product quality has a significantly larger effect on consumer preference for clothing AB-PSS than for bicycle AB-PSS (β = 1.66, p < .001). Apparently, consumers deem high-end brands more

favourable for clothing than for bicycle AB-PSS. This could be because consumers have different associations with the selected attribute 'brand' for bicycles and clothing, potentially because industries and organisations position brands differently (Bhat and Reddy, 1998). As outlined in the background section, clothing is used to express ones' identity and status which high-end branded clothes can enhance. For bicycles, a high-end brand is likely associated with robust, long-lasting bicycles. This might be less important to consumers as AB-PSS providers are generally responsible for repairing and replacing faulty products. It is thus possible that participants' interpretation of AB-PSS attributes differs between products which in turn again emphasises how product-dependent the perception of AB-PSS configurations is.

We also found that product characteristics have a larger effect on consumer preference for bicycle AB-PSS (i.e., number of gears) than for clothing AB-PSS (i.e., comfort) (β = -.58, p < .01). This adoption barrier is inherently product-specific and we chose attributes that for the products that relate to the both use comfort. Yet, participants might have perceived the difference between the attribute levels to be larger or clearer for the bicycle AB-PSS than for the clothing AB-PSS despite the pre-test thus leading to Product characteristics having a larger influence on rankings of the bicycle AB-PSS than of the clothing AB-PSS.

4.5 Discussion

Despite significant knowledge generated on AB-PSS, their environmental potential, and the recent linkage of AB-PSS to the circular economy concept (Tukker, 2015), the implementation of such business models in practice is still limited (Ritala et al., 2018). While many studies examined consumer adoption of AB-PSS, it is still unclear which adoption barriers are important and in what circumstances AB-PSS adoption barriers matter to consumers. Gaining more insight into these could facilitate better design and wider adoption of AB-PSS in the future. To address this, we investigated how the duration of use and the type of product impact the importance of AB-PSS adoption barriers in consumers' decision-making processes. As extant literature consisted of mostly qualitative studies, we designed a quantitative study to test these effects. We found that the duration of use and the type of product moderate the importance of AB-PSS adoption barriers to consumers.

The duration of use has implications for the relationship of consumers with the accessed products. Consumers seem to evaluate long-term use AB-PSS similarly to ownership, valuing products with superior product characteristics during use, such as bicycles with multiple gears or highly comfortable clothing. Belk (2014, p. 11) mentioned that "feelings of attachment and expressiveness are more likely with long-term renting and leasing than is the case with short-term renting." The reason for this could be that

product attachment is influenced by memories connected to the product which build up over time (Schifferstein and Zwartkruis-Pelgrim, 2008). In this context, Belk (2014) described a process of consumers taking possession, when first accessing products in AB-PSS with longer durations of use. People usually redecorate and often even repaint rental apartments and also place personal items in leased cars. This is usually not the case for products accessed for a short time because consumers focus on the functionality (Bardhi and Eckhardt, 2012; Catulli et al., 2017b), intangible aspects matter more to consumers in long-term use AB-PSS (Tunn et al., 2019b).

The type of product placed in an AB-PSS also impacts the importance of adoption barriers. For example, the barrier Contamination is significantly more important for clothing AB-PSS than for bicycle AB-PSS. This finding concurs with previous research that showed that contamination is a barrier that is particularly pronounced in products that are very personal, close to the skin, or made from soft materials (Catulli, 2012; Armstrong et al., 2015; Edbring et al., 2016). Further, the significant difference in the importance of Effort to access between the short-term bicycle AB-PSS and the short-term clothing AB-PSS can be explained by differences between the products. Bicycles are a mode of transport and a longer time to access these directly reduces the perceived benefit this AB-PSS delivers, whereas for clothing the Effort to access is mainly about how convenient the AB-PSS is.

Evidently, the duration of use and the type of product moderate the importance of adoption barriers to consumers. These aspects resemble two of the six dimensions of AB-PSS defined by Bardhi and Eckhardt (2012), namely temporality and the type of accessed object. It has been suggested that consumers view AB-PSS just like any other service (Rexfelt and Hiort af Ornäs, 2009) and thus judge these mainly by the perceived benefits or lack thereof (Tunn et al., 2020), which are again influenced by the duration of use. The duration of use and the type of product dictate the benefits that are relevant to consumers in a given AB-PSS. The difference in duration of use is likely most relevant for AB-PSS that involve products that are visible to others, that consumers build a relationship with, or that are frequently used.

Digitalisation has emerged as a major trend over the last decades and has enabled many contemporary AB-PSS. Digital service aspects can help to reduce touchpoint-related barriers in short-term use AB-PSS but are less important in long-term use AB-PSS (Belk, 2014). For example, the growth of short-term use AB-PSS bicycle sharing has been accelerated by the incorporation of digital technologies as the provided digital services make the AB-PSS more convenient and attractive (Shaheen et al., 2010). Consumer digitalisation and other emerging technologies can likely help to better embed AB-PSS in consumers' routines and lifestyles. In addition, smartphones might help to deliver

even more convenient AB-PSS in the future that are resource-efficient by optimising product use and incentivising desired consumer behaviour.

Reducing adoption barriers can come at the cost of the sustainability of an AB-PSS. For example, to lessen the product availability concerns of consumers, a short-term bicycle AB-PSS provider might place a large number of bicycles in a city. This can result in an oversupply of bicycles which end up idling and thus neither reduce relative nor absolute resource consumption (Kjaer et al., 2018). Besides, the temporality of AB-PSS influences their sustainability potential in the context of the circular economy. Products accessed through long-term use AB-PSS are likely to idle as much as owned products and are designed to be convenient thus unlikely to discourage overconsumption in the way that short-term use AB-PSS could (Meijkamp, 1998). This supports Tukker's (2004) proposition that leasing has a sustainability potential inferior to that of sharing and renting. Consequently, it is crucial to purposefully design AB-PSS for sustainability and to continuously estimate and assess the impacts in order to prevent unintended negative side effects.

4.6 Conclusions

We compared four AB-PSS to determine whether duration of use and type of product are indicators of the importance of AB-PSS adoption barriers to consumers. We found that in short-term use AB-PSS the barriers that relate to touchpoints have a major influence on consumer preference, whereas barriers that relate to the use-phase influence consumer preference for long-term use AB-PSS. The importance of adoption barriers to consumers is also influenced by the type of product. Contamination is more important for clothing AB-PSS and Effort to access is more important for bicycle AB-PSS. The effect of the duration of use is also moderated by the type of product for some adoption barriers. Our findings can help AB-PSS designers pinpoint the most important barriers for developing different types of consumer AB-PSS.

Based on the results of this study, we argue that the duration of use and the type of accessed product present important distinctions between AB-PSS offerings from a consumer adoption perspective. Apart from a handful of studies (Schrader, 1999; Lamberton and Rose, 2012; Antikainen et al., 2015; Möhlmann, 2015; Edbring et al., 2016; Akbar and Hoffmann, 2018), most studies of AB-PSS adoption have been either qualitative or conceptual. We contribute to this field with a quantitative assessment of the relative importance of several AB-PSS adoption barriers and how they differ between AB-PSS. In addition, to the best of our knowledge, this is the first study of AB-PSS adoption that takes consumers' digitalisation into account, by including digital service components, such as locating products with GPS data and online user reviews.

This makes our findings highly relevant to providers and developers of contemporary AB-PSS.

Finally, we would like to address potential limitations of this research that provide interesting avenues for future research. The participants ranked AB-PSS profiles according to their preference. Rank orders were thus based on the measure of the attitude towards the choices rather than behavioural intention. Whether the duration of use and the type of product influence AB-PSS adoption behaviour in the same way they predict the attitude towards AB-PSS could be tested in future research. In addition, it is crucial when comparing multiple conjoint analyses to control the preference for the different attribute levels beforehand to ensure that the results are comparable. Although the pre-test aimed to minimise these differences, our product type manipulation resulted in slight variations in preference for the attribute levels. Attribute levels were selected to be as similar as possible across the attributes and AB-PSS, yet differences between the AB-PSS might still have been influenced by the experimental set-up. Though, likely, these small differences in attribute level preferences did not influence the main conclusions of this research, future research is needed to test the effects of the duration of use in other AB-PSS.

Another limitation is the operationalisation of the barriers; for example, we used 'brand' as an attribute for Product quality; however, 'brand' might spark different associations in participants for different products, we recommend to pre-test the operationalisation of barriers more extensively in these types of studies. The results are based on a relatively small sample and for all tested adoption barriers, apart from Effort to access, the utilities varied greatly among participants. A larger sample could lead to clearer results. Although we only analysed two products in AB-PSS, it is likely that the duration of use and the type of product are generally highly relevant aspects of AB-PSS for consumers.

Finally, we specifically did not include the price in our analysis to be able to focus on testing and comparing the importance of the selected AB-PSS adoption barriers. Future research may look at different price points and trade-offs with factors such as effort to access or level of contamination. For example, are customers willing to go through more efforts if the price of a service is dropped? This type of research can be of value to business model developers seeking to expand their markets, or local policymakers in cities, seeking to increase the adoption of new bike-sharing schemes.

To conclude, when designing AB-PSS for wide consumer adoption, it is essential to compare the benefits of wider adoption with the impacts of changed AB-PSS offerings and wider effects on consumer behaviour to ensure they contribute to a sustainable circular economy.

Chapter 5
Enhancing consumer adoption of AB-PSS

This chapter is based on: Tunn, V.S.C., Fokker, R., Luijkx, K.A., de Jong, S.A.M., Schoormans, J.P.L., 2019. Making ours mine: Increasing consumer acceptance of access-based PSS through temporary customisation. Sustainability, 11, 274.

5.1 Introduction

In recent years, the circular economy concept has gained popularity as a path towards more sustainability through perpetual cycling of products, components, and materials, thereby reducing the need for new products and virgin materials (EMF, 2015). The circular economy concept requires business models that can help achieve these sustainability improvements. Product-service systems (PSS) have been suggested as business models that might support achieving sustainability and circularity (Manzini and Vezzoli, 2003; Tukker, 2015). A recent interview study with circular economy experts from academia, industry, and policy confirmed this. Among other business models, the experts suggested different PSS to achieve a circular economy and sustainable consumption (Tunn et al., 2019a). In PSS, products and services are combined to satisfy needs because a customer "does not really demand the products or services, per se, but what these products and services enable a user to achieve" (Manzini and Vezzoli, 2003, p. 851). PSS might prolong product lifetimes by eliminating incentives for planned obsolescence and through better maintenance of products (Ehrenfeld, 2003).

Access-based PSS (AB-PSS) have been suggested to be particularly promising; they can be implemented with the current products and technology and can potentially reduce the environmental impact of consumption. In AB-PSS, a providing organisation owns products and consumers pay to access them. In literature, AB-PSS are also referred to as use-oriented PSS (Tukker, 2004) and access-based consumption (Catulli et al., 2013). An example of a successful AB-PSS is car sharing. Consumers can satisfy the need for a personal vehicle, for example, for the weekly grocery shopping, through cars owned by

a company such as Greenwheels (2018). Car sharing could be more sustainable than car ownership because one car can be used by different consumers sequentially rather than each consumer owning a car that is idle most of the time.

The wide diffusion of AB-PSS is essential to realise their sustainability potential, but also to guarantee a financially viable business model. A sufficient number of consumers in the same geographical area need to be willing to access the provided products interchangeably. If only one consumer uses a shared car, impacts do not decrease compared with those of an owned car. AB-PSS need to be widely adopted and used by consumers to be more sustainable than owning products. In order to achieve intensified use of products in AB-PSS, the offering needs to be accepted by a large group of consumers. However, consumers compare PSS offers with purchasing the product, and the latter often scores higher (Armstrong et al., 2015), as these products better match individual consumers' preferences.

5.2 Background

Strategies are needed to satisfy consumer needs better and thereby achieve wider consumer acceptance of AB-PSS and realise sustainability goals. Armstrong et al. (2015, p. 38) suggested that emotional needs "could be met through PSS models offering personalized or customized design". In this paper, we focus on longer use durations, more specifically, one product being accessed for several months. Temporality is one of the dimensions that Bardhi and Eckhardt (Bardhi and Eckhardt, 2012) determined to describe AB-PSS offerings. They distinguish between the duration of the access option and the duration of the product use and argue that the use duration influences the product–consumer relationship. It can be expected that consumers will feel a stronger relationship with a product when they use it for an extended period.

5.2.1 Barriers to PSS diffusion in the consumer market

As mentioned in the introduction, consumer adoption is necessary for AB-PSS to reach their sustainability potential. However, at the moment, the acceptance of AB-PSS in the consumer market is a challenge. A number of studies have identified barriers and enablers for consumer acceptance and adoption of PSS. The identified barriers relate to the service and the product aspects of the PSS. Barriers and enablers that are related to the service are price complexity (Schmidt et al., 2016), availability of product information (Schenkl et al., 2014), the reliability of the service providers, and consumers' trust in the system (Poppelaars et al., 2018). Barriers that are also related to the service aspects of the PSS are the lower convenience because of availability (Tukker, 2015) and accessibility of products (Pedersen and Netter, 2015). Other barriers and enablers are related to the products involved in a PSS. PSS are less likely to be

adopted if the product requires consumers to alter their habits (Rexfelt and Hiort af Ornäs, 2009) or to learn new skills (Mylan, 2015). At the same time, relieving consumers of burdens of ownership such as repair and maintenance of products could make PSS more convenient than ownership (Cherry and Pidgeon, 2018; Poppelaars et al., 2018).

Several psychological aspects also influence consumer acceptance of products in PSS. Consumers have a desire to own products (Armstrong et al., 2015; Schenkl et al., 2014). Ownership goes hand in hand with perceived control over the products that one misses when using PSS (Tukker, 2015). People might not feel at ease using products through AB-PSS out of fear of accidentally damaging them (Cherry and Pidgeon, 2018). Edbring et al. (2016) found that consumers are concerned about hygiene when using PSS because other consumers have previously used these products. Baxter et al. (2017) explored the negative effects of the sequential use of products by different consumers in more detail. They emphasised the need for products that "can be used by multiple people and maintain a positive (or at least neutral) user experience" (Baxter et al., 2017, p. 513). Other barriers are the meaning that consumers extract from owning or using products and consumers' relationships with products. Santamaria et al. (Santamaria et al., 2016, p. 24) stated that PSS "will not be perceived as a desirable option for the user if it lacks the allure or symbolic value that other competing options provide". The findings of Armstrong et al. (2015), who extensively studied AB-PSS for clothing, confirm this. These authors concluded that consumers' desire to own a product goes beyond mere control, but also relates to the expression of social status and provides emotional value. In the last decades, companies have increasingly competed for the attention of consumers in the market by introducing soft, intangible product benefits next to product functionality. Until now, AB-PSS often fail to match the soft, intangible values that owned products deliver (Cherry and Pidgeon, 2018; Santamaria et al., 2016; Tukker, 2015).

5.2.2 Customised versus prototypical AB-PSS

In recent years, the concept of customisation has been introduced (Da Silveira et al., 2001). According to this concept, products and services should not be adapted to consumer segments, but rather to the preferences of individual consumers. The customisation of services is found in many markets nowadays. One example is online retail, companies like Amazon adjust their retail environment to the individual consumer using, for example, earlier buying behaviour, to provide purchase suggestions. Using this kind of service customisation is found to lead to higher consumer satisfaction when it benefits the consumer (Da Silveira et al., 2001). The studies of Sakao et al. (2017) and Fargnoli et al. (2018) both show advantages of the implementation of service customisation in AB-PSS. Service customisation might tackle some of the previously mentioned acceptance barriers. For example, consumers can nowadays

access information about the availability and location of bikes in many rental systems through a smartphone application. This reduces the barrier of product availability.

Customisation of product design has been implemented in diverse markets. For example, BMW and Adidas offer their customers the chance to personalise cars and shoes, respectively (Adidas 2018; BMW 2018). Consumers can customise their products on many product attributes and receive a car or a pair of shoes that perfectly fit their preferences. The downside of this is that customised product become so "idiosyncratic" that they only fit one specific consumer and as such do not fit the preference of a larger group of consumers. Consequently, the customisation of the product component of an AB-PSS might create an additional acceptance barrier for many potential consumers.

In order to avoid this barrier, AB-PSS need to incorporate products that most consumers would find acceptable rather than customised ones. Prototypical products might fulfil this requirement. Prototypical products are products that provide existing standard functionality (Ziamou and Ratneshwar, 2003). These products often also have a typical appearance that corresponds to the average value of the attributes of a category. A typical product appearance has the greatest familiarity for consumers (Loken and Ward, 1990). For example, the prototype of a TV would be a rectangular box with a grey or black colour (Mugge and Schoormans, 2012). For many PSS, using prototypical products is a good strategy. In particular, when consumers access a product mainly for its functionality, they prefer products with typical functionality and aligned appearance. In many AB-PSS, the functionality of the product is pivotal and, therefore, products in AB-PSS score high on typicality. For example, if a tourist wants to rent a bike for a day, the tourist seeks a bike with typical functionality. Next, the design of the bike needs to tell the tourists most of all that it is a (simple) bike, not more and not less.

The challenge is to design AB-PSS that achieve wide consumer acceptance while also satisfying individual consumers. As indicated before, the products that are used in AB-PSS are often quite typical. If the products are only used because of a functional goal or for a very limited time, this is a sensible choice. However, in many cases, consumers demand products that also relate to intangible, soft values that are thus less typical. As phrased by Ward and Loken (1988), "when the intangible benefits, for example, the status related to a product, become more important consumers like atypical products more". The evaluation of different rental scenarios showed that consumers accept typical products less if the use duration is longer (Bernards et al., 2018). In such a case, it is probable that the soft values of the product will become more relevant and as such, consumers' preference for typical products will decrease. After comparing Zipcar users and Harley Davidson users, Catulli et al. (2017b) concluded that "the proposition of a use-oriented PSS to types of consumers who look at their brand as a vehicle of self-

expression would be problematic". Soft values can be relevant in AB-PSS and not only in the case of high-status products, but also for other products.

5.2.3 Customising AB-PSS through personalisation of products

Product design is one of the prevalent ways of creating symbolic and emotional product value (Person et al., 2008). One possibility to create these intangible product values is by designing product personalities. Govers (2004) defined a product personality as the set of personality characteristics that people use to describe a specific product and to discriminate it from other products. Personalisation is "a process that defines or changes the appearance or functionality of a product to increase its personal relevance to an individual" (Mugge et al., 2009, p. 468). The product personality concept is directly derived from the (human) personality construct. One of the widely used and accepted models is the five-factor model (FFM) of personality (Goldberg, 1990). The five factors of the FFM are found to describe the human personality quite robustly and are also referred to as the Big-Five. These five factors are openness, conscientiousness, extraversion, agreeableness, and neuroticism, represented by the acronym OCEAN (Matthews et al., 2013). The FFM adopts the basic ideas that underlie trait theory (Chaplin et al., 1988). It suggests that individuals can be characterised in terms of relatively enduring patterns of thoughts, feelings, and actions and that these show a certain degree of consistency across situations (Chaplin et al., 1988).

The five OCEAN factors are rated on a scale from 1 to 5. Every extreme of the scale is a different indication of the personality score. For example, openness could be explained as conventional on one end and as imaginative on the other end. If the score ends up in the middle, this would mean in-between extremes (Asendorpf, 2010). Govers (2004) showed that in the case of products, three of the five OCEAN factors are appropriate to describe differences in product personalities, namely, conscientiousness, extraversion, and agreeableness. Design elements like form, colour, and material can be used to create a specific product personality. Product personalisation increases product preference if the product personality matches that of a consumer. Govers and Schoormans (2005) demonstrated that consumers have a higher acceptance for products that match their personality.

In AB-PSS, the importance of intangible value depends on the duration of product use. Intangible value increases product preference in an AB-PSS when consumers use a product for an extended period. A product can be personalised to increase one consumer's preference for the product, but this results in less typical products because consumers differ in personality. Consequently, a personalised product is less interesting for a larger group of consumers. Therefore, a challenge for AB-PSS design is balancing wide consumer acceptance with the satisfaction of individual consumers. A way of

overcoming this challenge is by customising a small product attribute that can be added to a product easily each time it is rented out—a temporary customisation of the product. The assumption is made that such a relatively small customised product attribute with a personality that matches the personality of the consumer, further referred to as product–person match, will increase the acceptance of the total PSS by the consumer. In this research, we answer the following research question: How does a temporary product customisation by personalising a product attribute affect the acceptance of AB-PSS in the case of longer product use periods? To be able to answer this question we defined the following two hypotheses:

H1: AB-PSS that involve products with a typical appearance are preferred over less-typical products.

H2: AB-PSS that involve products with a typical appearance that also match the personalities of the individual consumers are preferred more than products that do not match their personalities.

5.3 Method

For the study, an experiment with a 3 × 1 between-group design was used. In the following sections, the stimuli, sample, and procedure applied for this experiment are outlined.

5.3.1 Sample and stimuli

The participants were Dutch-speaking design students aged 18–27. This sample was chosen as the population of students in the town of research were the main target group of the studied AB-PSS for bikes. In this town, a number of commercial AB-PSS for bikes are available; they are all well-known and popular among students. The Dutch company Swapfiets (2018) offers simple bikes for a monthly fee, and the fee also covers maintenance and repair. Next to Swapfiets, Mobike and OV-fiets also offer bike AB-PSS. Mobike is a floating bike-sharing system (without docking stations), and OV-fiets rents out bikes at Dutch railway stations. The total sample comprises 86 students—58% female and 42% male. They received a small, non-financial incentive for participating. Furthermore, we conducted a pre-test in English (n = 10) that showed that participants had difficulties grasping the nuances of the English language. Therefore, the main study was conducted in Dutch.

Participants were presented with a questionnaire that included a stimulus. This stimulus showed one of three bikes. For the typical bike appearance, a picture of one of the most commonly used bikes in the Netherlands was used - a black roadster bike - depicted on the left in Figure 10. The bikes on the right side in Figure 10 are the personalised bikes.

Two different designs were added to the coat guard to change bikes. Two different designs were added to the coat guard to change the appearance of the bikes: the personalised bike pattern (bike in Figure 10b) and the personalised bike grapefruit (bike in Figure 10c). The changes to the coat guard had no impact on the functionality of the bike. To avoid possible brand effects, the brand name was removed from the stimuli.

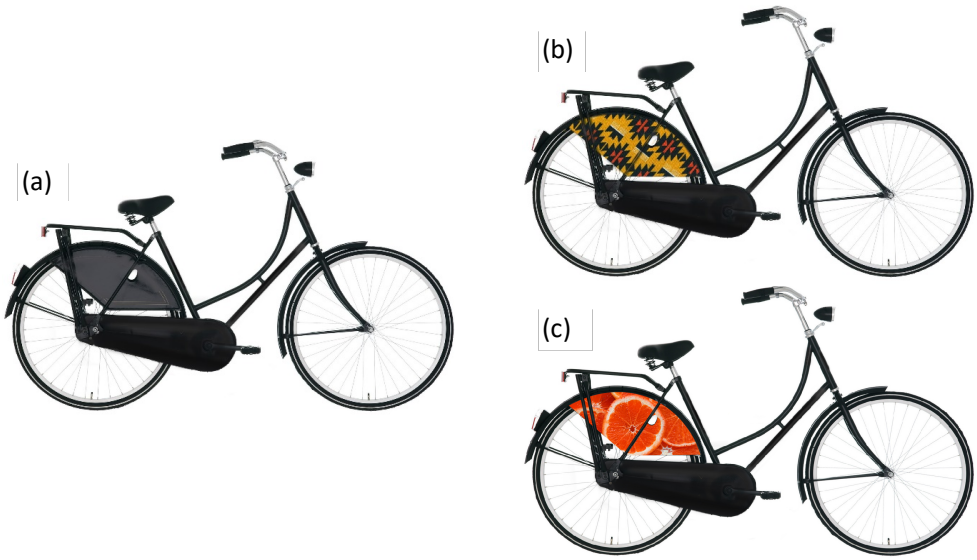

Figure 10: The three stimuli: left (a): typical bike, right (b and c): typical bikes with personalised coat guards, pattern and grapefruit.

5.3.2 Procedure

The participants completed the experiment individually. They were presented with a scenario that stated that students could rent the depicted bike for a fixed monthly payment (indicating a longer renting period of at least one month). They first assessed their personality. Subsequently, they assessed the product personality of one of the three bikes. To assess the personalities, we used a visual one-dimensional forced-choice personality test in the format of a tablet application. This application was developed by the Center for Applied Product Personality Research (Schoormans et al., 2018) and was based on the Big-Five personality traits model, OCEAN, which was developed through a factor analysis of 18,000 adjectives (Goldberg, 1990). Participants completed the experiment by filling in a questionnaire. With the questionnaire, participants rated product liking using the following four items: I would use this product, I think this product is a good product, I would subscribe to this product, I think this product is

attractive. Person/product fit was assessed with four items that were adapted from Govers and Schoormans (2005): considering the people who would use this product, I am exactly like them; considering the people who would use this product, I am similar to these people; this product matches my personality; this product is like me. All items used a five-point Likert scale.

5.4 Results

5.4.1 Manipulation check

We created three stimuli to test our hypotheses. We first checked that we succeeded in designing different product personalities in our three stimuli as intended. As indicated above, Govers (2004) demonstrated that product personalities differ between products mainly on three dimensions, namely, conscientiousness, extraversion, and agreeableness. We thus compared the perceived product personality of the typical bike with that of the two personalised bikes for these three dimensions. We used a one-way analyses of variance (ANOVA) to do so. The ANOVA calculate to what degree the means of the perceived product personalities differ between the three stimuli. The analysis shows that the three bikes differed significantly on perceived conscientiousness (F (2, 82) = 3.93, p = 0.023) and on perceived extraversion (F (2, 82) = 19.45, p = 0.000). No significant difference for the perceived agreeableness was found for the three stimuli.

Next, we used t-tests to check which of the means between the perceived personality dimensions of the three stimuli differ (see Figure 11). The t-tests show that the typical bike differs from both personalised bikes on the dimension conscientiousness (typical bike M = 3.64, SD = 0.68, N = 29) (personalised bike pattern M = 3.05, SD = 1.07, N = 30); t(47), p = 0.061; (typical bike M = 3.64, SD = 0.68, N = 29) (personalised bike grapefruit M = 3.03, SD = 1.01); t(44), p = 0.056. The same holds for the dimension extraversion (typical bike M = 1.8, SD = 0.80, N = 29) (personalised bike pattern M = 3.42, SD = 1.43, N = 30); t(47) p < 0.000; (typical bike M = 1.8, SD = 0.80, N = 29) (personalised bike grapefruit M = 3.38, SD = 1.03, N = 27); t(44), p < 0.000.

The results of the t-tests indicate that the typical bike (Typical (a) in

Figure 11), compared with the two bikes with the personalised attributes (Pattern (b) and Grapefruit (c) is considered to reflect less extraversion and more conscientiousness. Therefore, the personalised bikes differ in perceived personality on two of the three dimensions that are known to be relevant for product personalities. This indicates that our manipulation was successful, we succeeded in designing bicycles that differ in product personality. Therefore, we could use these stimuli to test our hypotheses.

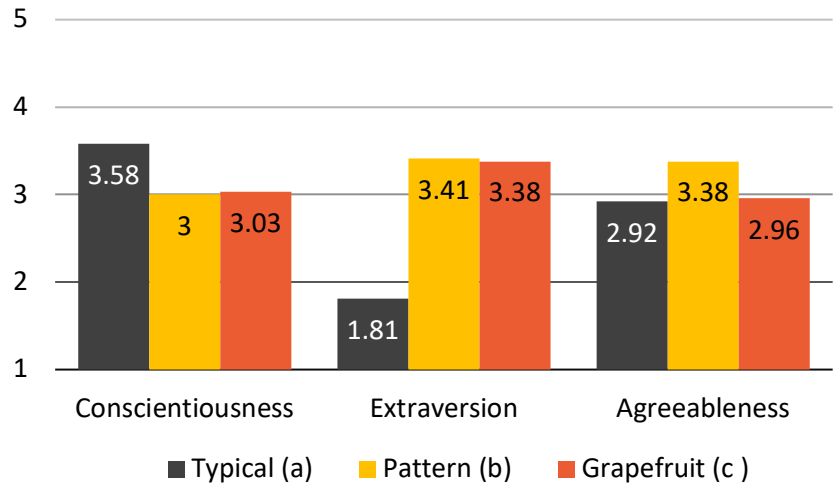

Figure 11: Means of perceived personality (scale 1-5) for the three stimuli using the personality factors relevant for product design according to Govers (2004).

5.4.2 Test of the hypotheses

We hypothesised that overall consumers prefer typical bikes. Additionally, we also hypothesised that the more a bike fits a person's personality, the more it will be preferred by that person. Before testing the two hypotheses, we created two factors, preference for the bike and product/person fit. Preference for the bike is based on the four items mentioned before. The items were added to form one scale, alpha = 0.85. We did the same for personality fit. The four items assessing this personality fit were added to form one scale, alpha = 0.77. Both scales show a good alpha, and thus it is acceptable to use the scales in the next step of the analysis.

To test both hypotheses, a standard regression analysis with product preference as the dependent variable was performed. The person/product fit is included in the regression as an independent variable. To be able to assess the effect of the three bikes, two dummy variables were formed (dummy 1 = typical bike versus the other two bikes; dummy 2 = personalised bike pattern versus the other two bikes). These two dummies were also included in the analysis as the independent variables. Using this specific regression, we can calculate if the product preference of the participants is influenced significantly by the degree of typicality of the bikes. Next, it allows us to see if the degree of fit of the personality of the bikes with the personality of the participants influences product preference, irrespective of the degree of typicality of the bike. The regression is highly significant, R2 = 0.489, F (3, 82) = 26.12, $p < 0.000$. The analyses further show in more detail that the first dummy 'typicality versus the personalised bikes' has a

significant effect: beta = 0.41, $t(82) = 4.5$, $p < 0.000$. This means that the product preference of the bikes is strongly influenced by the differences between the three bikes, as was expected. The second dummy has no significant effect. This means that the preference for a bike is stronger when the bike is more typical. All in all, this is still in line with hypothesis 1, which proposed that consumers prefer typical products over less typical products. The variable person/product fit shows a strong significant effect: beta = 0.595, $t(82) = 0.595$, $p < 0.000$. This means that participants prefer a bike that better fits their personality. This confirms our hypothesis 2.

5.5 Discussion and future research

The purpose of this study was to determine how customisation of a typical product by personalising a small product attribute influences consumer acceptance of AB-PSS, in which products are accessed for an extended period. We explored this using a typical bike and the same bike customised with a small, personalised attribute (coat guard). In this research, we determined participants' personalities, their perception of one of the products, and how this relates to the person–product personality match and product preference. We found that most participants liked the typical bike and would accept it within an AB-PSS. Further, our research shows that personalising a small attribute of a typical product changes the perceived personality of the product. Such temporary customisation can potentially increases consumer preference for the AB-PSS if the customised products fits the consumer's personality. However, it is also clear that a typical bike is acceptable for most consumers.

Wide adoption is crucial for AB-PSS to achieve their sustainability potential. On the one hand, previous research indicates that a high use intensity can lead to sustainability improvements (Tukker, 2004) and that products incorporated in PSS need to maintain at least a neutral experience (Baxter et al. 2017) — both arguments imply typical products. On the other hand, adding intangible value to PSS has been suggested (e.g., Armstrong et al., 2015; Catulli et al., 2017b; Tukker), pointing towards customisation. We brought typicality and personalisation together in the concept we refer to as temporary customisation. Temporary customisation uses typical products and a small feature is either adjusted or added, thereby making it better meet individual consumer's preferences.

Depending on the use duration of one product, the consumer–product relationship and consumers' expectations of products in AB-PSS differ (Bardhi and Eckhardt, 2012). The longer the period of access of one consumer to one particular product, the more important the satisfaction of consumers' intangible needs becomes, and hence personalisation. Very short access periods (e.g., one day), on the other hand, allow for

a high degree of typicality as consumers in this case mostly care about the functionality of the product.

The advantage of AB-PSS over other types of PSS is that they can be implemented now with current products and can potentially achieve sustainability improvements. To be clear, the transition to a circular economy requires radical innovation and change that goes beyond AB-PSS. At the same time the transition also requires rapid action and implementation of measures that can reduce environmental impacts now and not in a decade or two. Improving consumer acceptance of AB-PSS by adding intangible value through temporary customisation can improve the sustainability of consumption through the intensified use of products and a reduction of idle ones. Temporary customisation could further improve sustainability by giving consumers a sense of psychological ownership, causing them to take better care of the products (Baxter et al., 2015; Govers and Mugge, 2004). An AB-PSS itself needs to be designed carefully to ensure that it is more sustainable than the sold product it is substituting. This means that the ratio of products to consumers needs to be improved in AB-PSS compared with ownership (e.g., one bike per five consumers). Additionally, the attributes to customise products in AB-PSS need to be selected sensibly to ensure that they have a minimal sustainability impact. The coat guards discussed before in the bike case have a low sustainability impact and are easy to attach and detach when a bike is rented out or returned.

Some AB-PSS are already intuitively following this principle; the bikes of Mobike (2018) are used for a very short period by each consumer, and only one model is available, whereas the bikes of Swapfiets (2018) that are rented out for several months are available in different colours and optionally with multiple gears. However, Swapfiets users currently cannot choose their preferred colour and a bike with multiple gears is available for a higher fee. These two types of product differentiation cannot be easily customised and giving consumers free choice among the options would require increased stock levels. Applied to PSS in practice, temporary customisation could lead to wider diffusion of PSS in the consumer market, while also satisfying individual consumers needs for intangible value and enabling low levels of stock as products are interchangeable.

This study represents a first exploration of customisation through personalisation in the PSS context. We found that the majority of participants liked the typical bike because the typical design inherently closely matches the personality of many consumers. As a result of the between-group design we applied, the preference for the typical bike was the highest overall. In our experimental set-up participants were randomly allocated one of the stimuli and the stimuli thus did not necessarily match consumers' personalities. We recommend to either allocate or apply a forced-choice design with

more options for add-ons in future research for people to select the bike they prefer and that probably matches their personality. Thereby, the influence of a larger number of add-ons with different personalities can be tested. Further, we purposely selected a sample that is familiar with the type of offer we investigated, it is possible that other consumers need additional explanation, and perceive the offer differently as they are likely to own bikes already.

In this research, we investigated one way to customise AB-PSS, it would be interesting to study the effect of other types of customisation on consumer acceptance and sustainability. A bicycle is modular by design, whereas clothing items are rarely modular. Further, for everyday clothing, a good fit for one consumer is detrimental to achieve a long lifetime and high use intensity. Thus, different customisation strategies, circular strategies, and business models might be appropriate for different types of products (Tunn et al., 2019b), and should be investigated and compared. The takeaway for other AB-PSS from this research is that intangible value can be added to these offerings and that the product use time determines to what extent consumers desire intangible benefits.

5.6 Conclusions

Personalising a product in an AB-PSS might sound like a paradox because current AB-PSS offerings, for example, Greenwheels (2018) car sharing and Mobike (2018) bike sharing both offer extremely limited ranges of products. However, customisation of products in AB-PSS could help to tap into customer segments when the lack of intangible or emotional benefits represents a barrier to adoption (Armstrong et al., 2015; Santamaria et al., 2016). Allowing consumers to choose between a few different, low-impact customised options for products could make AB-PSS attractive for these segments and across subsequent use phases by different consumers (Baxter et al., 2015). This research is a step towards exploring PSS that support the need for self-expression through products, as suggested by Catulli et al. (2017b). Customising products using temporary customisation strategies could potentially even lead to a feeling of psychological ownership that in turn leads to consumers treating products with more care (Baxter et al., 2017), and probably to more intensified use.

The adoption of AB-PSS in the consumer market has been slow (Tukker, 2015), even though their sustainability and circularity potential has been mentioned repeatedly in literature. If many consumers adopt an AB-PSS, it has achieved diffusion in the market. In order to generate widespread market adoption, typical products are needed—products that fit many consumers. However, consumers increasingly demand products that also fulfil soft requirements—they prefer products that perfectly match their preferences. This paper suggests small changes in product appearance as a way to

customise products to these preferences and thereby increase consumer acceptance of AB-PSS. Temporary customisation is one strategy that can be used by product and PSS designers to create AB-PSS that are both sustainable and attractive for consumers beyond their functionality. It is also imaginable that service elements and payment schemes could be personalised to improve consumer acceptance of PSS. More research is needed to develop AB-PSS that are better able to compete with products that consumers like to own and that support the transition to a circular economy.

Chapter 6
Effects of digitalised AB-PSS on consumers

This chapter is based on: Tunn, V.S.C., van den Hende, E.A., Bocken, N.M.P., Schoormans, J.P.L., 2020. Digitalised product-service systems: Effects on consumers' attitudes and experiences. Resources, Conservation and Recycling, 162, 105045.

6.1 Introduction

To tackle the sustainability crisis, researchers and businesses have been searching for opportunities to conduct business more sustainably. In recent years, the circular economy concept has gained traction as it presents a pathway to simultaneously attain economic and environmental goals (Geissdoerfer et al., 2017; Kirchherr et al., 2017). To support the transition towards a circular economy, research has strived to identify and describe business models that help achieve these goals (e.g., Bocken et al., 2016; Lüdeke-Freund et al., 2019; Urbinati et al., 2017).

For instance, Urbinati et al. (2017) investigated to what extent companies have implemented circularity in their business models while Tunn et al. (2019a) explored how business models can simultaneously contribute to the circular economy and sustainable consumption. Recently, several systematic literature reviews have been conducted to capture the state-of the art of circular business models (Centobelli et al., 2020; Rosa et al., 2019). Centobelli et al. (2020) suggested that further research into the role of digital technologies in the development of circular business models is needed.

In the context of circular business models, access-based product-service systems (AB-PSS) have been studied (e.g., Roy, 2000; Tukker, 2015). Through AB-PSS consumers can use products for a fee without purchasing the products. AB-PSS could improve sustainability by transferring responsibilities for repair and maintenance to the provider, thereby potentially extending product lifetimes. In addition, granting consumers access to products for a fee might reduce the overall number of products

needed. So far, many consumers are not enthusiastic about consuming AB-PSS and still value owning products (Mashhadi et al., 2019; Mont, 2002; Poppelaars et al., 2018).

Roy (2000, p. 297) suggested that "the rapid advance of information and communication technologies, from smart cards to mobile communications, are likely to make many types of sustainable product-service system more economic and practical." Two decades later, digitalisation has changed many business models and penetrated consumers' everyday lives (e.g., Bouwman et al., 2018; Vor dem Esche and Hennig-Thurau, 2014). Digitalisation could enable the circular economy (e.g., Antikainen et al., 2018; Centobelli et al., 2020; Ingemarsdotter et al., 2019) if efforts in both directions were consciously aligned (Hedberg and Šipka, 2020). However, the effects of digitalised AB-PSS on consumers have received little attention. To better understand this phenomenon, we aim to answer the following question in this research: How does digitalisation of AB-PSS and consumers' digital confidence influence consumer attitudes and experiences? We thus explore when and how digitalisation influences consumer attitudes and use experiences in mobility AB-PSS.

6.2 Background

6.2.1 Digitalisation of products and services

Digitalisation has led to innovative, digitally-connected products that have opened pathways for new services and business models (Rijsdijk et al., 2007; Wünderlich et al., 2013). The seamless information exchange in the digital age has been used by entrepreneurs to develop personalised services, interact directly with consumers, and optimise AB-PSS offerings to make them attractive for consumers and viable for companies (Bocken et al., 2019; Rachinger et al., 2018). A few studies have explored the impact of digitalisation on business models (e.g., Bouwman et al., 2018; Rachinger et al., 2018). Bouwman et al. (2018) outlined the role of social media and big data in business model innovation; they concluded that these have a positive impact on business performance.

The recent rise of the 'sharing economy' and therewith the peer to peer sharing of resources has been frequently attributed to the wide diffusion of the internet (Belk, 2014a; Belk 2014b; Curtis and Lehner, 2019; Pouri and Hilty, 2020). Online platforms and social media are points where supply and demand can meet (Belk, 2014b). Similarly, digitalisation has facilitated the emergence of novel, potentially circular AB-PSS; business models that manage and allocate resources through online platforms and often involve Internet of Things connected products (e.g., Valencia Cardona et al., 2015). For example, pay-per-use appliance services have been enabled by digital

infrastructure that facilitates continuous data exchange between the AB-PSS provider and the devices in users' homes (Bocken et al., 2019).

A few recent studies explored the role of digitalisation in the shift towards a circular economy and circular business models. Okorie et al. (2018) reviewed literature linking the circular economy, digital technologies, and Industry 4.0. They found that publications within these areas are growing but that there are few publications connecting them. Some studies investigated how businesses are utilising digital technologies to support circular strategies. For example, Ingemarsdotter et al. (2019) outlined how the Internet of Things could theoretically support circular strategies and showed to what extent this is happening in practice so far. They conclude that some companies apply the Internet of Things to extend product lifetimes but only few companies use it to help close product and material loops.

In addition, several single case studies were conducted to explore this topic; Alcayaga and Hansen (2019) researched textile washing services in the business to business context and found that the implementation of smart textiles enabled the AB-PSS provider to track the textiles' location and condition, thus enabling the firm to better analyse the cycles and lifetimes of their textiles. Bressanelli et al. (2018) showcased through a case study of a company that provides household appliances through AB-PSS, how the Internet of Things and big data analytics could enable and support circular strategies. Bocken et al. (2018) found that Internet of Things connected washing machines placed in an AB-PSS operated on a pay-per-use model, can be used to stimulate more sustainable washing practices. While these studies provide interesting insights into digitalisation of circular business models, more research is needed to understand the influence and role of digitalisation in the shift towards circular business models, especially in consumer markets.

6.2.2 Digitalisation of consumer experiences

Consumers have become increasingly digitally active over the last decade and are progressively adopting digitalised services. Digitalisation has infused everyday life and shifted power from marketeers to consumers (Labrecque et al., 2013). Consumers can now easily access other consumers' reviews to assess providers and to compare offerings (Sparks et al., 2013). Further, consumers can customise products, track their orders, envision potential purchases in their homes with augmented reality, and influence public opinion of offerings – anytime and anywhere as long as they have access to the world wide web (Vor dem Esche and Hennig-Thurau, 2014). Digitalisation has influenced consumers and Young et al. (2017) demonstrated that social media and e-newsletters can, for example, be used to change consumer behaviour to reduce food waste.

The diffusion of smartphones has further accelerated digitalisation; nowadays, smartphones are indispensable for most consumers. Many consumers obtain decision-relevant information online (Vor dem Esche and Hennig-Thurau, 2014), shop online, and increasingly also conduct online shopping on their smartphones (Pantone and Priporas, 2016). In western Europe, smartphones reached a market diffusion of 67% in 2018 (Statista, 2019a) and 91% in The Netherlands (Statista, 2019b), the location of our study. Scholars developed an interest in determining people's digital confidence, which describes "users' digital literacy and confidence to use digital products" (Benson, 2019, p. 1). Sussan et al. (2016) suggested that digital confidence comprises two pillars, namely digital privacy and security, and digital adoption. Despite the wide spread of smartphones and digitalisation of consumers, the impact of digitalisation has not yet been fully grasped and the role of consumers' digital confidence on their attitude towards digitalised offerings has not yet been studied.

6.2.3 Research focus: Digitalisation of mobility AB-PSS

We study the effects digitalised mobility AB-PSS in consumers as mobility AB-PSS are examples of widely adopted, digitalised AB-PSS. The recent increase in mobility AB-PSS might have been enabled by digitalisation. For example, bicycle sharing systems have considerably grown in number within a decade, from 13 bicycle sharing schemes globally in 2004 (before smartphones were widely adopted) to 855 in 2014 (Fishman, 2016). Bicycle sharing systems have evolved since they were first implemented five decades ago; they started as a localised phenomenon, of free or coin-deposit shared bicycles, evolved into digitally enabled systems integrated with other modes of transport that could be accessed with smartcards (Shaheen et al., 2010), and further evolved into systems that users access through smartphone applications. We refer to these developments as the digital evolution of mobility AB-PSS.

Many mobility AB-PSS are digitalised today but it is unclear how this affects consumer attitudes and use experiences. Recent studies analysing digitalised AB-PSS, did not explicitly address the consumer side (e.g., Alcayaga and Hansen, 2019; Bressanelli et al., 2018; Ingemarsdotter et al., 2019). We aim to increase the understanding of the effects of digitalised AB-PSS on consumers by exploring how digitalisation of AB-PSS and consumers' digital confidence influence consumer attitudes and use experiences? Based on the previously introduced literature we developed a framework of consumer attitudes and use experiences in digitalised AB-PSS (Figure 12).

Leasing and sharing services are AB-PSS that differ in the temporality of access (Bardhi and Eckhardt, 2012). For example, consumers repeatedly obtain access to products for a short time through bicycle sharing while consumers access one product for an extended period in car leasing. This difference in temporality influences the importance

of product and service aspects; in long-term AB-PSS product aspects are more important as a consumer extensively uses that product while in short-term AB-PSS the service aspects are crucial as products are frequently accessed and released. Digital aspects of AB-PSS generally support service aspects. Belk (2014b) suggested that digital aspects are more important for AB-PSS providing short-term access than for those providing long-term access. Consumers' digital confidence is thus likely to only affect their attitude towards short-term AB-PSS.

More specifically, building on Belk's (2014b) and Bardhi and Eckhardt's (2012) work, our framework suggests that consumer's digital confidence influences consumers' attitude towards digitalised short-term AB-PSS but not their attitude towards digitalised long-term AB-PSS. In other words, consumers who are confident using smartphones are likely to have a more positive attitude towards digitalised short-term AB-PSS, while this confidence does not influence their attitude towards digitalised long-term AB-PSS. We hypothesise the following: **H1** : Consumers' digital confidence positively influences consumers' attitude towards digitalised short-term AB-PSS but not consumers' attitude towards digitalised long-term AB-PSS.

Beyond attitude, our framework suggests that digitalised AB-PSS also influence consumers' use experiences. As outlined above, we expect high digital confidence to lead to positive attitudes towards short-term AB-PSS, thus increasing the likelihood of adoption and consequently use of digitalised AB-PSS. So far, consumers' use experiences in digitalised AB-PSS did not receive much attention in the literature. A thorough understanding of positive experiences and negative experiences is needed, given that the sustainability potential of short-term AB-PSS lies in substituting the purchase of a product. Understanding use experiences is thus crucial to sustain consumers' positive attitudes and foster the continued use of the AB-PSS.

In this paper, we present the findings of a survey and user interviews that provide evidence that digital confidence plays an important role for consumers in digitalised short-term AB-PSS. This study contributes deeper insights into how digitalised AB-PSS affect consumer attitudes and consumer use experiences.

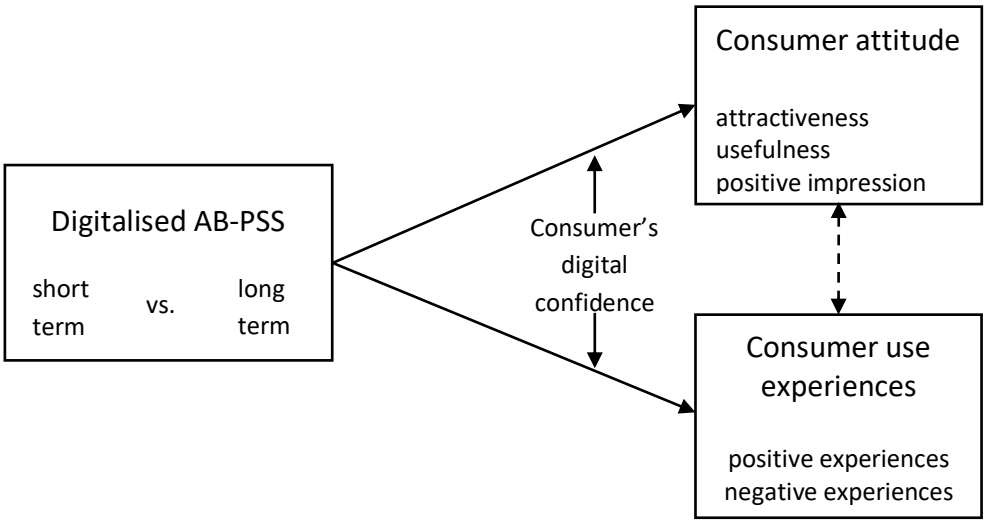

Figure 12: Framework of effects of digitalised AB-PSS on consumer attitudes and experiences.

6.3 Method

We applied a mixed-methods approach (Schoonenboom and Johnson, 2017). Mixed-methods approaches can be applied for different purposes, for example, a quantitative research can be followed by a qualitative one in order to elaborate on the initial findings (Brannen, 2005). Collecting both qualitative and quantitative data allowed us to gain nuanced insights into the effects of digitalised AB-PSS on consumers' attitudes and use experiences.

First, we surveyed the impact of consumers' digital confidence on their attitude towards digitalised AB-PSS, using a sample from the general Dutch population (n = 47). Building on the survey findings, semi-structured interviews were conducted with key informants who use mobility AB-PSS (n = 10). Consumers' experiences during the use of digitalised AB-PSS received little attention so far, and thus, necessitated a qualitative approach.

6.3.1 Survey

With the survey, we aim to determine when consumers' digital confidence influences their attitude towards digitalised AB-PSS. Participants were sampled from a consumer panel of Delft University of Technology. The sample comprises participants living in or near Delft in the Netherlands (n = 47). Participants were aged between 26 and 75 (Mage = 44) and 62% of the sample are female. Smartphones were used by 98% of participants.

About half of the participants (n = 23) evaluated hypothetical bicycle leasing services and the other half (n = 24) evaluated hypothetical bicycle sharing services. The hypothetical AB-PSS were designed to resemble AB-PSS that are available in the Netherlands to improve the validity of participants' responses. The questionnaires were part of a larger task that took participants 30-40 minutes, hence every participant only completed one of the two questionnaires. Both services can be considered digitalised AB-PSS as digital aspects were built-in; for example, websites and smartphone applications, online reviews, and GPS location of bicycles and service points.

After reading an explanation of the digitalised AB-PSS, participants completed the survey that assessed their attitude towards the digitalised services and their digital confidence. The attitude towards the AB-PSS was measured with three items on 7-point semantic differential scales (e.g., attractive - unattractive); namely the perceived attractiveness, usefulness, and positive impression of the AB-PSS (adapted from Van den Hende and Schoormans, 2012; Hassenzahl, 2001). Sussan et al. (2016, p. 326) suggested that digital confidence can be understood through an adoption lens and in this context "measures whether consumers recognize the opportunities of digitalization, as reflected in adoption rates of Internet, fixed and mobile broadband, various digital devices, and digital services". In this study, we applied this adoption perspective to digital confidence which is reflected in the three items through which we assessed it, namely the perceived ease of use of smartphone applications, the frequency of use of smartphone applications for services, and whether participants perceived that smartphone applications increased the ease of use of services (assessed on a 7-point Likert scale, strongly agree - strongly disagree).

6.3.2 Interviews with key informants

Building on the findings of the survey, we conducted semi-structured interviews with ten users of mobility AB-PSS. Through these interviews we explored consumers' use experiences in digitalised mobility AB-PSS. We selected key informants (n = 10) for the interviews, who all have used at least one mobility AB-PSS and live in the Netherlands (see Table 14). Their experience with mobility AB-PSS ranged from having used one a few times to having regularly used one or several AB-PSS for up to 20 years.

During the interviews, the key informants outlined their experience with mobility AB-PSS and the role of digital aspects within these services. The interviews lasted 20-40 minutes. The interviews were conducted in person, recorded, transcribed, and coded to discover themes (Ryan and Bernard, 2003) related to users' experiences using digitalised AB-PSS. Initially, the interviews were coded according to three main themes, namely the evolution of digital aspects, the positive experiences, and the negative experiences resulting from the digital aspects of the AB-PSS. Subsequently, quotes related to these three themes were placed in thematic clusters. To ensure the validity of our findings, the information obtained through the interviews was triangulated with secondary sources, such as the companies' websites, to retrace the development of the digital aspects. Further, most of the AB-PSS explored through user interviews were used by several interviewees, two AB-PSS were only used by one interviewee each. This ensured that insights are not AB-PSS provider specific but likely to apply to mobility AB-PSS in general.

Table 14: Interviewees used mobility AB-PSS (*names changed).

Name*	Age	Occupation	AB-PSS experience
Peter	19	Bachelor student	Swapfiets
Anna	25	Junior Service Designer	Swapfiets & OV-bike
Tom	19	Bachelor student	Swapfiets & OV-bike
Julia	25	Master student	Mobike & OV-bike
Ben	27	Researcher	Mobike & Felyx
Fenna	29	Researcher	ShareNow & OV-bike
Steve	45	Teacher	Greenwheels
John	33	Researcher	Greenwheels & OV-bike
Sophie	37	Researcher	Greenwheels
Martin	54	Project Manager Innovation	Greenwheels

All mobility AB-PSS used by interviewees incorporate some digital aspects. For example, Mobike (www.mobike.com) offers sharing bicycles without docking stations, this is enabled by a smartphone app that allows consumers to locate, reserve, and unlock bicycles, as well as pay. The bicycles are equipped with Internet of Things connected smart locks. OV-fiets (www.ns.nl/en/door-to-door/ov-fiets) offers shared bicycles at Dutch railway stations. These bicycles can be accessed with a smartcard of the Dutch railway service. This service is connected to the website and app of the Dutch railway service, where the availability of bicycles at the railway stations is displayed in real time.

6.4 Results

6.4.1 Survey: Digital confidence and attitude towards digitalised AB-PSS

We hypothesised that consumers' digital confidence has a positive influence on their attitude towards digitalised short-term AB-PSS but not on their attitude towards digitalised long-term AB-PSS. The reliability of the digital confidence scale (Cronbach's alpha = .72) and the AB-PSS attitude scale (Cronbach's alpha = .90) were above the .70 threshold and can thus be used in the analysis. A preliminary analysis of the attitude scale and the digital confidence scale for the two AB-PSS indicates that attitudes are more positive towards short-term AB-PSS ($M_{\text{short-term}}$ = 5.82; $M_{\text{long-term}}$ = 4.2) and that digital confidence in our sample is high ($M_{\text{digital confidence}}$ = 6.32; see Table 15 for details).

Table 15: Mean and standard deviation for consumers' digital confidence and AB-PSS attitude for both services.

	Short-term AB-PSS (n=24) M_{age} = 43 63% female	Long-term AB-PSS (n=23) M_{age} = 45 61% female	Total (n=47) M_{age} = 44 62% female
Digital confidence	*M* = 6.43 SD = .88	*M* = 6.20 SD = .76	*M* = 6.32 SD = .82
AB-PSS attitude	*M* = 5.82 SD = 1.16	*M* = 4.20 SD = 1.32	*M* = 5.03 SD = 1.47

We regressed AB-PSS attitude on digital confidence for each AB-PSS to test hypothesis 1. The regression analysis showed that consumers' digital confidence significantly influences their attitude towards short-term AB-PSS ($F(1, 22) = 8.463$, $p < .01$) with R^2 = .28. The higher consumers' digital confidence the more positive their attitude towards short-term AB-PSS. We analysed long-term AB-PSS in the same way and found that digital confidence has no influence on consumers' attitudes in this case ($F(1, 21) = .016$, $p = .9$) with $R^2 = .001$. These findings

thus, support our hypothesis; the digital confidence of consumers indeed only has an effect on consumers' attitude towards short-term AB-PSS but not on their attitude towards long-term AB-PSS. Having lower digital confidence is one factor that results in lower attitudes towards short-term AB-PSS, and thus, makes adoption and repeated use of the service less likely.

6.4.2 Interviews: User experiences in digitalised AB-PSS

Building on the results of the survey, interviews were conducted with digitally confident users of mobility AB-PSS. The focus of the interviews was on short-term AB-PSS as the survey and previous literature established that digital aspects are more important in short-term AB-PSS than in long-term AB-PSS (Belk, 2014b). Three main themes emerged from the interviews, namely the digital evolution of AB-PSS, negative use experiences, and positive use experiences in digitalised mobility AB-PSS. In this study, digital evolution refers to the changes of digital aspects of AB-PSS that interviewees noticed and experienced.

The interviewees described more digital aspects in the scooter and car sharing AB-PSS than in the bicycle AB-PSS. The complexity of the products could explain this; bicycles are relatively simple mechanical products whereas modern scooters and cars are more complex and contain electronics. These more complex products offer many possibilities for digitalisation, for example, by making use of built-in sensors, screens, and data (e.g., on usage, battery levels, and damages). In bicycle sharing, digitalisation is important to consumers but its role is mostly limited to locating and accessing the bicycles via smartphones.

As for digitalisation in long-term AB-PSS, some interviewees used leased bicycles from Swapfiets. As expected, for this long-term AB-PSS digital aspects were not of high importance and only mentioned in connection to service encounters such as the initial receiving and eventual repairs of the bicycle. Interviewees valued getting in touch with the long-term AB-PSS provider Swapfiets via the messaging application WhatsApp (Anna; Tom). The following sections present negative and positive use experiences related to of digital aspects of short-term AB-PSS and their evolution.

Effort required to use digital aspects

Greenwheels has provided shared cars in the Netherlands since 1995. Steve has been using their cars since 1999 and described how the service evolved. Initially, bookings had to be made via telephone, later a website, and subsequently an app were launched through which consumers could book cars. Martin remembered that he had to go through several steps when he used to book cars on his computer through the Greenwheels website, this required more effort than booking through the app requires now: "*I used to have to start my laptop, enter the online environment, having to reserve via the online environment*". The way users can unlock cars has also changed; initially cars were accessed using a Greenwheels card, soon users could unlock the cars with their Dutch public transport card as a result of a collaboration between Greenwheels and the Dutch railway service. Now users can open the cars using the Greenwheels app

on their smartphones. Steve explained why he still unlocks Greenwheels cars with his public transport card rather than with his smartphone:

"Since a couple of years, you can also unlock it with your phone but I don't really use it that much. I generally switch the GPS off on my phone because it saves battery so I'd have to actively switch on the GPS and then swipe it over. I always have my public transport card with my driver's license on me so for me it is a no-brainer." (Steve)

Flaws in the design and performance of digital aspects

Several interviewees described why they perceived certain digital aspects of the AB-PSS as unattractive or even useless. Fenna mentioned that she does not use the onboard system of ShareNow cars because *"it is so slow and it gives the wrong route or the slowest route […] and the interface isn't pretty."* John used to avoid opening the Greenwheels website on his smartphone because *"when you do it on a small smartphone screen things become, for my taste, a bit unhandy"*. For a while Greenwheels has been providing an app, Martin described how the Greenwheels app evolved: *"The app has become more sophisticated so that it has a little film inside and it has better visual quality but I liked the app as it was in the beginning, it was very straight forward."*

Furthermore, some interviewees found a mismatch between the digital information and physical artefacts. For example, Fenna recollected an incident when several cars were displayed as available in the ShareNow app; however, the cars were not accessible because they had been towed into a closed-off yard by the municipality. Similarly, Ben was irritated by the information provided when checking Felyx scooters for damages:

"You can see which damages there are to check whether it matches with the actual thing. It never matches, it is really weird. Even things like the mirror, it would say like there is no mirror and there are mirrors and vice versa. It'll say there are big damages but there are no damages and it is just really weird." (Ben)

Dependence on digital aspects

Some interviewees voiced negative emotions and concerns they had experienced because of the high degree of dependence on digitalisation in some AB-PSS. Several of the AB-PSS introduced in this section, rely on users' smartphones. Fenna revealed that she usually does not use the car sharing service if her phone battery charge level is below 50% and Julia described her worries about the smartphone running out of battery while using the service:

"What I just remembered about Mobike and what I found to be a big disadvantage is that on one occasion my mobile phone battery was nearly empty, and I thought 'What will happen if it's empty?' and that made me stressed out even more." (Julia)

In addition, some users depend on AB-PSS in their daily routines, a malfunctioning of digital aspects can disrupt these routines and cause emotional reactions:

"When it [the app] blocks or there is a big bug you're locked out of the car and you can't get home. […] So, we were doing the groceries and we had all the groceries in our hands and we were getting back to the car and we couldn't get back into the car. The car was in the parking lot, so you also have to pay for being in the parking lot and we couldn't access the car again and both of our mobile phones were not connecting. We just thought that it was a national issue and we just were like 'Nooooo, we just want to get home, please!'" (Fenna)

"I remember that one time that I had reserved via the app and that the app hadn't been rolled out for such a long time and that my reservation had not been processed so that when I put my card on the windscreen of the car it wouldn't open and then I had to call and then it took a long time because there was a glitch in the system meaning that there were a lot of people waiting to be given access and that made me quite angry because that was when I was travelling from home and I had to bring my daughter to one of her swimming lessons and then timing is essential and I can't lose 10 minutes on such a thing. (Martin)

Further, Julia raised concerns that digitalised AB-PSS might exclude less digitally confident consumers, for example, in her parents' neighbourhood:

"I think that my neighbours would not use it at all because they'd think: 'Oh, what is an app and what should I do with it?' So, the app would be a negative aspect there." (Julia)

Increased use efficiency because of stored data and privacy concerns

Most interviewees of this study outlined initial registration procedures before the first use of the AB-PSS. The AB-PSS providers store the data and create user profiles to which subsequent service interactions are linked. Hence, AB-PSS users do not have to sign a contract before each use thereby speeding up the service interaction compared to traditional rental services. John compared the OV-bike sharing systems with traditional bicycle renting:

"I think it is mostly the administrative part that is now streamlined which makes it more convenient for the companies as well as for me the user to have this service. Of course, I could have gone to the bicycle place before and rented a bike but then you have to go to the office, ask the guy there to let me rent a bicycle, then he would need a copy of my passport or driver's license, he would sign me into the register, I would pay the rental fee and probably a deposit beforehand, then he would have shown me the bicycle. Well, this whole thing would have cost more time and would have been more bothersome than just take the bike, scan and go." (John)

While interviewees perceived the time savings and convenience achieved through stored data and built-in sensors positively, some interviewees were concerned with data privacy especially when envisioning how these services might develop in the future (Steve; Martin).

Benefits of digital interaction with AB-PSS providers

The introduction of digital channels has simplified booking processes and made AB-PSS more convenient to use. Several interviewees preferred digital interaction with the AB-PSS provider over calling the customer service which they felt cost more time and hassle. Tom, Sophie, and Steve liked being able to contact the customer service or extend bookings through apps because they could do this swiftly during other commitments, such as lectures, meetings or family gatherings, if necessary. Anna found digitally interacting with the AB-PSS provider more relaxed than calling. Other interviewees emphasised time savings resulting from digital interaction, Martin explained how selecting and booking vehicles himself via the app saved time compared to talking to a customer service agent trying to find an available vehicle in his vicinity: *"It [relieves me from] having to think before starting [the journey to work] so I can do it very quickly so it saves thinking time."* Both Fenna and Ben mentioned that they were less likely to report damages caused by previous users if they had to call the customer service rather than being able to quickly enter the damages in the app. A few interviewees outlined how the channels through which they interact with the AB-PSS providers have evolved. For example, the introduction of apps sped up the reservation process of vehicles and shortened users' planning horizon:

"They introduced the app which made it easier because you didn't have to start the computer and login or call, you could just open the app because you were automatically logged in and it knew location wise already that you were in Delft. I remember it became easier with the app. […] The booking time, I think, also shortened [with the app]. While before you did it the day beforehand for sure or maybe even a couple of days in advance because it takes more time and effort to do it while now it is just on the go." (Sophie)

Systems integration

Interviewees experienced the integration of different digital aspects within the AB-PSS and the integration of AB-PSS into existing services and infrastructures as beneficial. Several interviewees emphasised that this integration made OV-bike and Greenwheels more convenient and accessible. While Peter is currently not using OV-bike he felt that the service would be more appealing if it were even more embedded in the app of the Dutch railway service: *"It would be nice if you could go to the [future] app directly from the Dutch railway service's online journey planner."* Martin has been using Greenwheels

car sharing since 2011 and explained that the integration of digital aspects made him experience the service as reliable and helped him build trust in the service:

“It works well because I reserve on my app and now it always pops open when I put my card on the windscreen and that is what I would like. […] So, it feels like the car is in connection with the rest and that is more now than it used to be. Because I used to feel like there is this system but then whether the car is connected to the system I was not so sure, most of the times it opened up but now it feels more like ‘Of course it will open up’. […] You do feel that it is one big thing, it is a reassuring system.” (Martin)

Direct feedback

Digitalisation can give AB-PSS users a sense of control by giving them access to relevant information. For example, by clearly displaying the availability and location of the vehicles. Further, some of the AB-PSS provide electric vehicles and Steve, Ben and Fenna mentioned that they check vehicles’ battery levels in the apps before selecting a vehicle to ensure it is sufficient to reach their destination or to also cover the return journey. Fenna explained that ShareNow cars have onboard computers that display the driver’s current sustainability score thus providing direct feedback on the driving. One interviewee explained how the app gives him a feeling control and peace of mind:

“Through the app you get a lot more sense of control; you know where they [the scooters] are, you know whether they are locked or not, you can look at it and it gives you feedback. It shows you that you have locked it, unlocked it and you have used it for this many hours. I sometimes look at the overview of the rides that you have taken. It gives you information on costs, I think that is really important. So, it shows you directly how minutes you did go, how many euros did that cost.” (Ben)

Advanced digital aspects

The interviews revealed how AB-PSS providers used advanced digital aspects to create more positive use experiences. A few interviews recalled incidents when the vehicles did not lock because one of the digital aspects did either not work or did not connect to the other digital aspects. For example, Ben and Fenna described that this caused them stress because it meant that costs kept rising despite them no longer using the vehicles. The car sharing system ShareNow evolved further and now use the built-in sensors to automatically lock the cars:

“I think with the new system you don’t have to log out on the app anymore because now it locks automatically. I remember sometimes the app takes a long time because your phone doesn’t always want to cooperate; so the app shuts down or your phone shuts down or it takes a shitload of time to get stuff going and I noticed lately that it’s been locking the car automatically without me even having to push on a button and

before that I was like: ‘Oh no, ahhh, the time is going on, leave me alone!’ So that was a good one.” (Fenna)

6.5 Discussion and recommendations

6.5.1 Discussion

Digital aspects of AB-PSS influence consumers’ attitudes and use experiences. We demonstrated that digitally confident consumers have a more positive attitude towards short-term digitalised AB-PSS than less digitally confident consumers. Users of these services seem to be generally digitally confident. Furthermore, digital aspects of AB-PSS had a lesser influence on consumer attitudes and use experiences in long-term AB-PSS, because digital AB-PSS aspects often facilitate consumers’ interactions with the service provider (e.g., the accessing and releasing of products). Such interactions occur frequently in short-term AB-PSS whereas they occur infrequently in long-term AB-PSS. Thereby, this study substantiates Belk's (2014b) conjecture that digital aspects are more important in short-term AB-PSS and limited to locating and comparing choices in long-term AB-PSS. Digitalisation contributed to the recent success and spread of short-term mobility AB-PSS in the consumer market. By now, digital aspects are ‘must-haves’ in many short-term mobility AB-PSS and ‘nice-to-have’ in long-term mobility AB-PSS. Digitalised AB-PSS are thus more likely to be adopted by digitally confident consumers than by less digitally confident consumers.

Digitalised AB-PSS can affect consumers in several ways. AB-PSS are generally complex (Tunn et al., 2020) and digital aspects add another layer of complexity. Digitalised AB-PSS rely on several digital aspects and are thus susceptible to disruptions. For example, the service delivery of AB-PSS can be compromised if a consumer's smartphone runs out of battery, the providers’ app has a bug, or a sensor built into the product fails. Consumers’ resulting negative use experiences can trigger negative emotions. This is interesting as consumers usually do not have strong emotional connections with products accessed through AB-PSS (Tunn et al., 2019b). Positive and negative use experiences can be closely related; for example, users felt that stored data and digital aspects made AB-PSS efficient and convenient, while they also voiced privacy concerns. While it is hoped that AB-PSS providers “collect rich data about consumers and translate these into meaningful, highly individualized services” (Valencia Cardona et al., 2015, p. 25), the digital aspects of AB-PSS also enable unwanted surveillance (Ziegeldorf et al., 2014). It is therefore crucial to design stable, reliable systems, and build consumers’ trust in the digitalised short-term AB-PSS.

With this study, we build on and extend previous research (Bardhi and Eckhardt, 2012; Belk, 2014b; Bressanelli et al., 2018; Tukker, 2015) by providing a consumer perspective

on digitalised AB-PSS. We contribute insights into the effects of digitalised AB-PSS on consumer attitudes and use experiences and demonstrate the role of consumers' digital confidence. Our findings can be directly attributed to digitalisation as interviewees described their experiences in the context of the digital evolution of AB-PSS.

While the presented research investigated mobility AB-PSS, some findings are likely to apply to other digitalised offerings. For example, it is likely that consumers' digital confidence also influences their attitude towards digitalised services and products in other application areas. In addition, digitalised AB-PSS from outside the mobility sector are likely to create similar use experiences for consumers. For instance, direct feedback about the availability of rental clothes via a smartphone app would probably contribute to a positive use experience. However, consumers are likely to interact less with, for example, a rented electric drill.

Digital technologies are still developing at a fast pace and in the coming years 5G mobile networks will be rolled out. This development is likely to have some implications for short-term mobility AB-PSS. We consulted an expert on this topic who suggested that 5G is most beneficial in densely populated areas as it allows more devices to connect and process higher data volumes, it also promises to increase the reliability of the network, and it will allow to connect many smaller devices and sensors. Therefore, digital aspects of AB-PSS such as built-in sensors and scanners could be directly connected to the mobile network and for instance, inform the AB-PSS provider about the status of the products to trigger maintenance and repair before users notice and report component issues or failures. Overall, the implementation of a 5G mobile network could increase the reliability of these services and could enable new, data-heavy applications and services that require data exchange in real-time.

AB-PSS need to be purposefully designed to enable the transition towards a sustainable, circular economy (Kjaer et al., 2019). When assessing the sustainability of digitalised AB-PSS, the impacts of the required digital infrastructure need to be considered in addition to impacts created by operating the service (Kjaer et al., 2019), and impacts caused by adverse consumer behaviour (Schaefers et al., 2016). The question is whether the digitalisation of an AB-PSS helps to make the service so much more attractive that the AB-PSS substitutes unsustainable consumption alternatives and whether these potential sustainability gains outweigh the additional impacts created by operating the AB-PSS including the required server infrastructure and other digital aspects (Pouri and Hilty, 2020).

6.5.2 Recommendations

Based on the findings of this study, a few key recommendations for AB-PSS designers and app developers have been formulated. Services such as AB-PSS should provide

digital communication channels as phoning is seen as somewhat outdated and less convenient by consumers. Digitalised short-term AB-PSS should target digitally confident consumers. When designing short-term AB-PSS, digital aspects are essential and it should be ensured that digital aspects such as smartphone applications are user-friendly and highly reliable. This can help consumers build trust in the AB-PSS and experience benefits such as convenience and time savings.

In addition, AB-PSS designers should keep in mind that more complex products (e.g., cars) offer more opportunities for digitalisation than less complex products (e.g., bicycles). However, designers should deliberate whether digital aspects are needed and beneficial or merely creating additional environmental impacts. Finally, the sustainability potential of digitalised AB-PSS should be analysed when designing them as required sensors and server infrastructure cause environmental impacts that might outweigh their benefits.

The applied methodology and set-up of the study entail some limitations that provide avenues for future research. Future research could test the effect of digital confidence on consumers' attitude and behavioural intention with a larger sample also taking participants' values into account. In addition, digital aspects should generally be considered more in AB-PSS research and consumers' digital confidence should be taken into account when AB-PSS targeting consumer markets are studied. For the interviews, we deliberately selected key informants who were users of mobility AB-PSS; however, non-users might perceive the digital aspects differently. The digital aspects might even be the reason why some consumers are not using mobility AB-PSS. In addition, it stands out that the digital confidence of consumers in our survey sample is very high. This seems to be representative of the Dutch population of whom 91% had already adopted smartphones in 2018 (Statista, 2019b). We suggest using larger samples and including non-users and users with lower digital confidence in future research. Finally, we would like to encourage more research assessing the environmental impacts of digitalisation to understand when and how digitalisation can support the transition towards a sustainable, circular economy (Hedberg and Šipka, 2020; Rahmana et al., 2020).

6.6 Conclusions

Many circular business models such as AB-PSS have been enabled by digitalisation. However, the effect of digitalised business models has received little attention so far. Recently, an increasing number mobility AB-PSS such as bicycle sharing systems have been implemented and subsequently adopted by consumers (e.g., Fishman, 2016). We thus studied the effects of digitalised mobility AB-PSS on consumer attitudes and use experiences using a mixed-methods approach. With the presented research, we illustrated how digitalisation has enabled the recent spread of mobility AB-PSS. We

contributed insights into the effects of digital aspects on consumers' use experiences of AB-PSS and presented when and how consumers' digital confidence influences consumers' attitudes towards these services.

We found that consumers' digital confidence has a significant effect on consumers' attitudes towards short-term AB-PSS. The effect of digital aspects and consumers' digital confidence is limited in long-term AB-PSS such as bicycle leasing. Well designed and integrated digital aspects can enhance consumers' use experiences in short-term AB-PSS. Digital aspects can increase convenience, lead to time savings, create perceived control, and help users build trust in the service.

Yet, digitalised short-term AB-PSS depend on the functioning of several digital aspects including consumers' smartphones and are thus prone to technical issues that can render the service unusable and upset consumers. In addition, digitalisation of short-term AB-PSS excludes less digitally confident consumers. However, considering the wide diffusion of smartphones among the Dutch population and the planned introduction of the 5G network, digitalised AB-PSS and other digitalised services have a large and growing target group.

Chapter 7
Consumer product care in circular business models

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7.1 Introduction

During the last decade, the circular economy has emerged as an economic model that aims to reconcile economic and environmental interests. To implement this concept at company level, circular business models have been developed that enable the reuse of products, components, and materials (e.g., Kirchherr et al., 2017; Lewandowski, 2016; Nußholz, 2017). Circular business models aim to maintain products at their highest value for as long as possible. Consumers impact the sustainability of products and services through their use and behaviour patterns. Even well-designed circular business models can fall short of their sustainability potential because of rebound effects if consumers use products or services differently or more than intended (Hertwich, 2005; Kjaer et al., 2019; Zink and Geyer, 2017).

Product care describes all activities initiated by consumers that prevent the shortening of products' lifetimes (Ackermann et al., 2018) and thus influences the length of the useful life of products. A lack of product care in circular business models can result in rebound effects that impede or diminish their sustainability potential (Agrawal et al., 2012; Bardhi and Eckhardt, 2012; Kjaer et al., 2019; Tukker, 2004). For example, access-based product-service systems (AB-PSS) are circular business models that allow consumers to use products' functionalities without purchasing the products. The sustainability potential of AB-PSS hinges on the assumption that the providing organisation maintains and repairs the products, thereby prolonging product lifetimes

(Cooper, 2005; Mont, 2002a). However, product lifetimes are only extended in AB-PSS if products are treated with a reasonable level of care but people often fail to take care of their products and thereby do not fully make use of products' potential lifetimes (Ackermann et al., 2018; Cooper, 2005). The level of product care in AB-PSS is unclear despite frequently being noted as an important consideration in previous literature (e.g., Bardhi and Eckhardt, 2012; Tukker, 2004). Some authors suggest that consumers handle accessed products with more care because they feel more restricted in their use or are worried about potential consequences of usage signs (Cherry and Pigeon, 2018; Tukker, 2015). Other authors found that consumers behave more recklessly with accessed products as they do not bear the responsibility and risks of wear and tear, and hidden damages (Bardhi and Eckhardt, 2012; Schaefers et al., 2016).

In this study, we compare product care in linear and circular business models in order to address the following research question: How do circular business models influence product care? To explore this, we conducted an online survey with consumers who use washing machines or bicycles through either linear or circular business models. Both products have a high functional value and were selected because product care can reduce their environmental impact (e.g., King et al., 2006; Schick et al., 2020), for example, by extending product lifetimes. Further, both products can be bought new, second-hand, and be used through AB-PSS in the Netherlands, where we collected the data. Our findings quantitatively demonstrate that product care is strongly influenced by the chosen business model and that it is significantly higher in ownership models (linear sales and second-hand sales) than in AB-PSS. In addition, our study provides a deeper understanding of the relationships between consumers, products, and business models in a circular economy. Practitioners can use the insights of this study and the developed design strategies for product care to design circular business models and products that are less susceptible to rebound effects caused by poor product care.

7.2 Background

7.2.1 Product care

Product care is defined as activities initiated by consumers that prevent shortening of products' lifetimes or even extend products' lifetimes (Ackermann et al., 2018). It includes activities such as repair and maintenance, but also careful handling, and the use of adequate accessories. Most research in the field of product care is built on qualitative studies, which examined product care for certain products through interviews and case studies (see e.g., Cox et al., 2013; Young, 2017) thus not providing a broader understanding of the factors influencing this behaviour. Findings so far suggest that the product as well as the consumer characteristics influence product care (Evans and Cooper, 2010; Harmer et al., 2019; Scott and Weaver, 2014). In general, a

value-action gap can be observed; consumers realise the necessity to take care of their products, yet they fail to include these activities in their daily lives (Ackermann et al., 2018).

Table 16: Design strategies to stimulate product care (adapted from Ackermann et al., 2020).

Design strategy	Explanations and examples
informing	static (manuals, tutorials) or interactive (workshops, websites) information
enabling	providing flexibility (through compatibility with standard tools or easy accessibility of all parts) and necessary means (e.g., tools), offering a service
social connections	social connections as a result or as facilitators of product care (e.g., repair cafés); shared ownership of products
appropriation	enable the adaptation of the product during the use phase (e.g., through modular design) and facilitate creative approaches with the product (e.g., personalisation)
reflecting	designing a product in a way so that it holds meaningful memories and shows traces of use; create a positive product care experience
control	the product takes the initiative for product care or even forces the consumer to take care of it (by refusing to work until it has been taken care of)
awareness	alerting the user of care needs, for example through push messages (e-mail, smartphone); changes in product appearance, functionality, or performance
antecedents and consequences	anticipating effects of care and non-care; rewarding for care activities by positive after-effects (e.g., especially shiny surface)

In order to address the lack of product care, several design strategies to foster product care have been proposed (Ackermann et al., 2020; see Table 16). These strategies do not only focus on the facilitation of product care by informing and enabling the consumer, but also include approaches that aim to increase consumers' motivation as prior research has shown that the ability alone does not lead to product care. One example are social connections that are based on shared experiences of product care. They can stimulate product care because people are more motivated to take care of their product in presence of others. Shared ownership has also been mentioned as a motivator for care activities, because people experience social pressure to take care of the products. While this strategy refers to products being owned by multiple consumers at the same time, such as a coffee machine in a shared flat, it might also be relevant for AB-PSS, where consumers might at least consider that other people will use the product later. The next two strategies, appropriation and reflecting, concern the consumer-

product relationship; if a product is highly adapted to a consumer's needs or is associated with cherished memories, the consumer will probably take better care of it. However, personalisation is currently limited in AB-PSS because products need to be relevant to several consumers sequentially and it is unclear to what extent consumers perceive psychological ownership or emotional attachment (see e.g., Mugge, 2007) for accessed products (Baxter and Childs, 2017; Tunn et al., 2019b). The design strategies control and awareness are both serving as triggers to make consumers aware of the need for product care. While awareness is a subtler approach, such as push notifications or a slow decrease in performance, the product takes the initiative within the control strategy. For instance, a coffee machine could automatically open the coffee grounds tray when it needs to be emptied or stop working entirely until maintained appropriately. The final strategy describes the communication of positive consequences that can be expected by taking care of the product and negative consequences if it is not being cared for.

Product care research so far has focused on products that consumers own, or that are shared in a very defined environment, such as a shared flat. Research on how a lack of ownership influences product care and which design strategies could promote product care in circular business models is still missing.

7.2.2 Circular business models

New business models have been developed to help implement circular economy principles in companies. Business models describe "how a company does business" (Osterwalder et al., 2005, p. 2). This concept was soon adapted to describe sustainable business models (e.g., Boons and Lüdeke-Freund, 2013; Schaltegger et al., 2016) and circular business models (e.g., Lewandowski, 2016; Nußholz, 2017). Circular business models incorporate resource efficiency strategies to slow, close, and narrow resource loops (Bocken et al., 2016). Specifically, this means business models are designed to enable the reuse, repair, refurbishment, and remanufacturing of products thereby maintaining them at their highest value for as long as possible (Nußholz, 2017; Geissdoerfer et al., 2018b). Second-hand sales and AB-PSS are circular business models that facilitate the reuse of products and could extend product lifetimes (Cooper, 2005; Den Hollander and Bakker, 2012). AB-PSS are a type of circular business models (Lewandowski, 2016) that allows consumers to obtain products' functional value for a fee, examples are leasing, renting, and commercial sharing services (Mont, 2002a; Roy, 2000; Tukker, 2004). These services could improve sustainability by either maximising product utilisation during products' lifetimes or by extending products' lifetimes (Roy, 2000). We study long-term AB-PSS (that grant consumers exclusive access to a product for several months or years) because product care falls into the use phase which is

highly relevant when consumers use one product for an extended period. In the remainder of this paper long-term AB-PSS are simply referred to as AB-PSS.

7.2.3 Product care in circular business models

In a circular economy, products should be maintained at their highest value for as long as possible. Wastling et al. (2018) mention product care as a behaviour expected of consumers in both ownership and access-providing circular business models to extend product lifetimes. In literature, product care has been mentioned as an issue in AB-PSS (e.g., Bardhi and Eckhardt, 2012; Tukker, 2004). It has been argued that AB-PSS for durable products only contribute to sustainability if product lifetimes are extended (Agrawal et al., 2012) as careless consumer behaviour might outstrip the benefits of professional maintenance and repair (Tukker, 2004).

Consumer-product relationships in AB-PSS differ from those in ownership models (Bardhi and Eckhardt, 2012). In AB-PSS, the consumer-product relationship is generally based on consumers obtaining the functional value of products, the exchange is governed by contracts rather than trust. For example, using products through AB-PSS usually does not lead to product attachment (Catulli et al., 2017b). Baxter and Childs (2017) argued that the frequent dispossessing of products in AB-PSS hinders the development of psychological ownership and prevents product care. Indeed, many car-sharing users admitted abusing the cars and stated they felt no responsibility for potential long-term damages as those were the car sharing providers' responsibility (Bardhi and Eckhardt, 2012; Schaefers et al., 2016). Similarly, it has been reported that shared bicycles are frequently abused by users as well as non-users (Fishman, 2016). In stark contrast, a few studies suggest that consumers treat accessed products more carefully than owned ones (e.g., Baumeister and Wangenheim, 2014; Ozanne and Ozanne, 2011) or worry more about accessed products (Catulli et al., 2017a; Cherry and Pidgeon, 2018). Yet, this might be to avoid financial repercussions rather than because of a feeling of responsibility for the state of the product (Ozanne and Ozanne, 2011). Linder and Williander (2017) reported that uncertainties regarding the lifetime costs of an electric bicycle AB-PSS, influenced by external factors such as consumers' use of and care for the products, prevented the business model from being scaled up after a successful pilot.

While standard maintenance and repair are generally part of the service of the AB-PSS provider, users are still expected to take a reasonable level of care of the accessed products. For example, the Dutch companies Swapfiets (2019) and Homie (2019) offer AB-PSS for bicycles and washing machines respectively and take care of maintenance and repairs. The terms and conditions of Swapfiets (2019) state the expectation that "the Rental Customer makes normal use of the Bicycle and takes due care of the Bicycle"

and the service contract of Homie (2019) demands customers "to take good care of the washing machine". Overall, current literature is inconclusive about actual levels of product care in circular business models while a lack of care can be detrimental to their sustainability potential.

7.2.4 Consumers, business models, and product care

Business models govern the consumer-product relationship, we therefore take a business models perspective on product care in this study. We compare product care of consumers using bicycles and washing machines they own and consumers using these products through AB-PSS. To determine whether potential differences in product care are caused by ownership versus access or by linear versus circular business models we further differentiate ownership by whether products were obtained new through linear sales or used through second-hand sales. Second-hand sales and AB-PSS are both considered circular business models that facilitate product reuse (Lewandowski, 2016). While consumers can purchase second-hand products through different business models, we assume that these lead to similar product care behaviour. We found no quantitative study that provides a detailed understanding of product care or the lack thereof across different business models. We thus address the research question: How do circular business models influence consumers' product care?

Based on product care and circular business model literature, a conceptual model was developed to explain product care for products obtained through a) linear sales, b) second-hand sales, and c) AB-PSS (see Figure 13). In addition to the direct effect of business models on product care, the model also includes product-related and person-related variables because previous research has demonstrated their effect on product care (Ackermann et al., 2018, Cooper, 2004). Product-related variables comprise characteristics of the product and the consumer-product relationship. These include consumers' quality perception, satisfaction, attitude, involvement, and usefulness of the product as well as their disposal tendency and (emotional) attachment to the product. These variables were included because previous research has shown that the more positive a product is perceived by a consumer, the more he/she will take care of it (Mugge et al., 2005). Person-related variables describe attitudes and characteristics of the consumer that motivate him/her to consume in a conscious and environmentally friendly way. It includes frugality, environmental concern, long-term orientation and use innovativeness, which describes the tendency to use and alter products in a creative way. As previous research has shown (Ackermann et al., 2018), people vary greatly in their product care behaviour, and these individual traits seem to play a crucial role. However, we assume that these person-related variables might not only affect product care directly, but might also influence the decision to buy a product new or second-hand or to select an AB-PSS. Building on this extant literature, we developed our model that

includes the effect of business models on product care (1) and on product-related variables (2), and the effect of product-related variables on product care (3). Further, the impact of person-related variables on business model choice (4) as well as on product care (5) is included in the model.

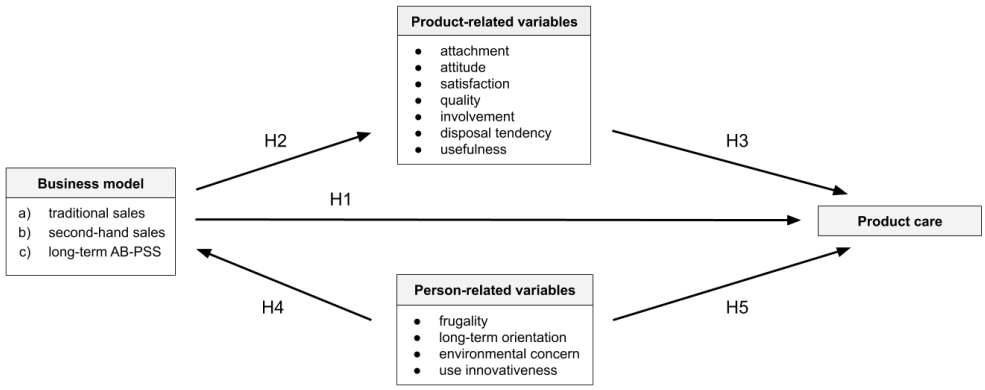

Figure 13: Conceptual model of factors that we expect to influence product care.

Based on the presented literature, we defined the following hypotheses:

H1: The business model influences the level of product care.

H2: The business model influences the product-related variables.

H3: The product-related variables influence the level of product care.

H4: The person-related variables influence the choice of business model.

H5: The person-related variables influence the level of product care.

7.3 Method

To explore product care in circular business models, an online survey was conducted to collect data from users of circular and linear business models. Subsequently, care levels were compared among the business models under investigation. The collected data was analysed using ANOVA and path analysis to gain a better understanding of the relationships between business models, person-related variables, product-related variables, and product care.

7.3.1 Survey

One survey with two versions focussing on respondents' everyday bicycle or washing machine was created. First, respondents were asked about their mode of consumption of that product; whether they bought it new, second-hand, use it through an AB-PSS, or another mode of consumption. Subsequently, several established scales were used to measure respondents' values, their perception of the product, and their level of product care for their bicycles and washing machines respectively.

The product care scale is based on extensive research by one of the authors that is currently under review. The 10 items always refer to a specific product, in our case to washing machines or bicycles. The scale consists of three subscales that represent main factors contributing to product care: The first subscale, relevance, describes general care behaviour and its importance to the consumer. It contains items such as "*I try to prevent my [product] from failure*" and "*It is important for me to take care of my [product]*". The second subscale, easiness, refers to the perceived ability of the participants to take care of their product (e.g., "*I am experienced in looking after my [product]*"). The third subscale, positive experience, refers to the emotional aspects of product care, such as the experience ("*In general, looking after my [product] is a positive experience*") and the feeling of taking care ("*Taking care of my [product] gives me a good feeling*").

We further included and tested 6 items from the environmental concern scale (Kilbourne and Pickett, 2008), 8 items from the frugality scale (Lastovicka et al., 1999), 9 items from the use innovativeness scale (Girardi et al., 2005), 8 items from the long-term orientation scale (Bearden et al., 2006), 5 items from the attitude scale (Ahluwalia and Burnkrant, 2004), 3 items from the usefulness scale (Cox and Cox, 2002), 3 items from the satisfaction scale (Crosby and Stephens, 1987), 4 items from the attachment scale (Schifferstein and Zwarthuis-Pelgrim, 2008), 4 items (as used in Bower and Landreth, 2001) from the involvement scale (Zaichkowsky, 1985), 3 items from the quality scale (Grewal et al., 1998), 4 items from the disposal tendency scale (Mugge, 2007). For the attitude, usefulness and satisfaction scales, a 7-point semantic differential was applied. All other variables were assessed with 7-point scales (1= strongly disagree to 7 = strongly agree).

7.3.2 Participants

The implementation and adoption of AB-PSS is still rare (e.g., Tukker, 2015; Tunn et al., 2020) which makes 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). Links to the survey were posted in social media groups for housing, second-hand furniture, and

second-hand bicycles to reach consumers using the business models under investigation. Business models for both products were defined as linear sales (n = 52), second-hand sales (n = 94), and long-term AB-PSS (n = 66). The sample comprises Dutch respondents and expats living in the Netherlands. However, the sample composition should not impact our results because the researched products primarily provide functional value and are widely used in the Netherlands, irrespective of cultural background. Of the 306 started surveys, 166 were completed (54%) and 212 surveys were sufficiently completed to be included in the analysis. Of the respondents, 58% are female and 75% were aged 30 or younger. Respondents could enter a prize draw to win a €10 gift voucher.

7.4 Results

The analysis of frequencies showed that care activities correlate with product care measured by the product care scale on a high level (r = .51, p< .01). The frequency in which respondents conduct product care activities differs among the three business models. For example, 14% of respondents who bought new bicycles, 23% of respondents who bought second-hand bicycles, and 69% of respondents using bicycles through AB-PSS indicated that they never oil the bicycle chain. Similarly, 25% of respondents who bought new washing machines, 20% of respondents who bought second-hand washing machines, and 59% of respondents with washing machines through reported that they never change the filter. The different levels of product care could be influenced by the costs and conditions that these business models imply for consumers. We therefore analysed the average expenditure of consumers in these business models. For instance, newly bought washing machines incurred high one-off costs for respondents (€485 on average) but typically come with a two-year warranty (e.g., www.coolblue.nl) during which the financial risk lies with the producer or vendor. In contrast, AB-PSS incur relatively low monthly costs (e.g., on average €17 per month or included in apartment rent) for consumers and replacing and fixing broken or malfunctioning products is generally the responsibility of the AB-PSS provider (Vermunt et al., 2019). Washing machines obtained through second-hand sales had significantly lower one-off prices (€90 on average) and consumers usually carry the financial risk for products bought second-hand. While the costs of the business models potentially impact product care, our focus is on exploring the relationships between business models, person-related aspects, and product-related aspects, and their effects on product care.

A Wilcoxon rank sum test revealed that product care for bicycles and washing machines does not differ significantly (W = 5669, p = 0.57). In addition, a one-way ANOVA for dependent samples demonstrated that the chosen business model predicts product

care for bicycles ($F = 5.936$, $p < .05$) as well as for washing machines ($F = 4.109$, $p < .05$), with the lowest product care level for the accessed products and the highest level for products that were obtained new through linear sales models. This result was explored in more detail by dividing the participants according to the business models. In these three groups product care also did not differ significantly between the two products. Thus, we decided to combine the data of bicycles and washing machines for the subsequent analyses. For the analysis of the product-related and the person-related variables, we calculated the means for each scale, with disposal tendency being recoded so that a high value represents a low tendency to dispose of the product. The hypotheses were tested through regression analysis, using the psych package of RStudio 1.1.463. The three business models were represented by dummy variables.

H1: The business model influences the level of product care.

A one-way ANOVA revealed that the business model has a significant influence on product care ($F = 11.01$, $p < .01$). Subsequent planned contrasts demonstrated that in the circular business models (second-hand sales and AB-PSS) product care was significantly lower ($t(209) = -2.15$, $p < .05$) than in the linear sales business model. Further, product care for products used through AB-PSS is significantly lower than for second-hand products ($t(209) = -3.10$, $p < .01$). Overall, products used through AB-PSS are taken care of the least ($M_{\text{AB-PSS}} = 3.78 \pm 1.44$), while products that have been obtained through linear sales ($M_{\text{linear}} = 4.56 \pm 1.34$) are being cared for the most. Product care for products obtained second-hand ($M_{\text{second-hand}} = 4.43 \pm 1.31$) lies in between these values. Respondents' mean product care levels for the three business models, and the two products are illustrated in Figure 14.

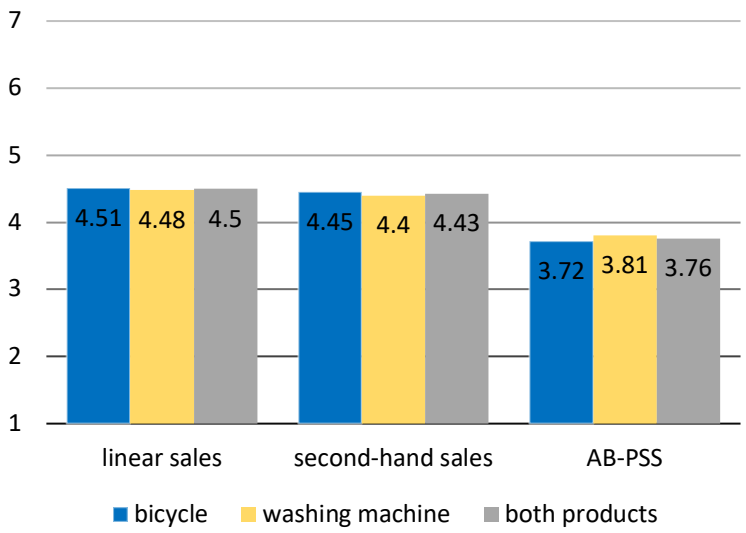

Figure 14: Mean of product care for bicycles, washing machines, and both products, used through different business models (scale from 1 low to 7 high).

H2: The business model influences the product-related variables.

The business model has a significant effect on attachment ($t(165) = -2.73$, $p < .01$) and disposal tendency ($t(165) = -2.18$, $p < .05$). This means that consumers have a high tendency to dispose products they use through AB-PSS ($M_{\text{AB-PSS}} = 4.71 \pm 1.00$); consumers might quit the AB-PSS or exchange the accessed product. Consumers' tendency to discard second-hand products ($M_{\text{second-hand}} = 4.89 \pm 1.28$) is slightly lower than for products used through AB-PSS but higher than for products obtained through linear sales ($M_{\text{linear}} = 5.24 \pm 1.19$). Further, consumers are more attached to washing machines and bicycles they bought second-hand ($M_{\text{second-hand}} = 4.05 \pm 0.97$) than to those they bought new ($M_{\text{linear}} = 3.66 \pm 0.95$) or to which they have long-term access ($M_{\text{AB-PSS}} = 3.16 \pm 0.99$). The evaluations of quality, attitude, involvement, satisfaction and usefulness are not significantly influenced by the business model, which means that a positive evaluation of products is also possible for products obtained second-hand and through AB-PSS.

H3: The product-related variables influence the level of product care.

All tested product-related variables influence product care on a significant level (attachment: ($t(165) = 4.84$, $p < .01$); attitude: ($t(168) = 3.99$, $p < .01$), disposal: ($t(165) = 3.10$, $p < .01$), involvement: ($t(168) = 4.74$, $p < .01$); quality: ($t(165) = 2.35$, $p < .05$); satisfaction: ($t(168) = 4.61$, $p < .01$); usefulness: ($t(168) = 2.53$, $p < .05$)). In general, the more positive a product is perceived by the consumer, the more he/she will take care of it. This holds true for more objective variables such as quality and usefulness, but also for emotional variables such as attachment, which is in accordance with previous research (Mugge et al., 2005).

H4: The person-related variables influence the choice of business model.

Effect estimates for the person-related variables on the business models were on a significant level for environmental concern ($t(172) = 3.05$, $p < .01$), for frugality ($t(172) = 2.08$, $p < .05$), but not for long-term orientation ($t(172) = 0.08$, $p = .94$) and use innovativeness ($t(172) = 1.29$, $p = .20$). This means that consumers decide to use an AB-PSS for reasons of sustainability, but also because they expect a financial advantage of this business model compared to buying the product.

H5: The person-related variables influence the level of product care.

Long-term orientation ($t(187) = 3.95$, $p < .01$), frugality ($t(187) = 3.07$, $p < .01$), and use innovativeness ($t(187) = 4.58$, $p < .001$) have a significant effect on product care. Use

innovativeness describes the tendency to use products in a creative way, to find new purposes for existing products and to change products according to one's needs. The relevance of use innovativeness can be explained by Fogg's (2009) behaviour model; to conduct a certain behaviour, motivation and ability are needed. Consumers with a high level of use innovativeness are often very hands-on, and experienced in craftsmanship, product care activities are thus easy to conduct for them. As product care often postpones the need for repair and contributes to an extension of products' lifetimes, it delays the purchase of repair services and new products, hence frugality also plays an important role in product care. Long-term orientation on the other hand serves as a strong motivator for product care as one part of a more sustainable way of consumption.

Subsequently, a path analysis was conducted to test the data for moderator and mediator effects. The model was built with product care as the dependent variable and the choice of business model as the independent variable. The product-related variables as well as the person-related variables were tested as moderator and mediator variables. However, no significant moderator or mediator effects were found. We can thus conclude that the above-mentioned direct effects (see Figure 15) estimates are suitable to describe our model.

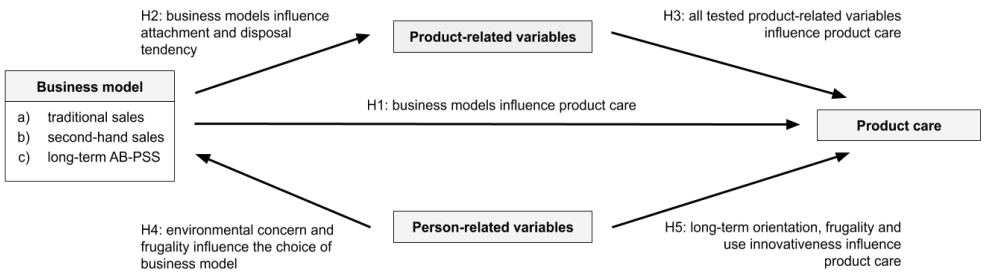

Figure 15: Overview of the significant effects found during the path analysis.

7.5 Discussion and recommendations

7.5.1 Discussion of findings

Extant research addressing product care in AB-PSS has been largely qualitative (e.g., Bardhi and Eckhardt, 2012) or conceptual (e.g., Tukker, 2004). While Agarwal et al. (2012) contrasted the sustainability of leasing and linear sales business models, and Schaefers et al. (2016) conducted a consumer survey to assess behaviour in a hypothetical car sharing service, we are not aware of previous research that quantitatively compared the levels of product care of actual users of circular and linear

business models. We are contributing a quantitative study of product care in linear and circular business models that elucidates antecedents of product care and business model choice. Our findings demonstrate that product care varies among business models; being highest for products that consumers obtained new through linear sales business models and lowest for products used through AB-PSS. Therewith, these results quantitatively confirm what Tukker (2004) theorised and Bardhi and Eckhardt (2012) found qualitatively. In addition, these results are translated into design strategies to stimulate product care in AB-PSS as available design strategies focused on owned products (Ackermann et al., 2020). While the existing design strategies aim to influence the consumer-product relationship, designing for product care in AB-PSS also has implications for communication and contract design. These design strategies are presented in the next section.

We found that product care was on a moderate level across the examined business models. This result supports findings from the literature (Brook Lyndhurst Ltd., 2011) indicating that workhorse products, in other words products that mainly serve a functional purpose, are taken care of less than, for example, investment products that are either expensive or are in another way special to the consumer (e.g., because of a feeling of emotional attachment). Further, product care did not significantly differ between washing machines and bicycles. Both products are durable, provide primarily functional value, and product care is not complex; the findings can thus be generalised for products with similar properties, such as dishwashers. The findings might not be applicable to products primarily providing emotional value yet these products are generally less suitable for AB-PSS (Schrader, 1999; Stahel, 2010). Further, we can extrapolate from our findings that product care levels are likely to be even lower in short-term AB-PSS because damages are harder to retrace and can also be the result of vandalism by non-users. On top of that, consumers do not rely on one specific product to obtain the desired functionality when using short-term AB-PSS; if one product is broken or breaks, consumers can easily access another one (see Schaefers et al. (2016) for more insights into product care in short-term AB-PSS). Hence, consumers might take even less care of products used through short-term AB-PSS than of those used through long-term AB-PSS.

Business models influence consumers' disposal tendency which also influences the sustainability of AB-PSS. If AB-PSS encourage consumers to use the service more or stimulate frequent product replacement the additional impacts of logistics, cleaning, and eventual remanufacturing of products, might outweigh potential sustainability benefits. AB-PSS may even heighten consumers' expectations regarding the state of the product so that no traces of use are acceptable resulting in products and components requiring remanufacturing or becoming obsolete sooner than in ownership. Our results

suggest that the 'soft' benefits of ownership that enhance product care, such as product attachment, are lacking in AB-PSS thus confirming Baxter and Childs' (2017) research. However, product attachment is not low in all circular business models; interestingly, consumers were more attached to products they bought second-hand than to products they bought new while levels of product care were at comparable levels in these business models.

7.5.2 Recommendations for practice

Based on our findings we suggest three design strategies to stimulate product care in circular business models with a focus on AB-PSS. First, products placed in circular business models should be designed to increase product care. This could be achieved by transferring the design strategies to stimulate product care for owned products introduced earlier in this paper. For example, the informing and enabling strategies could be used to make product care easy for AB-PSS users as the user and provider have an ongoing relationship. Care activities could be made easy by providing product care as a service so that consumers do not have to organise care activities themselves. Alternatively, users could receive the appropriate tools and information for product care when they initially obtain the product. In addition, appropriation could be stimulated by designing elements into circular business models and in particular into AB-PSS to create attachment, for instance, by temporarily customising the products (Tunn et al., 2019b). These strategies could increase product care and might also discourage frequent replacement of accessed products, thereby mitigating potential rebound effects and helping AB-PSS providers to ensure that the AB-PSS are financially viable. In general, providers of circular business models should make product care as easy and as relevant as possible for consumers. Yet, it is again important to ensure that if repair and maintenance services are offered they are not overused or lead to an abuse of the products.

Second, during product design the business model through which the product will be used should be considered to design for the anticipated consumer behaviour and level of care. For example, products for long-term AB-PSS should be designed to be especially durable, easy to repair and maintain (see e.g., van Nes and Cramer, 2005), of high quality, and long-lasting to withstand poor care. Thereby, designers can ensure that AB-PSS actually improve sustainability (see Agarwal et al., 2012; Kjaer et al., 2019). Similarly, products that are designed in this way for linear sales models are more likely to last and be eventually sold through second-hand sales. These sustainability benefits should be communicated to consumers because environmental concern significantly influences consumers' business model choice.

Third, product care should also be considered when developing circular business models. Business models can be implemented and designed to encourage consumers to take care of products. For example, by offering incentives such as a financial refund if consumers return products in a good state – this applies to both AB-PSS and second-hand sales. Alternatively, in AB-PSS the expected level of product care can be specified in the contract between the AB-PSS provider and the users, penalising users if they do not take sufficient care of the products. This again needs to be clearly communicated to consumers in order to encourage product care and to prevent consumers from being surprised by fines.

7.5.3 Limitations and recommendations for future research

Our research set-up implies several limitations. Online surveys are prone to yield results influenced by social desirability of behaviours. However, it was necessary to resort to an online survey as AB-PSS users are difficult to identify. In addition, our results show that overall product care levels are only moderate whereas high product care levels are socially desirable. The anonymity of the online survey might have in fact encouraged consumers to be honest about their use behaviour. This leads to the next limitation, in our study we collected data on self-reported product care rather than objectively measured or observed product care. We encourage using different research methods to further explore this phenomenon, collecting and comparing data on actual use behaviour and on wear and tear of products across different business models would be very insightful.

Based on our research we suggest several directions for future research. We recommend future studies with larger, representative samples to allow for structural equation modeling, this could help to understand the relations between the variables even better. This approach would also allow to explore additional variables and constructs that might influence product care, such as the product's price or the financial risk of product failure, social control or other "soft" factors (e.g., psychological ownership). Further, future research could compare a wider range of products with different price points and include products that provide intangible value (e.g., clothing and cars). As a next step, we would then suggest testing the proposed design strategies for product care through small-scale experiments in practice.

While we did not specifically explore the impact of product price on product care, it is likely that consumers' costs and financial risks associated with the business models influence product care. Consumers' financial risk of product failure is determined by the price of the product and by contractual conditions that govern the responsibilities for the product. Hence, it is likely that consumers take better care of product if the financial risk of product failure is high for them. The effects of social connections and awareness

as well as consumer acceptance of products that take over control to ensure product care are also interesting topics for future research. In addition, qualitative elements could be added in future studies to understand consumers' decisions better and to inform the improvement of circular business models. Finally, conducting a similar study in another cultural context where AB-PSS are perceived differently (Iran et al., 2019) could show whether culture also impacts product care in AB-PSS.

7.6 Conclusions

Product care differs significantly between business models. Levels of product care are significantly lower in business models that provide access (AB-PSS) than in business models based on selling products to consumers (linear sales and second-hand sales). Yet, product care was only moderate across all three analysed business models. Several factors directly and indirectly influence product care; consumers' environmental concern influences their choice of business model which in turn impacts consumers' attachment to products which then influences product care. In addition, consumers' long-term orientation and use innovativeness positively influence product care. Our findings show that circular business models such as second-hand sales can lead to product care levels similar to linear business models. However, product care for functional products such as washing machines and bicycles was moderate across the examined business models and should be encouraged through product design, service elements, and contract design. We therefore developed design strategies to stimulate product care in AB-PSS in which it is particularly problematic. We recommend to generally apply the presented strategies when designing circular business models to increase their sustainability potential by avoiding rebound effects related to poor product care.

Chapter 8
Conclusions

8.1 Summary of main findings

The studies presented in this thesis investigate the design, adoption, and use of circular business models from a consumer perspective. The findings of this thesis provide insights that help elucidate the overarching research question: *How can circular business models be developed to enable sustainable consumption?* The research addressed three key challenges identified in the introduction chapter, namely 1) uncertainties regarding the design of circular business models that lead to sustainable consumption, 2) a lack of consumer adoption of circular business models, and 3) a lack of understanding of consumers' use experiences and behaviours in circular business models. The structure of this section mirrors that of the introduction; the main findings related to the design, adoption, and use of circular business models are presented.

Circular business models should be *designed* to contribute to sustainable consumption. The design of circular business models to achieve sustainable consumption was explored in Chapter 2. Several elements of business models can enable sustainable consumption. In particular, an organisations' resource strategy, revenue model, objective for consumption level, and the consumer effort to use their offering, are business model levers for sustainable consumption. Each of these elements provides a range of options that can be combined to describe business models for sustainable consumption in the circular economy.

To enhance consumer *adoption* of circular business models, adoption barriers need to be identified and addressed. Three studies investigated the adoption of circular business models, more specifically of AB-PSS, and were presented in the Chapters 3, 4, and 5. First, consumers' AB-PSS adoption motivators and barriers were identified (Chapter 3). Consumers tend to compare the perceived benefits and drawbacks of AB-PSS with the purchase of the product. A follow-up study showed that adoption barriers significantly differ between short-term and long-term AB-PSS and different products (Chapter 4). Consumers' preference for short-term AB-PSS is strongly influenced by barriers related to service aspects whereas barriers related to the products have a greater effect on consumers' preference for long-term AB-PSS. One barrier to consumer

adoption of long-term AB-PSS is that accessed products, such as shared bicycles, usually do not provide intangible value (Chapter 5). Temporary customisation through adding a small, personalised part was explored as a way to increase the relevance of products to individual consumers while maintaining products' relevance for the general market. A fit between product and consumer personalities increases preference for the associated AB-PSS.

The *use* of circular business models influences consumers' perception and the sustainability of consumption. Two studies explored the use of circular business models and were presented in the Chapters 6 and 7. In Chapter 6, the influence of digital AB-PSS aspects on consumers' attitudes and use experiences was analysed. Consumers perceive digital components as indispensable in short-term AB-PSS and as nice-to-have in long-term AB-PSS. Further, consumers' digital confidence influences their attitude towards digitalised short-term AB-PSS because these often rely on digital components. In Chapter 7, consumer product care during the use phase of products was explored as this care affects the sustainability potential of circular business models. Consumers tend to take better care of products they own than of those used through long-term AB-PSS, irrespective of whether products were bought new or second-hand. Yet, product care for owned products was also only moderate. This indicates that well designed AB-PSS could increase product lifetimes if the products are durable and the contractual conditions and communication are designed to foster product care.

8.2 Implications for theory

In this section, the value of the findings of this thesis is outlined. First, the contributions to theory are presented and discussed in the context of extant literature. Then limitations of the presented studies and avenues for future research are highlighted.

8.2.1 Contributions to theory

The research presented in this thesis contributes a consumer perspective to the academic discourse of *circular business models*. Several authors have criticised that the consumption side has received little attention in the circular economy and circular business model debate (Camacho-Otero et al., 2018; Elzinga et al., 2020). To address these shortcomings of the current circular business model literature, this thesis explored the design, adoption, and use of circular business models. Several different methods were applied to explore these aspects (e.g., qualitative interviews, quantitative online surveys, conjoint experiments). As a result of the taken mixed methods approach, this thesis offers multi-facetted insights into the development of sustainable, circular business models for consumer markets, bridging the fields of circular business models and sustainable consumption. In the following, the

contributions of this thesis to the research fields of circular business models and product-service systems are outlined and discussed.

Chapter 2 built on business model (e.g., Osterwalder et al., 2005; Richardson, 2008) and sustainable business model literature (e.g., Bocken and Short, 2016) and incorporated sustainable consumption (e.g., Jackson, 2005; Lorek and Spangenberg, 2014). Through two rounds of iterative interviews with circular economy and sustainable consumption experts, business models emerged that combine these fields. This study provides a framework for the development of business models that combine these objectives. The findings of this study suggest that the availability of diverse business models for sustainable consumption would be beneficial as this would enable consumers with different needs and lifestyles. This is also reflected in the current business model landscape in which even individual companies operate several circular or circular and linear business models in parallel (Whalen, 2017).

The studies included in this thesis aimed to develop insights to inform circular business model development in practice. In contrast to many previous studies that relied on hypothetical, circular business models (e.g., Armstrong et al., 2015; Catulli et al., 2013; Cherry and Pidgeon, 2018; Rexfelt and Hiort af Ornäs, 2009), the circular business models investigated in this thesis have either already been implemented in practice or closely resemble existing circular business models. For several studies presented in this thesis users of circular business models were sampled (Chapters 3, 6, 7).

Further, this thesis contributes the first quantitative comparison of consumer product care in linear and circular business models. In Chapter 7, a quantitative comparison of product care in linear and circular business models was presented as product care influences the sustainability of circular business models. This study quantitatively confirms that product care is lower in AB-PSS than alternative ownership models as theorised by Tukker (2004), qualitatively observed by Bardhi and Eckhardt (2012), and noted by Sumter et al. (2018). Thus, low levels of product care are likely to decrease the durability of leased products and thus the sustainability of leasing AB-PSS in comparison to ownership.

In addition, this thesis contributes a better understanding of consumers' adoption, experience and behaviour within AB-PSS to the *product-service system* literature. Product-service systems are one category of circular business models. More specifically, in the Chapters 3 to 5 the adoption of AB-PSS was investigated with a focus on mobility AB-PSS. Chapter 6 shed light on the digital side of contemporary mobility AB-PSS and consumers' perception thereof. The contributions of these studies to the product-service system literature are outlined in the following.

This thesis adds insights into why consumers adopt or reject AB-PSS (Chapter 3). Building on previous literature (e.g., Mont and Plepys, 2003; Rexfelt and Hiort af Ornäs, 2009; Schrader 1999), barriers to consumer adoption were identified through a literature review and analysed using Rogers' (1995) innovation attributes in Chapter 3. Many adoption barriers were identified due to the inherent complexity of AB-PSS, barriers can relate to product, service, and infrastructure aspects. Further, most adoption barriers relate to consumers' perceived lack of relative advantage of AB-PSS compared to ownership.

This thesis contributes the identification of two factors that influence AB-PSS consumer adoption barriers, namely the duration of access and the type of product (Chapter 4). These factors correspond to two of Bardhi and Eckhardt's (2012) six AB-PSS dimensions. Our findings highlight that the type of product and duration of use are crucial aspects to be considered when designing AB-PSS for the consumer market.

This thesis presented and tested temporary customisation as a way to embed intangible value in long-term AB-PSS in order to increase consumer preference for the service (Chapter 5). Previous literature recommended adding intangible value to AB-PSS (Armstrong et al., 2015; Catulli et al., 2017b; Tukker, 2015). This study demonstrates that intangible can be added to long-term AB-PSS through temporary customisation, this entails personalising an easily detachable component of the product.

In addition, this thesis contributes a better understanding of consumers' use of AB-PSS. In Chapter 6, the effects of digitalised AB-PSS on consumers' use experiences and attitudes were explored which previously had not been studied from a consumer perspective (e.g., Alcayaga and Hansen, 2020; Bressanelli et al., 2018; Ingemarsdotter et al., 2019). The findings show that digital AB-PSS components as well as consumers' digital confidence are more relevant in short-term AB-PSS, which require frequent digital interaction with the AB-PSS provider, than in long-term AB-PSS. Our findings thus confirm Belk's (2014b) assertion that digital components are less relevant in long-term AB-PSS.

8.2.2 Limitations

The sampling approaches and the chosen scope of this thesis imply some limitations. The limitations resulting from the overall approach are outlined in this section and complemented with suggestions for future research. The method and study-specific limitations have been discussed in the previous chapters.

One limitation is that the majority of studies included in this thesis were conducted in the *context of the Netherlands*. The consumer studies presented in the Chapters 3 to 7 are based on samples of consumers living in the Netherlands; thus, conducted within a

specific context. For instance, the Netherlands are densely populated and have a landscape and infrastructure that is advantageous for circular business models such as bicycle AB-PSS, similar AB-PSS might face different challenges in mountainous countries or countries with poor bicycle infrastructure. Hence, not all findings can be directly transferred to other countries. Additionally, the circular economy is high up on the Dutch governments' agenda which aims to transition to a circular economy by 2050 (Government of the Netherlands, 2020). The overall findings can be cautiously generalised by taking contextual differences into account, such as geographical and infrastructure conditions, and socio-cultural factors (e.g., Armstrong et al., 2016; Gaur et al., 2018; Iran et al., 2019). We applied sampling approaches that facilitated answering the research questions under investigation but we do not claim that the samples are representative of the general Dutch population. For example, in Chapter 7 we investigated users' behaviour in different circular business models and thus only sampled participants who use one of these business models. Similar studies with larger samples, in different geographical and cultural contexts, and comparisons between cultural contexts are encouraged.

Another limitation results from the *focus on AB-PSS*, one category of circular business models, in several studies. This focus on AB-PSS was necessary to obtain meaningful insights but might hamper wider generalisation. However, many other circular business models also face barriers entering the consumer market (Rizos et al., 2016; Vermunt et al., 2019). For example, both remanufactured and products in AB-PSS frequently lead to negative consumer perceptions (Camacho-Otero et al., 2017). It would thus be interesting to explore to what extend consumer adoption barriers and use experiences were similar across circular business models to transfer insights. In addition, studies comparing the environmental benefits of different circular business models are needed.

Finally, the studies presented in this thesis investigated *specific products and industries* which might hamper wider generalisation of the findings. Throughout this thesis several studies examined consumers' adoption and use of mobility AB-PSS (Chapter 3) and in particular bicycle AB-PSS (Chapters 4, 5, 6, 7). In addition, clothing was analysed in two studies (Chapter 2, 4) and washing machines in one (Chapter 7). In two chapters products were compared; in Chapter 4 the adoption of AB-PSS for clothes and bicycles was contrasted and in Chapter 7 the use of different business models for washing machines and bicycles was analysed. Both studies resulted in findings that were similar for the two products. The main findings of the chapters are likely to be generalisable for other products, for example, consumers' digital confidence is probably important for consumers' attitude towards all kind of products and services that involve digital components and not just digitalised AB-PSS (Chapter 6) and factors that are generally relevant for a specific product category (e.g., contamination for clothes) are even more

relevant for AB-PSS (Chapter 4). Overall, the focal products were selected because circular business models are already available for them in practice, hence consumers' reactions to them have a higher validity and the obtained insights can inform the development of similar business models for other products.

8.2.3 Avenues for future research

Based on the findings in this thesis, four areas are suggested for future research: 1) role of digitalisation in circular business models, 2) financial implications of AB-PSS for consumers, 3) segmentation of the consumer market for circular business models, and 4) the sustainability of circular business models. These four areas are presented in the following.

One area that has received relatively little attention in the circular economy debate is *digitalisation*. Digitalisation has enabled many new circular business models and is likely to play an important role in the future development of these business models. For example, the recent bourgeoning of mobility AB-PSS (i.e., Felyx; Lev; Mobike) can be largely attributed to digitalisation (Chapter 6). Other circular business models have also benefitted from digitalisation; for instance, over the last few years many digital platforms have emerged that connect consumers and companies in order to decrease waste and idling resources (also see Konietzko et al., 2019). Consumers are increasingly using smartphones and digital services and digital technologies are developing at breakneck speed. The implications of these trends are two-fold for circular business models; first, the market for digitalised, circular business models is likely to expand and second, technological developments such as the implementation of the 5G mobile network will open up new possibilities for circular business models. In addition, more platforms are needed to unite circular business models and make them more accessible to consumers. For example, many consumers now have several apps for different mobility AB-PSS installed on their smartphones (i.e., over time my partner installed 19 mobility AB-PSS apps on his smartphone; 10 car sharing and renting apps, 5 bike sharing apps, and 4 e-scooter sharing apps). In response to this challenge, the company Hely.com started to serve as a platform access shared vehicles of various AB-PSS providers. These are some preliminary insights, more research into how digitalisation and platforms enable circular business models and could increase consumer adoption is needed.

A second area relates to the *financial implications* of circular business models for consumers. A shift towards more AB-PSS implies changes of consumers' expenditure patterns. Instead of encountering high, one-off investment costs for products and maybe eventually repair costs, consumers commit to monthly payments when consuming through AB-PSS. While consumers obtain ownership through purchasing

products and therewith the right to resell the products at a later time this is not the case in AB-PSS where the provider retains ownership. Hence, questions have been raised regarding the consequences of unemployment or health issues, in other words a sudden drop or loss of income, for consumers' accessed products (Cherry and Pidgeon, 2018; Samadder, 2019). Would consumers inability to pay the monthly fees lead to a complete removal of the accessed products? Would AB-PSS providers downgrade these consumers to a cheaper, basic version of the accessed products? Can consumers estimate the costs of accessed products over the product use time? What would AB-PSS imply for consumers ability to build financial assets, for example, for their own retirement or to support their children? In addition, some consumers generally dislike fixed monthly payments (Catulli et al., 2013; Lidenhammar, 2015; Rexfelt and Hiort af Ornäs, 2009). A shift towards consumer AB-PSS for many essential products might also require a new type of social security or insurance to safeguard consumers in times of sickness or unemployment and in old age. More research is needed to understand the financial consequences for consumers of widely implementing AB-PSS.

A third area for future research is the development of a *segmentation* approach of the consumer market for circular business model. Consumers' preference for specific circular business models is influenced by consumers' lifestyles and values (e.g., Mugge et al., 2017). For example, rental furniture could be very attractive for exchange students who would use it for six months while it might be less suitable for a settled family. It has been suggested that a diversity of circular business models would be beneficial to enable many consumers to consume sustainably (Chapter 2). Exploring which circular business models are most suitable for different consumer segments, for instance based on consumers' lifestyles and attitudes, could speed up the adoption of different circular business models.

A fourth research area relates to the *sustainability* of circular business models. Business models coined *circular* do not necessarily improve environmental sustainability. One major problem is that it is widely assumed that secondary production will substitute primary production and thereby decrease material throughput. Yet, in practice secondary production could occur in addition to primary production or only partially substitute the latter, thereby circular business models might only slightly decrease environmental impacts or even increase them (Makov and Font Vivanco, 2018; Zink and Geyer, 2017). AB-PSS in particular have received attention for their circularity potential as well as criticism for short-comings in terms of their environmental sustainability in practice (Agrawal et al., 2012; Bardhi and Eckhardt, 2012; Mont, 2004b; Tukker, 2004). The sustainability potential of AB-PSS assumes that product utilisation is increased during products' lifetimes, either by intensifying product use or by extending product lifetimes (Hollingsworth et al., 2019; Tukker, 2004; Yang and Evans, 2019; Zamani et al.,

2017). Yet, product lifetimes might be shortened in AB-PSS compared to ownership if consumers treat accessed products carelessly (Bardhi and Eckhardt, 2012; Chapter 7; Sumter et al., 2018). In addition, Agrawal et al. (2012) demonstrated that the environmental sustainability potential of leasing AB-PSS is highly dependent on the type of product placed in them as extending the lifetime of products with high use impact is unsustainable if technological developments improve their efficiency. Consequently, AB-PSS need to be designed for sustainability and circularity (Kjaer et al., 2019). Overall, quantitative assessments of the environmental impacts of circular business models and AB-PSS are still lacking and present a vital next research step to ultimately guide the development of sustainable, circular business models.

8.3 Implications for practice

The practical relevance of CBMs motivated me to pursue this PhD. In this section, the implications of the research findings for practice are discussed. First, the extent and way in which circular business models can contribute to sustainable consumption in practice is illustrated using exemplary cases. Thereafter, this thesis closes with practical recommendations for organisations interested in developing circular business models for consumer markets.

8.3.1 Circular business models for sustainable consumption?

In this section, the overarching research question: How can circular business models be developed to enable sustainable consumption? is discussed as the specific findings of the studies have been discussed in the respective chapters. While this thesis primarily focused on the consumption phase, sustainability should be addressed in all lifecycle stages of circular products and services for them to contribute to sustainable consumption. In the circular economy the lifecycle of products and services comprises the production, consumption, and end of life phases. The specific configuration of these phases influences the contribution of a circular business model to sustainable consumption. In the following, I use a few cases that I have studied closely during my PhD to illustrate how sustainability can be stimulated through circular business models and associated challenges. The following cases illustrate how diverse and context-specific circular business models are (Ünal et al., 2019).

The circular business model of Fairphone (www.fairphone.com) aims to improve the sustainability of the production and consumption of smartphones. Fairphone is committed to sourcing socially and environmentally sustainable components and smartphones are designed to be modular and thus easily repaired by consumers. The price of spare parts for Fairphone smartphones is much lower (e.g., €83,29 for a Fairphone 3 display) than the price of the smartphone (€400 for a Fairphone 3) thereby

encouraging consumers to replace broken components rather than the entire smartphone. The business model of Fairphone raises their customers' awareness for product repairs, potentially resulting in spillover effects to related behaviours such as repair of other products (Thøgersen and Ölander, 2003).

HOMIE (www.homiepayperuse.com) on the other hand operates a long-term AB-PSS for white goods appliances such as washing machines and focuses on the consumption phase. The company was founded in 2016 as a university spin-out to explore whether a pay-per-use business model could be used to steer consumers towards more sustainable behaviour. HOMIE retrofits standard washing machines with sensors to digitally transmit consumers' usage data over the internet. Users pay for each use of the washing machine, thereby HOMIE creates awareness for washing frequency and disincentivises the washing of half-loads. In addition, the price per wash depends on the sustainability of the selected programme, the higher the temperature the higher the price while selecting the eco-mode reduces the price. This pricing structure steers consumers towards more sustainable washing behaviour. (Bocken et al., 2018) Yet, as a relatively small company HOMIE uses standard appliances and has no influence on the production of the machines. Similarly, HOMIE cannot (currently) set-up a fully-fledged remanufacturing or high-value recycling system themselves because of the relatively low volume of appliances. The sustainability of HOMIE's service in the production and end-of-life lifecycle stages thus depends on finding suitable suppliers and partners.

The business model of Leapp (www.leapp.nl) is built on the refurbishment of used Apple-branded devices and thus addresses the consumption and end of life phases. Leapp obtains used devices such as smartphones, tablets, and laptops, then tests, cleans, and repairs them. The refurbished devices are sold to consumers for around 30% below the price of the new devices. Refurbished products from Leapp come with a two-year warranty to overcome consumers' uncertainties regarding the reliability and quality of refurbished products (Van Weelden et al., 2016). The refurbishment of these devices can potentially contribute to sustainable consumption as the devices' lifetimes are extended. However, consumers might not purchase refurbished devices instead of new ones but purchase refurbished devices in addition to new ones (Makov and Font Vivanco, 2018; Zink et al., 2014). In addition, Leapp cannot influence the production of the devices while design changes decided by Apple can make refurbishment more difficult and expensive.

OV-fiets provides a short-term AB-PSS for bicycles in which sustainability is considered in all lifecycle phases. OV-fiets rents out bicycles at railway stations for 3,85€ for 24 hours (NS, 2020). The bicycles are specifically designed for this system: the frame is sturdy, the saddle easily adjustable, and the components are built to last. The system is also designed to stimulate desirable consumer behaviour, consumers access and return

the bicycles at railway stations by having their registered railway cards scanned, often by service personal. This ensures visibility and accountability of consumers for the state of the bicycles after use. Further, this system encourages the use of public transport by solving the last mile problem. Finally, at the end of life OV-bikes are remanufactured by their partner Roetz, a company with a circular business model focused on the remanufacturing of bicycles. Roetz remanufactures 70% of the components of OV-bikes that are then used in the production of new OV-bikes. (Roetz, 2020) This service stands out because sustainability is considered in the design of all lifecycle stages and the service is integrated with other sustainable modes of transport.

These cases illustrate that circular business models can take many forms and shapes depending on the providing company. Circular business models should not be directly transferred between contexts. Instead, the wider ecosystems of circular business models should be considered to assess their impact on sustainable consumption (Konietzko et al., 2020a). Further, the successful development and implementation of circular business models is often only achieved through collaboration (Brown et al., 2019; Sousa-Zomer et al., 2019).

8.3.2 Developing circular business models for the consumer market

In this section, I provide recommendations for the development of sustainable circular business models for the consumer market are provided based on insights I obtained during my PhD. These recommendations are targeted at practitioners interested in circular business models, such as business developers, service and product designers, entrepreneurs, and consultants. Overall, I found that the development of circular business models is complex because they need to simultaneously contribute to the companies' bottom line, sustainability, and satisfy consumers. Several tools have been proposed to aid the development and implementation of circular business models (e.g., Baldassarre et al., 2020; Chapter 2; Konietzko et al., 2020b). Developing circular business models for consumer markets adds an additional layer of complexity because consumers are often less rational in their decision making than procurement departments of organisations. In the following, advice for the development of sustainable circular business models that appeal to consumers is outlined.

Circular business models need to be purposefully designed to support sustainable consumption. As explained in the previous section, sustainability needs to be considered in all lifecycle stages of circular business models. This means that sustainability should be considered in the design, production, consumption and end of life phases. For example, the sustainability of production should be improved by selecting suitable sustainable resources (e.g., renewable or recycled materials), and by

reducing material input (Chapter 2). Companies can also shape the consumption phase, for instance, by providing care instructions or maintenance services. In addition, companies should aim to reduce overall consumption levels through strategies such as the design of durable products (reducing the replacement frequency) or by providing shared products (potentially decreasing the number of idling products). It is also important to consider what a circular business model replaces, for instance, whether a refurbished smartphone is purchased instead of a new smartphone. Finally, companies should delay the end of life of products and ensure that product components can ultimately be reused or recycled.

The same aspects also need to be considered when designing sustainable AB-PSS. In addition, it is crucial that AB-PSS increase product utilisation during the products' lifetimes compared to similar owned products. Companies can achieve this either through intensified use in short-term AB-PSS (i.e. sharing services) and through extended product lifetimes in long-term AB-PSS. Further, additional impacts related to the service such as logistics, spare parts, infrastructure etcetera need to be considered. The sustainably of AB-PSS is highly dependent on the exact configuration of the AB-PSS and the context. For example, while the bicycle sharing system OV-fiets contributes to circularity and sustainability, many other bicycle sharing services probably have a negative impact on the environment based on the short lifetimes of the products.

Circular business models need to be perceived as attractive by consumers to be adopted. Companies developing circular business models need to identify the benefits relevant that are for consumers. Companies should identify and address the most prevalent adoption barriers, for AB-PSS companies can identify the most important adoption barriers based on the type of product and duration of access to the product (see Chapter 3 and 4). Barriers and needs that are generally important for a product category are even more important in AB-PSS (e.g., contamination is very important for clothing AB-PSS). In short-term AB-PSS, service aspects should receive special attention while product aspects are more important in long-term AB-PSS. Similarly, digital aspects are more important in short-term AB-PSS than in long-term AB-PSS because these generally support service components (see Chapter 6). For digital AB-PSS aspects to increase consumer satisfaction, companies need to ensure that the digital aspects are well embedded in the service, user-friendly, and reliable. In general, companies should provide convenient digital communication channels as these fit into digital consumers' lifestyles. To appeal to many consumers, prototypical products should be placed in AB-PSS. For products provided through long-term AB-PSS companies can provide sustainable (easily reversible) personalisation options to enhance consumer preference (see Chapter 5).

To conclude, many circular business models are imaginable for the consumer market. In general, a diversity of circular business models is beneficial in the consumer market as these enable diverse consumer segments to consume sustainably. Yet, the development of circular business models for the consumer market is complex because local regulations, culture and infrastructure, the target segment, and many other contextual factors need to be considered.

To ensure sustainability, circular business models, including AB-PSS, need to be designed to contribute to sustainability considering all lifecycle phases of the product or service. Companies should invest time to identify suitable circular business models and adjust them to the specific context they operate in to ultimately deliver benefits for the company, consumers, and the environment. Finally, the successful development and implementation of circular business models will likely always require multiple iterations to satisfy consumers, be economically viable and sensible, and contribute to sustainability.

Since the start of this PhD project in November 2016, public awareness for environmental issues has increased dramatically. Yet, most circular business models only recently have been introduced on a small scale or tested in consumer markets. Many circular business models are still new to consumers; the majority of whom have not yet heard about them let alone tried them. Given the increasing environmental awareness, the diffusion of circular business models in consumer markets is likely to accelerate over the next years.

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Appendices

Appendix A: AB-PSS scenarios (Chapter 4)

Scenario 1: Short-term bicycle sharing

Ingrid lives in a city in the Netherlands and works for a company in her town. Twice per month she has appointments with clients in another city. The best way for Ingrid to get to the clients' office is to catch a bus and then use a bike. In the city where her clients are based several bicycle-sharing companies are operating. All available bicycle-sharing offers are supported by a smartphone application and website. Ingrid can find user reviews of the short-term bicycle-sharing companies online. GPS data on the companies' websites and in the smartphone application help her to find the nearest bicycle. She has to decide which bicycle-sharing company to choose. Please help Ingrid to evaluate the different bicycle-sharing companies for her client visits twice per month.

Scenario 2: Long-term bicycle leasing

Ingrid lives in a city in the Netherlands. She would like to cycle to work. She is very busy at work and not good at fixing bicycles herself. She is considering leasing a bicycle for her daily commute to work. For a monthly fee Ingrid would get a bicycle, and the company takes care of standard maintenance and repair during the leasing period. The maintenance and repair services are provided at a convenient location, for example, outside Ingrid's home or office. All available bicycle leasing offers are supported by a smartphone application and website. Ingrid can find user reviews of the long-term bicycle leasing companies online. GPS data on the companies' websites and in the smartphone application help her to find the nearest service points where bicycles are issued. She has to decide which bicycle-leasing company to choose. Please help Ingrid to evaluate the different bicycle-leasing companies for her daily commute to work.

Scenario 3: Short-term rental clothes

Ingrid lives in a city in the Netherlands. She works for a company with a casual dress code. Twice per month she has meetings with clients from the financial sector. She needs to wear formal clothes during these meetings. She is considering rental clothes as they would allow her to change outfits frequently and she would only have to pay for the clothes for the limited time when she needs them. When clothing is returned it is cleaned professionally. Rental clothes typically maintain their shape, colour and feel throughout many washing cycles and are in a visually attractive state. All available rental-clothes offers are supported by smartphone applications and websites. Ingrid can find user reviews of the short-term rental clothes companies online. GPS data on the companies' websites and in the smartphone application help her to find the nearest

location for picking-up and returning clothes. She has to decide which rental-clothes company to choose. Please help Ingrid to evaluate the different rental-clothes companies to rent formal clothes for client meetings twice per month.

Scenario 4: Long-term leasing clothes

Ingrid lives in a city in the Netherlands and needs 3-4 different jackets per year to match the different seasons. She has little storage space in her home and is considering to lease jackets according to the seasons. For example, when spring starts Ingrid would receive the corresponding jacket and return the winter jacket. When clothing is returned by a customer it is cleaned professionally. Leasing clothes typically maintain their shape, colour and feel throughout many washing cycles and are in a visually attractive state. All available leasing clothes offers are supported by smartphone applications and websites. Ingrid can find user reviews of the long-term clothing-leasing companies online. GPS data on the companies' websites and in the smartphone application help her to find the nearest location for picking-up and simultaneously returning clothes. She has to decide which clothing-leasing company to choose. Please help Ingrid to evaluate the different clothing-leasing companies for leasing jackets for the different seasons.

Appendix B: Orthogonal design (Chapter 4)

Card	Code	Effort to access	Contamination	Trust	Product Quality	Product Characteristics
1	*	Level B	Level B	Level B	Level B	Level A
2	+	Level A	Level A	Level B	Level B	Level B
3	=	Level A	Level B	Level B	Level A	Level B
4	?	Level A	Level B	Level A	Level B	Level A
5	!	Level A	Level A	Level A	Level A	Level A
6	/	Level B	Level A	Level B	Level A	Level A
7	#	Level B	Level B	Level A	Level A	Level B
8	<	Level B	Level A	Level A	Level B	Level B

Seed value: 2345

Level A: Favourable version of attribute (e.g., 4 min walking to access shared bicycle)

Level B: Slightly worse version of attribute (e.g., 9 min walking to access shared bicycle)

List of abbreviations

AB-PSS	Access-based product-service system
CE	Circular economy
EMF	Ellen MacArthur Foundation
OV	Public transport (Dutch: Openbaar vervoor)
PSS	Product-service system
SC	Sustainable consumption

List of figures

List of tables

Publications

Journal papers:

Tunn, V.S.C., Bocken, N.M.P., van den Hende, E.A., Schoormans, J.P.L., 2019. Business models for sustainable consumption in the circular economy: An expert study. Journal of Cleaner Production, 212, pp. 324-333.

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About the author

After a year of working and traveling in Australia, Vivian started her Bachelor studies in Business Administration and Marketing. This program entailed alternating three-month intervals of working in a company and studying, allowing her to gain experience in consulting and HR in parallel with her studies. Vivian also completed courses in Strategic Management and International Business during an exchange semester at Staffordshire University in the UK.

Upon completion of her Bachelor's degree in 2014, Vivian moved to the UK to pursue a Master's degree in Innovation and Technology Management at the University of Bath. She obtained a competitive scholarship from the university. During her Master's degree, Vivian applied innovation theories to explore sustainability issues. In her Master thesis she researched the impact of sustainability principles on companies' product innovation. She successfully completed her MSc degree in 2015. Based on her thesis, she wrote a conference paper.

Driven by her desire to have a positive impact, Vivian moved to Amman, Jordan, in 2016 to intern at UNICEF for a few months. She worked in the education section, advised partner charities on how to improve their reporting process and internal communication. In addition, Vivian frequently visited the Azraq and Zaatari refugee camps where she taught young refugees in Makani centres.

Vivian started her PhD at TU Delft as part of the Marie Skłodowska-Curie Innovative Training Network *Circ€uit* in November 2016. During her PhD, she published several journal articles, presented at international conferences, and was involved in teaching activities. She also returned to Jordan to give lectures at the Princess Sumaya University for Technology and discuss the potential of the cicular economy concept in the Jordanian context with the students. Next to her PhD, Vivian learned Dutch, volunteered with refugees in the Netherlands, travelled, and discovered her love for race biking.