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Implementation of a Circular Product Design –
Case Study of a Smartphone Manufacturer

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Abstract

The majority of today's products are not designed for a long service life. Rather, the focus of the current take-make-dispose economy is on the rapid procurement and satisfaction of needs. However, the production of goods requires a large amount of primary resources. In addition, products that end up as waste also have a negative impact on the environment. For this reason, a circular economy is proposed as an alternative in which conservation of value is the top priority.

Product design for a circular economy is characterized by special characteristics. This study is based on a circular design concept and aims to examine how a company deals with challenges that arise during the implementation of circular design strategies.

Shift GmbH, which produce smartphones with a circular design, are in the focus of the case study. The data, which are collected through two interviews, are structured through a qualitative content analysis. The analysis reveals that the individual challenges can be assigned to problem areas. These are product attachment and trust, standardization and compatibility & upgradability and adaptability, ease of maintenance and repair & re- and disassembly, financial resources, and market network. In combination with solution approaches, nine strategies can be identified on how Shift deals with the challenges of implementing a circular product design. These strategies are (1) Building a relationship with the product, (2) Enabling reparability of single components, (3) Establishing repair support systems, (4) Using spare parts from old devices, (5) Coordinating the product development, (6) Opening the software code, (7) Financing by private investors, (8) Strengthening of cur-rent cooperation agreements, and (9) Network extension. By implementing these strategies, Shift's smartphones produced should be part of the circular economy.

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Abbreviations

CE	Circular Economy
CEO	Chief Executive Officer
CSM	Centre for Sustainability Management
DR	Daniel Rauh
e.g.	exempli gratia
EMF	Ellen MacArthur Foundation
et al.	et alia
GmbH	Gemeinschaft mit beschränkter Haftung (engl. Ltd.)
GPS	Global Positioning System
Gt	Gigatonnes
ICT	Information and Communications Technology
i.d.	id est
IQD	Institute for Integrated Quality Design
IT	Information Technology
OECD	Organization for Economic Cooperation and Development
OS	Operating System
SW	Samuel Waldeck
WBCSD	World Business Council for Sustainable Development

1. Introduction

1.1. Problem Framing

“Single-use plastics: New EU rules to reduce marine litter” (European Commission 2018). This was the title of the European Commission press release of 28th of May 2018. The aim of the introduction of a new directive is to identify and eliminate the ten single-use plastic products that are most frequently found on beaches and in the sea and thus contribute to the large amount of waste in the environment. Single-use plastic products are one example that product design does not primarily focus on utility but on short-term satisfaction of needs. This is clearly shown by the prevalent linear economic “take-make-dispose” model: things are produced, consumed, and discarded, ending up as landfill or in incinerators (Mugge 2017).

The quantity of materials extracted from natural resources worldwide has doubled in just thirty years, reaching 72 Gt in 2010, and is expected to reach 100 Gt by 2030 (OECD 2015). A steadily rising number of products and their relatively short lifespan contribute to scarcity of resources and a rising amount of waste (Umweltbundesamt 2016; WBCSD 2010). As information and communication technologies (ICT) in general and smartphones in particular constitute examples for resource intensive consumer goods, they shall be at the center of attention. Reducing the environmental footprints associated with these products is of critical importance in addressing the environmental sustainability challenge (Ramani et al. 2010).

To meet the long-term challenges of resource scarcity and environmental damage, a consequence of excessive recycling and disposing, economy’s focus has to change. The Vice President of the European Commission, Frans Timmermans, has noted in a comment concerning the new CE package for the EU: “The circular economy is about reducing waste and protecting the environment, but it is also about a profound transformation of the way our entire economy works” (European Commission 2015). New types of economies have emerged, aiming at transforming the paradigm from linear models to circular ones (Ellen MacArthur Foundation 2013). A circular economy (CE) aims at restoring material flows through closed-loop processes and thus requires a special product design. Together, all design stages in the product development process have a direct influence of approximately 70 percent (Fabrycky 1987)

on the final product because it is where the most critical decisions with respect to longevity, durability, reparability are made (Bhamra & Lofthouse 2016).
Although numerous approaches of circular product design have been developed, the mostly disruptive nature of their implementation has posed many challenges to companies, e.g. of economic or organizational nature. Research has already been carried out on the challenges that arise during implementation (Bakker et al. 2010; Prendeville et al. 2017; Nissen et al. 2017). However, there is a lack of scientific debate on how companies deal with these challenges. Therefore, the strategies and associated approaches of a company are to be exploratively identified in this work.

1.2. Research aim and research question

Using the case study of the smartphone producer "Shift GmbH", ways of dealing with challenges will be worked out. Therefore, the guiding research question of this thesis will be:

How does the company “Shift GmbH” deal with challenges resulting from the implementation of a circular product design?

The hypothesis is put forward that Shift pursues certain strategies in dealing with the challenges.

1.3. Thesis structure

This thesis begins with a general introduction into the concept of the CE in Chapter 2, followed by an overview of various approaches of circular product design and the embedding of ICTs in the CE. The third chapter explains the methodological approach. One of the design approaches described above serves as a theoretical framework. The results are presented in the fourth chapter, they will be divided into seven categories. Chapter 5 covers the discussion in which the results are first structured and then discussed with the help of the literature. Based on the discussion,

recommendations for policy and practice are made in the sixth chapter. Chapter 7 summarizes all findings of the work once again and gives an outlook on possible future research issues.

2. Conceptual foundations and literature review

2.1. Concept of the Circular Economy

Concepts had already emerged in the second half of the past century as predecessors of the CE. Increasing attention for a conscious handling of resources resulted from rising environmental damages that the widespread report “Limits of Growth” (Meadows et al. 1972), initiated by the Club of Rome, had outlined. Changes in the socio-economic and regulatory landscapes, for example the change in resource price volatility which was caused by growing modern economies, and the burgeoning of middle-class consumers entering the market, caused people to question the feasibility of traditional, linear operating economy following the ‘take-make-dispose’ approach (Accenture 2014; World Economic Forum, Ellen MacArthur Foundation, & McKinsey & Company 2014). Focusing on characteristics of self-reinforcing and regeneration, the Ellen MacArthur Foundation (EMF) has developed the most recognized and comprehensive approach to describe a CE bringing together different schools of thought and disciplines. At all times, keeping the highest value of products, components or resources is in the focus.

With its roots in waste management, the concept is characterized “as an economy that is restorative and regenerative by design” (Ellen MacArthur Foundation, 2015). The so-called butterfly-diagram (see Figure 1) illustrates the continuous flow of biological and technical materials.

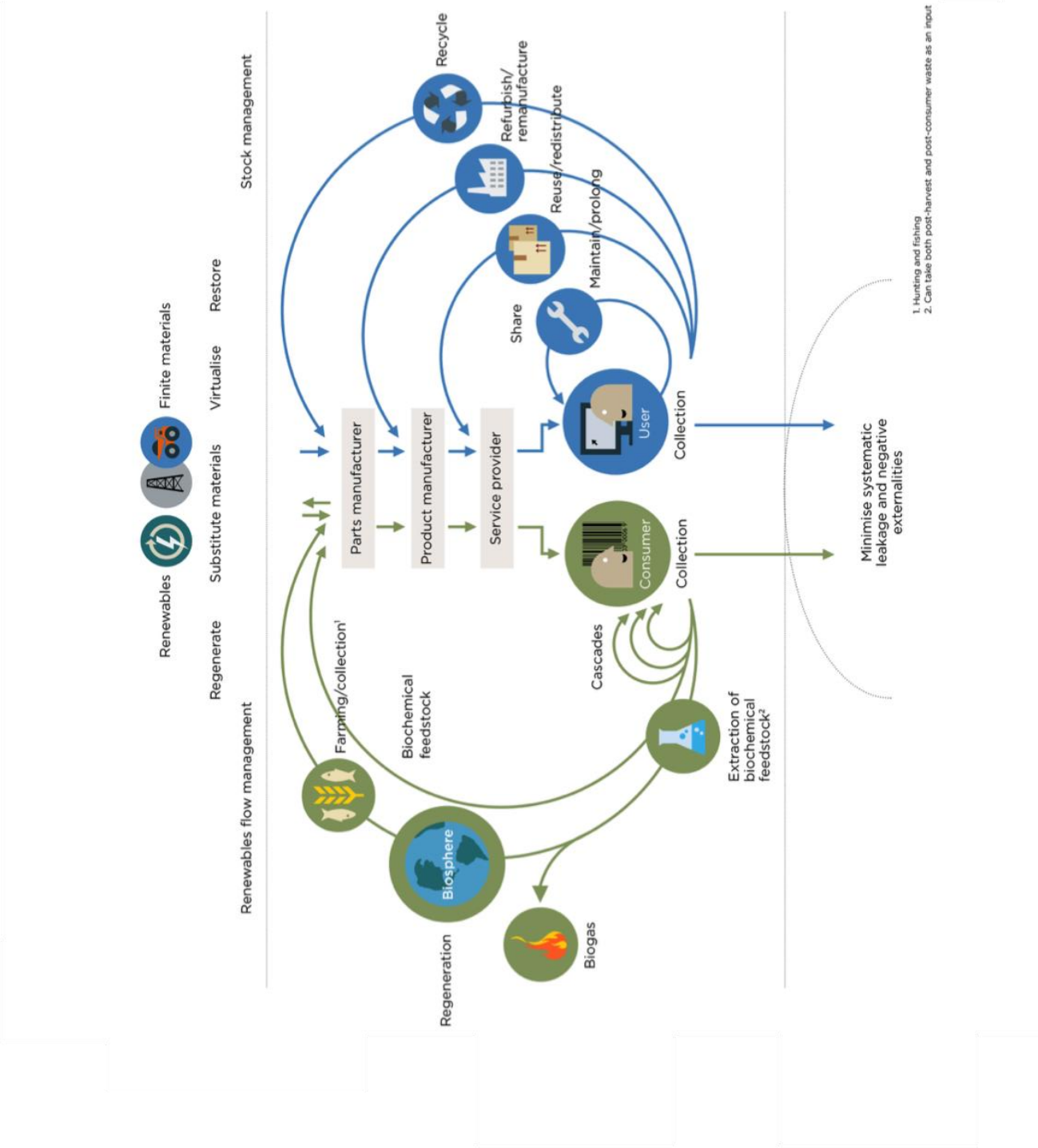


Figure 1: Concept of the Circular Economy (Ellen MacArthur Foundation, 2015)

The distinction between these two types of cycle – the biological and the technical – provides multiple value creation and preservation mechanisms which are decoupled from the consumption of finite resources. In the technical cycle, products, components, and materials are kept in circulation in the economy as long as possible. In the biological cycle, the strategy is to restore nutrients into the biosphere, where they

rebuild natural capital. Technical cycles are usually designed for products made from non-biodegradable materials, such as metals. Here, the biological cycle serves as a model for the technical. The cascade-like use of materials and products is intended to increase the efficiency of use and the service life. Since the focus of this work is on a technical product, the biological cycle is neglected in the following.

Apart from ecology aspects, there are several economic advantages in moving towards a CE. Since it maximizes the value of products and materials through their entire life cycle, it makes companies resilient to externalities such as supply risks and the expected fluctuating resource prices. Further benefits lie in the potential to improve customer loyalty, to secure revenue streams, and to generate such by offering a range of service loops. Currently shifting relationships between organizations and consumers from consumption (product-based) to use (performance-based) support this point (see chapter unterhalb). As performance-based business models are most labor-intensive, this last aspect has a great employment potential (Kraaijenhagen et al. 2016).

In the following sections, the aspects of loops and business models in the CE will be specified.

2.1.1. Loops in the Circular Economy

As mentioned in the section above, products and resources are circling in various loops in the CE. The innermost circle is the loop of s*hare*. This term, also known as "sharing economy" and "collaborative consumption", describes the shared use of completely or partially unused resources, and comprises the shared use of goods and services by several users, as well as collaborative production, and open and free access to knowledge and community financing (Botsman & Rogers 2010). *Maintain/prolong* refers to the maintenance of a product in the form of minor repairs (Weetman 2016). Within the loop of *Re-use/redistribute* goods are redistributed, e.g. via online platforms or used goods trade. Outer loops like *refurbish/remanufacture* describe the technical refurbishment and reprocessing of a product. After this, it is in mint condition and in most cases comes with a similar warranty as a new product (ibid.). In the *recycling* loop, the focus is not on maintaining the functionality of a product, but on separating the processed materials with the highest possible purity (Ellen MacArthur Foundation 2015).

Various business models are conceivable for the different loops. They will be discussed in the next section.

2.1.2. Business models in the Circular Economy

The CE model requires companies to rethink their business models. Business models describe the rationale of how an organization creates, delivers, and captures value (Osterwalder & Pigneur 2010). They serve as conceptual tools to help understand how a company does business. Business models are also used for analysis, comparison and performance assessment, management, communication, and innovation (Osterwalder et al. 2005). In order to fit the new business approach, companies will have to integrate CE principles into their business models (Bocken et al. 2014). Instead of generating profit from the sale of products according to traditional linear business models, in a CE companies make profits from the flow of materials and products over time (Bocken et al. 2016).

Angelis (2018) asserts three propositions concerning circular business models. The first one refers to value propositions: It is characterized by enhanced customers' value as a result of more comprehensive 'circular offerings' (e.g. products as service, dematerialized products) and 'circular relationships' (access over ownership). The second proposition comprises value creation and delivery which are characterized by diffused value creation, maximization of resources' value across the activity system, and local/regional supply chains. With regard to value capture mechanisms (costs and revenue streams) of circular business models, Angelis' third proposition points out their idiosyncratic character. The consequence of this is not only a change of the source of revenues (from sale to product use/access) but also a reduction of costs through the recovery of materials that may be difficult to procure otherwise because of price and resource supply volatility.

Following these characteristics of circular business models, the matter of setting-up reverse supply chains gains importance (Ellen MacArthur Foundation 2018). These reverse logistics are related to take-back management, incentivized return and reuse, and the collection of used products (Lewandowski 2016).

To implement these aspects into business models, Bakker et al. (2014a) developed the following five business model archetypes for the CE. Implementing the *classic*

long-life model, companies aim at developing high-quality products with a long lifespan. To ensure the longevity, service and repair are required.

If a long-lasting product is completely dependent upon a replaceable part with a limited functional lifespan, then the business model is called h*ybrid*. In a hybrid business model, the indispensable exchangeable part needs to facilitate high-quality functionality, but at the same time, it has a clear limit of lifetime.

Businesses following the *gap exploiter model* mostly offer services. Entrepreneurs are always looking for gaps in the markets; many professions are defined by repair and maintenance. Their workshops are cheaper than the ones operated by the original brand and they are often willing to use cheaper third-party spare parts. Internet platforms play an important role in this business model.

For products that are unnecessary or unaffordable to possess full-time, companies offer short-term ownership. This *access model*, frequently used in connection with sharing, benefits from developments in digital communication.

The implementation of the p*erformance model* means that the value proposition does not concern a certain product but functionality. Something is taken care of for the client who pays a certain fee in return. As the provider owns and maintains the products, the responsibility for quality as well as for material flows rests with him.

It is emphasized that product design and business model strategies for the CE need to be implemented in conjunction.

The five business models explained, using the washing machine as an example, are presented in Figure 2. To adjust products to the requirements of such business models they need to have special characteristics, which will be subject of the next section.

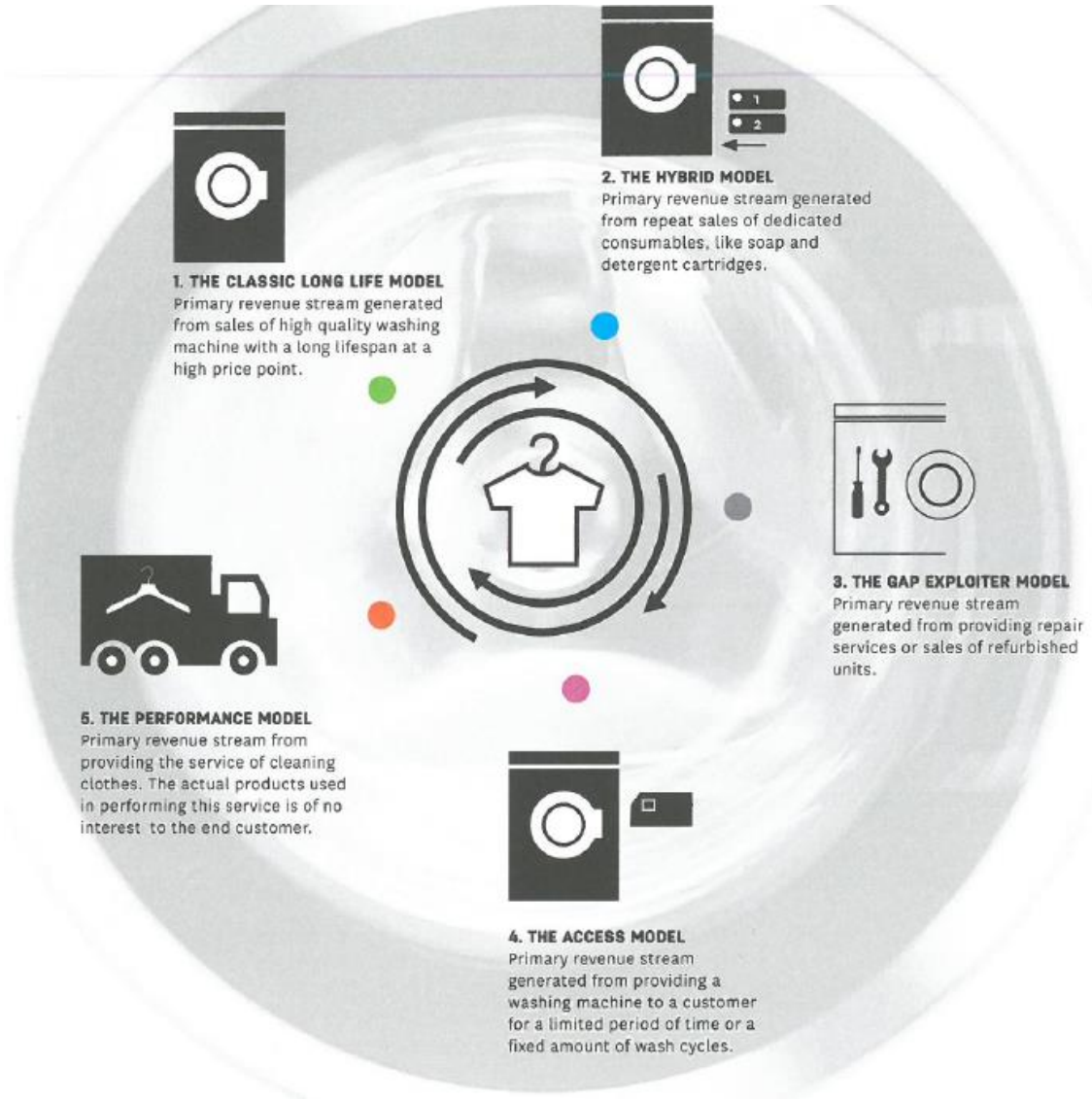


Figure 2: Five business model archetypes explained, using the washing machine as an example (Bakker et al. 2014a, 50)

2.2. Product design in the Circular Economy

A circular product design makes the extension of product-life possible through the loops of Maintain/prolong, Re-use/redistribute, Refurbish, Remanufacture, and Recycle. Products are designed to be 100 percent ready to circulate in closed material loops (Lewandowski 2016). Along with the development of concepts of a CE, concepts of circular product design have emerged.

The various approaches towards circular product design mostly focus on different aspects. Four approaches shall be presented in this section.
The best-known approach is probably the one developed by Michael Braungart and William McDonough (2002). Their “Cradle to Cradle” framework attempts to turn materials into nutrients by ensuring their perpetual flow within the biological or technical metabolism. In this scenario, biodegradable materials (biological nutrients) are absorbed and, thus, have a positive effect on the environment (eco-effectiveness). Synthetic or mineral materials (technical nutrients) remain safely in the closed loop system between manufacture, reprocessing, and reuse in order to maintain their material value through the loops (Braungart et al. 2006). Any product design in such a scenario requires dealing with issues like biodegradability, disassembly, recyclability (or upcyclability), reverse logistics, and material toxicity (McDonough & Braungart 2002). The authors emphasize minimization of energy consumption and materials use, minimization of material diversity to promote disassembly and value retention as well as product processes and systems for further life cycles (ibid.).

Another approach to circular product design is suggested by Mestre and Cooper (2017). They emphasize the importance of closed material loops which should be the ultimate goal of a circular product design process. Their approach comprises design strategies for a technical cycle (strategies to close the loop and to slow the loop) as well as design strategies for a biological cycle (bio-inspired loop strategies and bio-based loop strategies). Any design in the technical cycle aims at minimizing material and energy inputs and emission outputs throughout the product’s whole life cycle, while maximizing value proposition for the consumer. Accordingly, bio-inspired loop strategies strive for the adoption of biomimetic approaches, whereas the utilization of biological materials with biodegradability character is the main concern of bio-based loop strategies. The authors stress the necessity of a parallel implementation of design strategies for the technical and the biological cycle.

In their publication “Products that last”, Bakker et al. (2014a) present yet another circular product design approach, consisting of six strategies in total. The first design strategy for product attachment and trust counteracts emotional obsolescence by creating long lasting products that people will love and trust. The design strategy for product durability aims at creating products resistant to wear and tear. The choice of

material is essential in overcoming functional obsolescence. Counteracting systemic obsolescence, the design strategy for standardization and compatibility focuses on designing product parts and interfaces suitable for other products and aims at multi-functionality and modularity. The fourth design strategy, design for ease of maintenance and repair, counters functional obsolescence by creating a product easy to maintain. Like the third design strategy, the design strategy for upgradability and adaptability tries to avoid systemic obsolescence. It does so by upgrading a product's value and performance and, at the same time, by making adaptions and modifications to align the product to the changing needs of users. As a precondition for other strategies, the design strategy for dis- and reassembly ensures that products and their parts can be separated and reassembled easily. This includes the possibility to be dismantled and to be stored in reuse.

Easy dismantling is also pursued by Bogue's (2007) approach. His "Design for Disassembly" strategy entails the implementation of three disciplines: the selection and use of materials, the design of components and the product architecture, and the selection and use of joints, connectors and fasteners. Bogue points out various design rules related to product structure, materials, fasteners, joints and connection, characteristics of components for disassembly, and disassembly conditions. Regarding the product's structure, a modular design with minimized component count and product variants as well as optimized component standardization is proposed. When selecting materials, the minimization of the use of different materials, the elimination of toxic or hazardous materials, and the recyclability of materials should be taken into account. The number of joints should be minimized; the visibility of existing joints must be ensured. Fasteners are preferable to adhesives. Characteristics of components for disassembly are good accessibility, low weight, robust and endurable parts, and non-hazardousness. All these aspects can also be geared towards automated disassembly through eliminating the need for specialized disassembly procedures.
An overview of the approaches is shown in Table 1.

Table 1: Overview of the chosen circular product design approaches

Braungart & McDonough (2002)	**Mestre & Cooper (2017)**	**Bakker et al. (2014a)**	**Bogue (2007)**
The "Cradle to Cradle" framework attempts to turn materials into nutrients by ensuring their perpetual flow within the biological or technical metabolism. It aims at having a positive effect on the environment (eco-effectiveness). Concerning product design, dealing with biodegradability or material toxicity is essential.	This approach comprises design strategies for a technical cycle (to close the loop and to slow the loop) as well as design strategies for a biological cycle (bio-inspired loop strategies and bio-based loop strategies). A parallel implementation of design strategies for both cycles is necessary.	The authors formulate six design strategies to implement circular product design: design for attachment and trust, for product durability, for standardization and compatibility, for ease of maintenance and repair, for upgradability and adaptability, and for dis- and reassembly.	This approach entails the implementation of three disciplines: the selection and use of materials, the design of components and the product architecture, and the selection and use of joints, connectors and fasteners. Characteristics of components for disassembly are good accessibility, low weight, robust and endurable parts, and non-hazardousness.

2.3. ICT and smartphones in the Circular Economy

The design of electronic products is marked by the use of relatively small amounts of many valuable and scarce materials that are often intimately mixed and deserves particular attention (Balkenende & Bakker 2015). Information and communications technology (ICT) products belong to resource intensive consumer goods, especially smartphones contain a high diversity of materials. In the product's manufacturing and usage phase, a high energy consumption occurs (Evans et al. 2011). A large part of smartphone production takes place in Asia, where the energy mix used comes predominantly from a coal-based power system (Greenpeace 2017).

As most of ICT devices are fast-moving goods with short lifetimes, the electronic intensive lifestyle in prosperous countries contributes to a rising consumption of metallic resources, a great amount of electronic waste (and its improper disposal), and a high risk of dissipation of in-built materials (Patrignani 2017; Reller et al. 2009). This results in three million tons of small IT and telecommunication equipment e-waste, including mobile phones, GPS, pocket calculators, routers, personal computer, printers, and telephones (Baldé et al. 2015). It is estimated that only one percent of old mobile phones worldwide reach metal refineries where precious and special metals

can be recovered (Hagelüken 2006). Another share of old mobile telephones ends up in the domestic drawer after a regular period of use of two to a maximum of four years (Dießenbach & Reller 2016). It is assumed that 124 millions of hoarded mobile phones are in German households alone (Bitkom 2018). Further end-of-life scenarios comprise improper disposal (e.g. household waste) or “backyard recycling” in developing and emerging countries, i.e. improper disassembly (Dießenbach & Reller 2016).

According to Stiftung Warentest (2013), the main reasons why consumers replace their smartphones are technical defects (most frequently mentioned are the display, battery, and buttons), a weak battery or technical innovations. In addition, many smartphones can only be repaired at great expense (Umweltbundesamt 2016).

Furthermore, social problems of resource extraction has pushed the rising discussion about sustainability challenges in the smartphones sector (Dießenbach & Reller 2016). While high sustainability expectations had previously been restricted to consumer segments like food and clothes, these are now increasingly transferred onto the electronics industry as well (Dießenbach & Reller 2016). Calling attention to these challenges and providing a more circular product design, companies like Shift GmbH (www.shiftphones.com) or Fairphone (www.fairphone.com) try to contribute to a CE.

3. Methods

Flick, Steinke and von Kardorff (2013) recommend the application of qualitative research approaches where the development of a previously little researched area of reality is concerned. As an explorative science, qualitative research is characterized by the fact that open questions are formulated in order to grasp and understand complex contexts in their respective background. Therefore, the objective of the study dictates a qualitative approach. A qualitative approach should not limit the possible scope of results a priori and thereby prematurely reduce the potential gain in knowledge. Nevertheless, previous research in the field in advance of the case study has been taken into account to gain an overview.

The methods used are described in the following sections. The central quality criterion of qualitative social research is the comprehensible documentation of the investigation procedure, which is to be met (Mayring 2015; Steinke 2005).

3.1. Case Study

The methodological approach of a case study is considered appropriate because it allows to retain a real-world perspective and an in-depth view of an original company (Yin 2009). The inclusion of all dimensions aims for a comprehensive, realistic picture of the considered case (Lamnek 2005).

Limits of the case study approach are stated as missing validity and reliability. To counter this, the principle of maintaining a high degree of transparency with regard to the research procedure will be adhered to.

3.1.1. Case Sample

The selection criteria for case companies include engagement in activities related to the implementation of a circular product design in the smartphone sector and a location in Germany to allow a site visit. As far as the market could be analyzed, Shift GmbH is currently the only German smartphone manufacturer that implements a circular product design. According to the statement on Shift's website, there is no comparable device worldwide apart from their latest launched product, the Shift 6m (see Figure 3), which stands in the middle of attention of this bachelor thesis (Shop Shiftphones 2018). For this reason, a single case study with an extreme or unique

case is conducted (Yin 2009). The aim of the case study is to study the experience of one explicit example.
Ferdinand Paul Revellio, researcher at the Centre for Sustainability Management (CSM) at Leuphana Universität Lüneburg, operated as a “gatekeeper” and established the first contact with the company.

Shift GmbH is an ICT consumer goods producer with its office in Falkenberg (Germany). The company’s development started with a crowdfunding project in April 2014. The first products, a phablet (phone and tablet) and smartphones, were launched in 2015. The latest model, which is in the delivery phase at the time of development of this thesis, is the Shift 6m, which is characterized as a "modular" smartphone (Shop Shiftphones 2018). In the development of the Shift 6m, Shift pursues the goals of reparability by the user and the use of powerful components. The annual turnover of Shift is less than 1 million (CEBIT 2018).
The case study primarily focuses on the Shiftphone 6m, but aspects that refer to earlier models have also been taken into account.

Figure 3: Component parts of the Shift 6m (Shift GmbH, 2018)

3.1.2. Data Collection

Data were collected from various sources between January and April 2018. Collected data include personal interviews with a company manager as well as a product designer from the company, and a site visit captured through field notes. Beside this "special access" information, publicly available information (i.e. company's homepage, press-releases, company brochures) were examined.

In qualitative research, the semi-structured expert interview is the most common source of information origination. There is the expectation that in the relatively open design of the interview situation the points of view of the interviewee will become clearer rather than in standardized interviews or questionnaires (Flick 2007). In addition, this is a suitable type of data collection if the central research question cannot be answered by literature research. In such cases, present knowledge or the experienced assessment of professionals is needed (Mieg & Näf 2006).

Bogner and Menz give a definition of experts and expert knowledge:

> "The expert has technical, process and interpretative knowledge relating to his specific field of action. […] In this respect, [expert knowledge] has to a considerable extent the character of practical or action knowledge that integrates various and quite disparate maxims of action and individual rules of decision, collective orientation and patterns of social interpretation. [...] As the expert's knowledge has an effect on practice, it structures the conditions of action of other actors in the expert's field in a relevant way." (Bogner & Menz 2009, 54f.).

According to Bogner et al. (2005), there are three types of expert interviews: the exploratory, the systematizing, and the theory generating one. Each has a different function. As the nature of a single case study indicates, the present thesis is based on exploratory expert interviews. These are used to cover new ground of complex topics (Flick 2007).

The interviews are semi-structured. They consist of open-ended as well as structured (closed) questions. This enables the interviewees to rethink the central contents and the general topic, to reflect and to link their own experiences and perceptions with them, and to also incorporate new perspectives (Bogner et al. 2005).

During the interviews, further subsidiary questions were asked individually, e.g. in case of comprehension difficulties or the need for specification. In this way, the inter-

viewer can deal with comprehension difficulties and, if necessary, can “dig deeper”. The order of the questions was adapted to the course of the interview; questions may have been omitted, where they had already been answered.
The different number of questions per interview results from the fact that some questions were adapted or reformulated owing to the company representative’s profile and the different working areas.
The interview with Samuel Waldeck (SW), CEO of Shift, was conducted personally at the company headquarter. For logistical reasons, it was not possible to conduct a personal interview with Daniel Rauh (DR), product designer of Shift, which is why communication was established on the phone.
The interviewers’ expertise and prearrangement with regard to probing and moderating is a fundamental element for a successful semi-structured interview (Bogner et al. 2005; Mieg & Näf 2006). Therefore, the interview guideline was sent to the interviewee by e-mail one week before the interview date; further queries and privacy policy questions regarding the audio recording were clarified before the interviews were conducted.
The audio data can be found on the CD enclosed.

3.1.3. Data Analysis

The interview was analyzed with the help of the content analysis method. In social science, content analysis is a widely used approach to analyze qualitative data. It focuses on taking up the viewpoint of the communication partner (Mayring 2015). The aim of the content analysis is to analyze material coming from any kind of communication. This method is used, among others, to find hypotheses and form theories, for pilot studies or for individual case studies. To analyze the interviews conducted, this study follows Mayring’s approach (ibid.) of qualitative content analysis.
The aim of the analysis is to structure the content to find approaches of dealing with emerging challenges in the implementation of a circular product design, so that a structured overview will emerge for data interpretation. For this purpose, the linguistic material is systematically analyzed with the help of categories[1]. The categories are developed according to the theoretical framework and the data collected and they are

[1] The category system is available in the appendix.

revised and reviewed during the analysis (Flick 2007; Mayring 2015). For this study, a deductive construction of categories is preferred, but it is open to inductive theories that result from the interview. This is in line with the explorative nature of this thesis. The transcription was performed according to Kuckartz (2014, p. 136).[2]

Because of constraints of the nature of this bachelor thesis, the application of the qualitative content analysis approach is limited to the main aspects. It is realized through computer-aided software (MAXQDA 2017).

3.2. Theoretical framework

Serving as a structure-giving framework for this research, a circular product design approach was chosen. For this purpose, four circular product design approaches (presented in 2.2) are compared in Table 2.

Table 2: Comparison of four circular product design approaches

	Braungart & McDonough (2002)	**Mestre & Cooper (2017)**	**Bakker et al. (2014)**	**Bogue (2007)**
Scope	product design within the C2C-vision	whole product life cycle; biological and technical cycle; life cycle design strategies; design strategies in	concrete product characteristics for the CE	technical characteristics of a circular product
Focus on aspects of the Circular Economy	circling of nutrients	whole life cycle of the product; no direct connection to loops of the circular economy	focus is on modularity (Standardization, Compatibility, Upgradability etc.) and technical aspects	disassembly of products
Transferability to the empirical field of smartphones	low transferability; strong focus on the material which plays a subordinate role in the circularity of smartphones; low consideration of	low transferability; too wide-ranging; biological cycle is not in the focus concerning smartphones; always emphasized, that	high transferability; especially suitable with its focus on modularity	high transferability; disassembly plays an important role especially with smartphones
Suitability as a framework for the analysis of challenges	not suitable; provide a vision of cradle to cradle but no concrete concept; the implementation is	suitable but too wide-ranging	suitable	just suitable for technical challenges
Limits of knowledge on the part of the	no limits	no limits	no limits	limits; because of an enhanced level

[2] The interview transcripts are available in the digital appendix and upon request.

Having compared the four approaches, it can be stated that the approach of Bakker et al. (2014a) provides the best foundation for the analysis of circular designed products from the ICT and smartphone sector. The approach comprises concrete product characteristics for the CE. In particular it mentions modularity (inter alia standardization and compatibility), which plays an important role in circular design of smartphones. Because of its high importance in the progress of this work, the approach is once again described in greater detail.

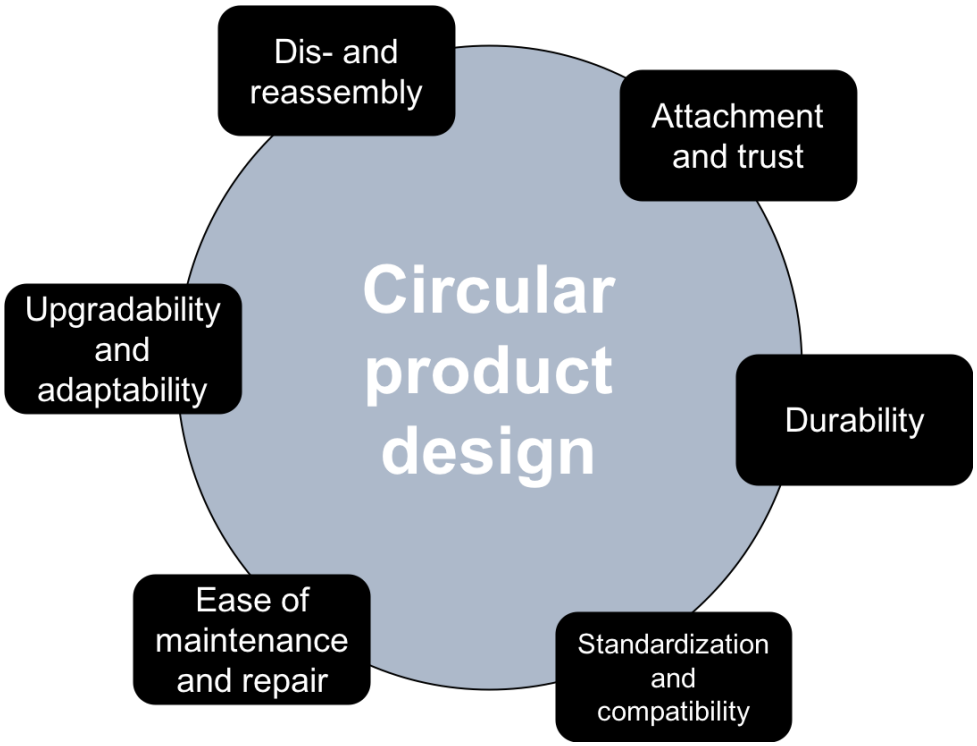


Figure 4: Visualization of the circular product design approach following Bakker et al. (2014a)

The authors present six product design strategies (see Figure 4). The *design for product attachment and trust strategy* refers to emotional obsolescence by creating long lasting products that people will love and trust. Uniqueness and interaction between user and product are presented as criteria.

The *design for product durability strategy* aims at creating products resistant to wear and tear. The choice of material is essential in overcoming functional obsolescence. The need for product tests is stressed.

Counteracting systemic obsolescence, the *design for standardization and compatibility strategy* focuses on designing parts and interfaces for the product that are suitable

for other products, and aims at multi-functionality and modularity. Aiming at standardization, the effort is to get an overview of previous and recent inventions, of investments in design and equipment, and of the standards to be set.

The *design for ease of maintenance and repair strategy* counters functional obsolescence by ease of maintenance to keep a product in working condition. Non-challenging reparability and replacement of broken parts shall ensure the extension of the end of life. This strategy requires a high level of cooperation between designers and engineers.

As the preceding strategies, the *design for upgradability and adaptability strategy* strives to avoid systemic obsolescence by upgrading a product's value and performance and, at the same time, adapting and modifying it towards the changing needs of a user. This strategy targets uncertainty of the future.

As a precondition for other strategies, the *design for dis- and reassembly strategy* ensures that products and their parts can be separated and reassembled easily. This includes the possibility to be dismantled and to be stored in reuse.

4. Findings

In this chapter, the analyzed data are described in detail. The categories follow the theoretical framework by Bakker et al. (2014a, see 3.2). In addition, as mentioned in the methods section (see 3.1.3), further categories derived from the analyzed material. The category of product durability was excluded because there are no results in this area.

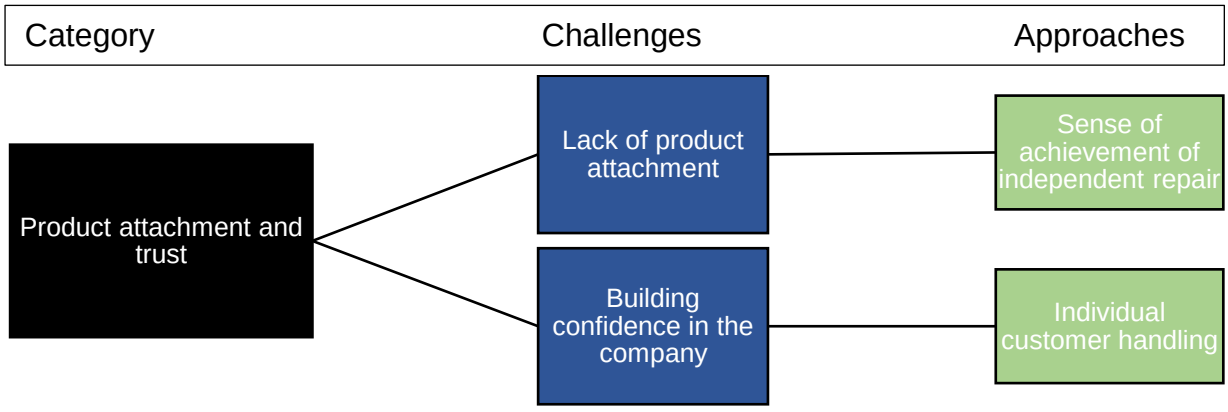
According to the research question, increasing challenges are presented followed by approaches. Unless otherwise indicated, the findings are based on the interviews conducted.

4.1. Category: Product attachment and trust

The challenge of product attachment is described as “multilayered” (DR, 40a), comprising a lack of product attachment and building confidence in the company. The interviewee assumes that, by repairing their smartphones themselves, users associate something positive with the product. An independent repair makes users feel that they have made an achievement.

Aiming at building confidence in the company, Shift strives for an individual customer handling which is effected by communicating personally and showing an interest in the customer’s specific request, even if it is of a very fundamental nature.

During presentations, Shift’s employees act as brand ambassadors, and “try to create a connection and understanding through the way [they] present [their] products” (DR, 40b).



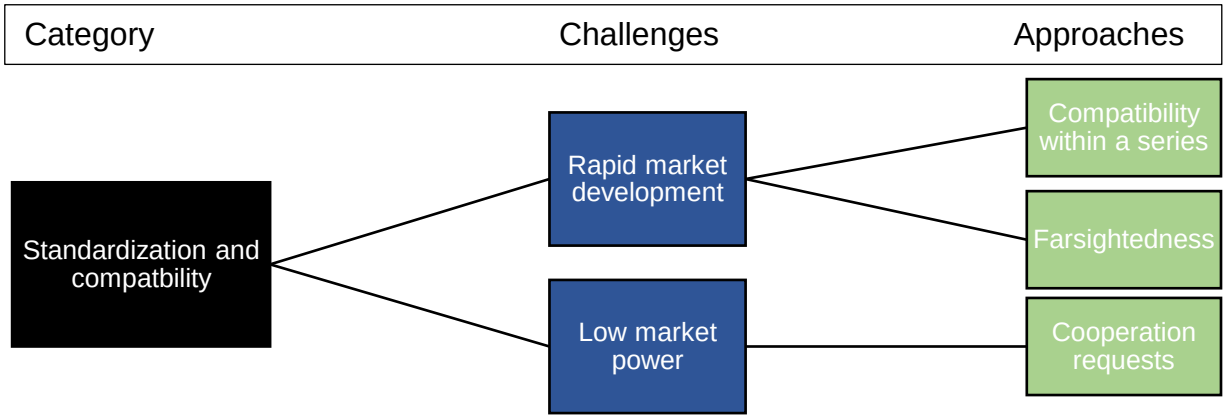
4.2. Category: Standardization and compatibility

The smartphone market is characterized by a rapid development. Individual components of smartphones become better and more specific. Therefore, providing compatibility over several years for different smartphones is challenging. It is stated that, from a certain point in time, innovations or ideas are so fundamental that a cut has to be made. Hence, compatibility will no longer be possible.

Another challenging aspect is the difference between smartphone housing sizes. For this reason, Shiftphone components are largely compatible within one series but between series compatibility is limited. For example, “[t]he batteries are not compatible because we always try to get the optimum size and capacity” (SW, 54).

Another approach is farsightedness. “It's good to think about it: Where does the journey go?” (DR, 36). The main board for the 6m has been designed so that it can also be used for future products that are already in a planning stage. This way, development work can be saved. In addition, the supply of spare parts is easier due to less diversity. This step was possible because Shift developed the mainboard itself.

Aiming at setting standards, for example concerning mainboards, Shift’s low market power poses a challenge. As an approach, Shift sent cooperation requests to other smartphone manufacturers with the intention to develop a mainboard together but they have not received positive feedback so far.

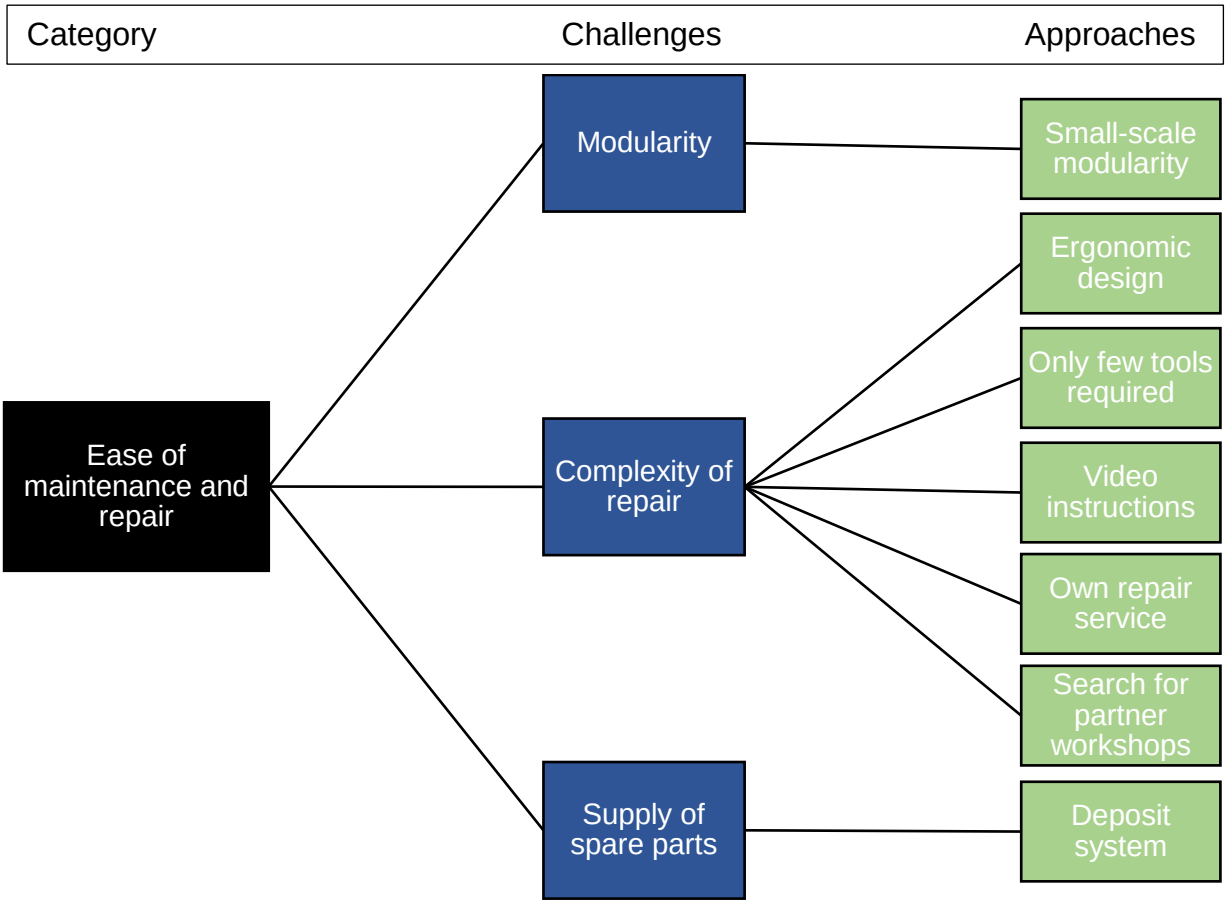


4.3. Category: Ease of maintenance and repair

To realize ease of maintenance and repair, a manufacturer has the choice of modularity at different scales. Modularity is the division of a whole into parts. Small-scale modularity, in which the modules consist of only a few individual components, uses fewer resources but sets the inhibition threshold of self-repair relatively high. Conversely, larger modules of large-scale modularity are easier to replace but use more resources because components that are still functional are disposed. Shift deals with this challenge by focusing on the conservation of resources: “For us, for example, it was not a solution to choose modularity where we exchange entire module groups. This was important for us to really have modularity on a very small level. That I can really remove individual parts with little waste of resources... Because otherwise this sustainability aspect is no longer so great” (SW, 20).

To lower the inhibition threshold of self-repair, Shift provides video instructions via YouTube. Another way to meet the challenge of the user’s ability to repair is an ergonomic design: “Through product design and modularity, we try to present things that are easy for the user to understand […] so that he really dares to do so” (DR, 12). In particular, the parts that are replaced most frequently should be easily accessible and aesthetically pleasing so that repair is easy. This includes back cover, battery, SIM cards, and memory expansion. For example, the back cover can be opened only with the help of the fingernail. To reach underlying components, only few tools are required. Each device is supplied with a special screwdriver to open all existing screws (only one type of screw is used). If a user does not feel competent enough to do the repair himself, Shift provides a repair service. To make access even easier, Shift is also working towards cooperating with repair workshop platforms such as kaputt.de.

To guarantee long-term reparability of a device, the supply of spare parts must be ensured. However, it makes neither economic nor ecological sense to store large quantities of spare parts, if they are not requested (for example because of innovations or product durability). In order to deal with this challenge, Shift has introduced a deposit system. The price of the new device includes a deposit of 22 Euro, which the user receives back on return of the device. “This means that we always get spare parts from old equipment and can then bring them back to the market” (SW, 40). If no spare parts are available, Shift provides the opportunity of hardware upgrades (see 4.4). The goal is to provide spare parts for a period of ten years for the Shift 6m.

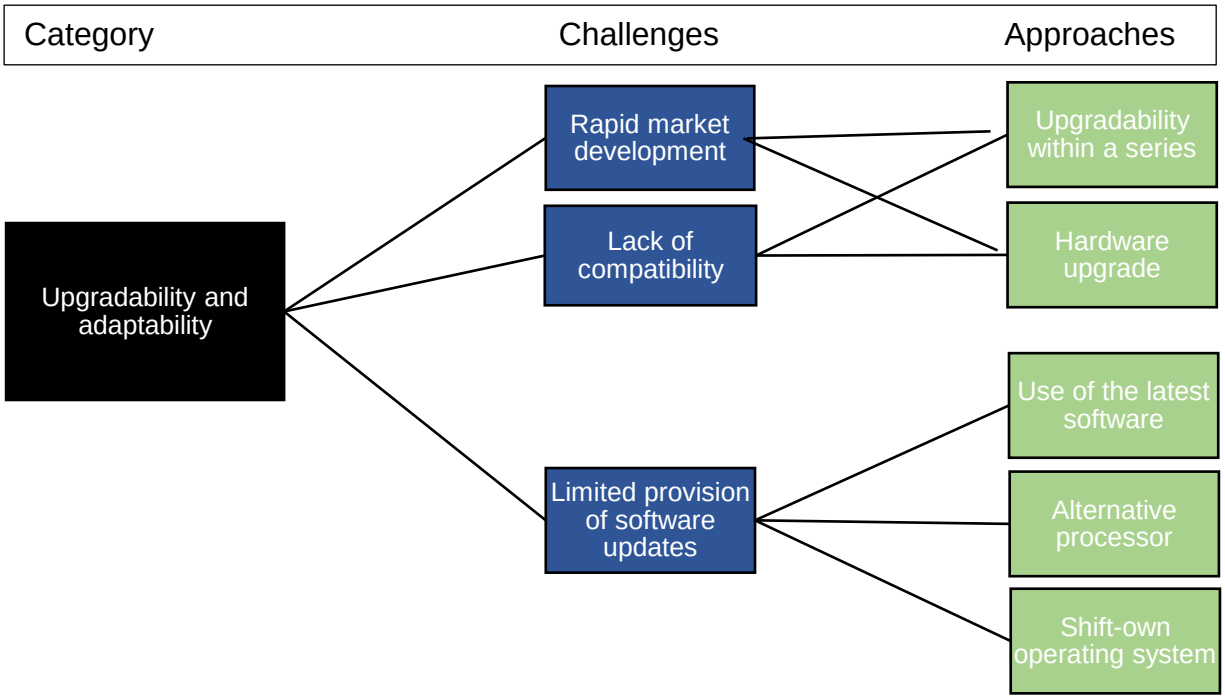


4.4. Category: Upgradability and adaptability

Upgradability requires compatibility which, as mentioned in the section 4.2, is challenging on the rapid smartphone market. One approach is a limited upgradability within a series. Within a series, Shiftphones are compatible to a large extent. In addition, there is the approach of hardware upgrades. Customers have the possibility to replace their old devices by a newer one at a reduced price. Shift takes back the old equipment and repairs it or uses its spare parts.

Providing software updates is challenging as well because software providers only offer updates for a limited period of time. More and more necessary storage space for newer software, a lack of experience with new software, and a lack of openness of the driver policy of large manufacturers contribute to this. Shift deals with this challenge through the use of the latest software. Although no experience with Android 8 had been available yet, Shift has chosen it because the software promises a long-

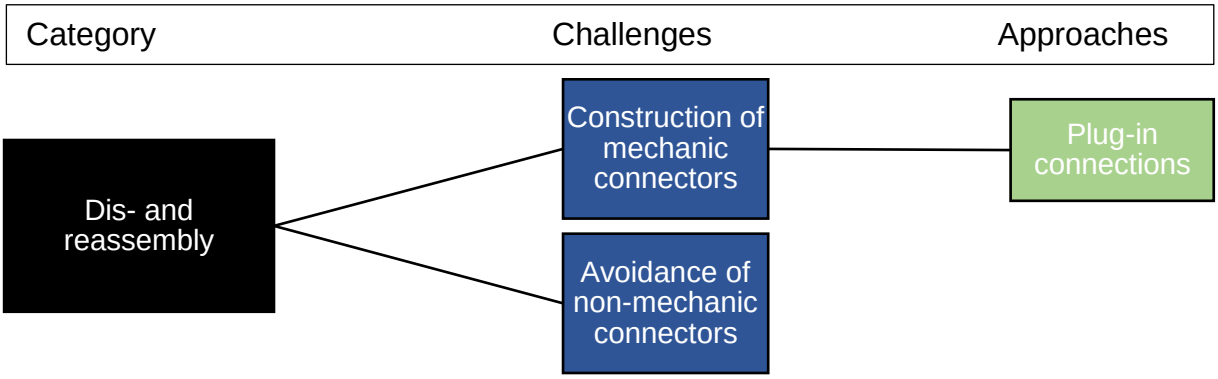
term supply of updates. In addition, the model Shift 6mq with an alternative processor is offered to allow disclosure of the software code. This should give the user even more freedom. Another idea is to develop an own operating system, ShiftOS, based on Android 8, “so that the customer can decide for himself what data he wants to have in stock or in which area he then wants to use the Google services or use other services, whether it be Facebook or WhatsApp. He has his privacy in his own hands, which is important to us in this regard” (SW, 48). Shift aims at providing software updates for their users for a minimum of four years.



4.5. Dis- and reassembly

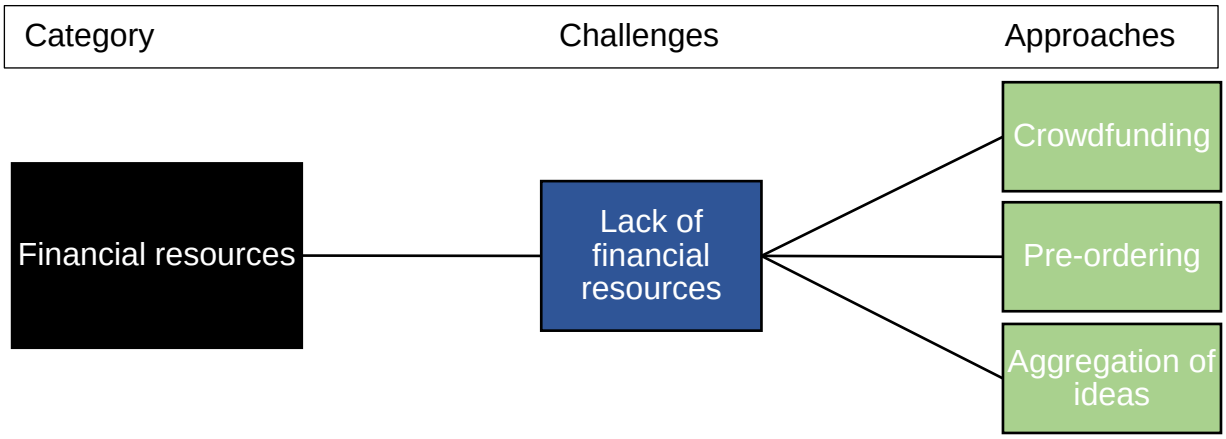
To enable easy disassembly of the smartphone, mechanical connectors should be used. However, everything in the smartphone is in miniature format, which is why the mechanical connectors must also be very small and are nevertheless subject to high requirements. Mechanical connectors had already been present in previous Shiftphones, but their construction made them susceptible to material breakage. The connectors for the 6m were now demanded to have a low error rate during repair on the one hand but to have a small size on the other. “[The challenge] has less to do with material now but more with the construction. That they [the connectors] are as

small as possible, so that the main board can be as filigree as it is, but still easy to repair" (SW, 68). The decision was made to use plug-in connectors. Many components of the board are therefore "plugged in" and thus meet the requirements.
However, not all components can be connected like that. Some components must be soldered, for example the processor, which cannot be connected mechanically due to transmission requirements.



4.6. Financial resources

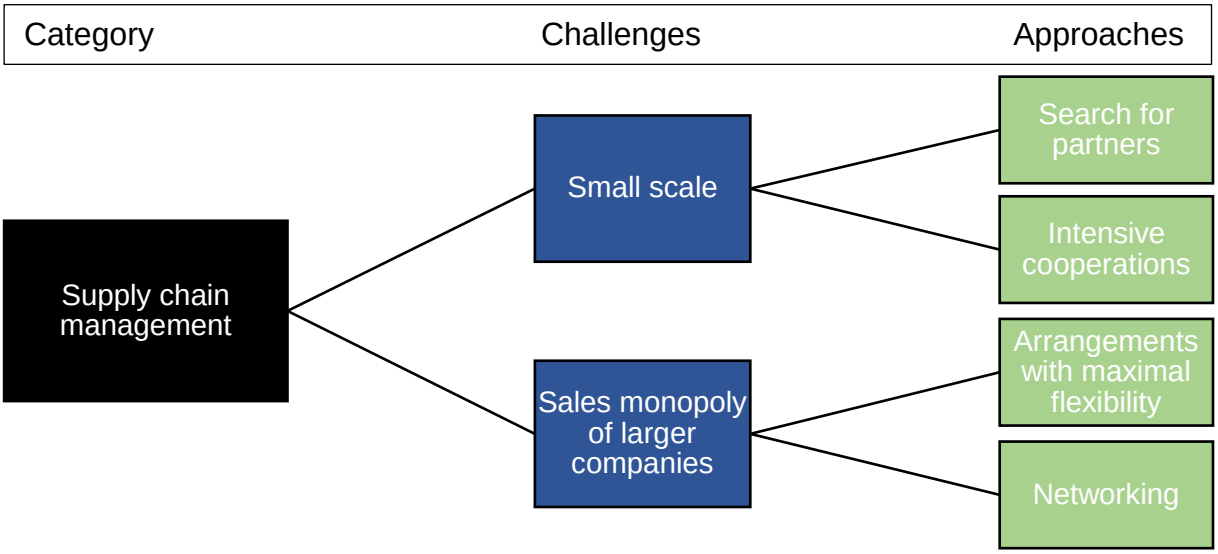
There are no ready-made concepts for circularly designed smartphones on the market. Development work therefore requires financial resources that are not available in small companies like Shift. "So, the main part of the costs are not materials, but development. This was very complex for us and that was also one reason why we did not start with a modular device right away. We had this wish right from the start to build such a modular device but it would not have been feasible for us in terms of costs" (SW, 70).
In tackling these challenges, ideas that arose over time were collected and then implemented together. In addition, crowdfunding and pre-ordering, and thus pre-paying, are used to deal with limited financial resources. Investor participation should be avoided, because investors usually want to have a say in the company's business: "Designing and launching a product together with the crowd and not having to be talked into by an investor was great. It was a great opportunity to implement an idea independently and with the customers who were interested in developing a joint product" (Mamadenkt 2018). However, it is stressed that these financing models take up a considerable amount of time.



4.7. Supply chain management

Due to the low quantity of items that Shift purchases, it is difficult to find new suppliers. To meet this challenge, Shift searches for cooperation partners who need the same parts to be able to purchase a bigger number of parts from the supplier. Another possible solution is strengthening and consolidating existing cooperations: “For the partners we work with these are very exciting cooperation models, because they also learn a lot and find our methods very good” (SW, 36).

Another challenge with regards to supply chain management is the existence of sales monopolies of single companies. For some highly specialized components, such as camera chips or displays, there are only a few manufacturers. They have a "quasi-monopoly”. “[Y]ou have to be so specialized that you somehow have to be in the market with a certain standing. There are few such start-ups that are in the area” (SW, 38). In some cases, the specialized companies predefine partners. Shift has made arrangements with maximal flexibility. They have a partner, “with whom [they] have a very good relationship and who lets [them] do a lot ourselves, with whom [they] have made various agreements so that [they] can simply implement a lot [themselves]” (SW, 88). Another approach to deal with this challenge is networking. There is an ongoing exchange with current partners about synergies, and existing and potential partnerships.


Category
Challenges
Approaches
Supply chain management
Small scale
Sales monopoly of larger companies
Search for partners
Intensive cooperations
Arrangements with maximal flexibility
Networking

5. Discussion

Qualitative analysis (see chapter 3.1.3) was used to identify the ways Shift deals with challenges in the context of the implementation of a circular product design. In the following discussion, the collected data is compared to the existing knowledge about challenges and the ways of dealing with them. Selected interactions between the challenges are considered and discussed.

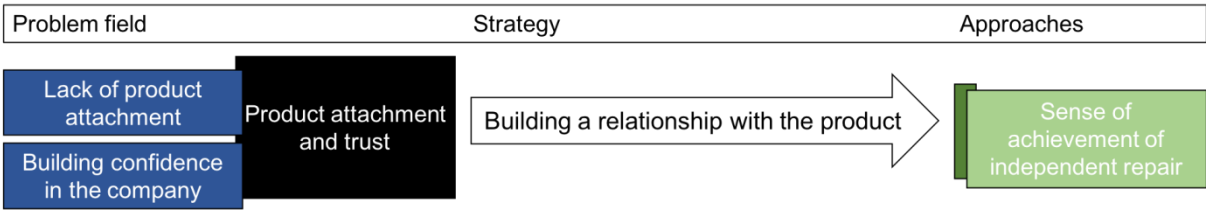
5.1. Analysis of the findings

While going through the results, it became clear that some challenges are related. They result from the same or similar circumstances. Hence, challenges are assigned to so-called problem fields. Their names are based on the categories which were developed in consequence with the theoretical framework and the collected data. In addition, the possible approaches are allocated to the problem fields. Some approaches belong to more than one problem area.

The assignment of the approaches to the different problem areas has revealed coping strategies which help Shift to deal with the problem fields. These strategies are represented by arrows in the diagrams.

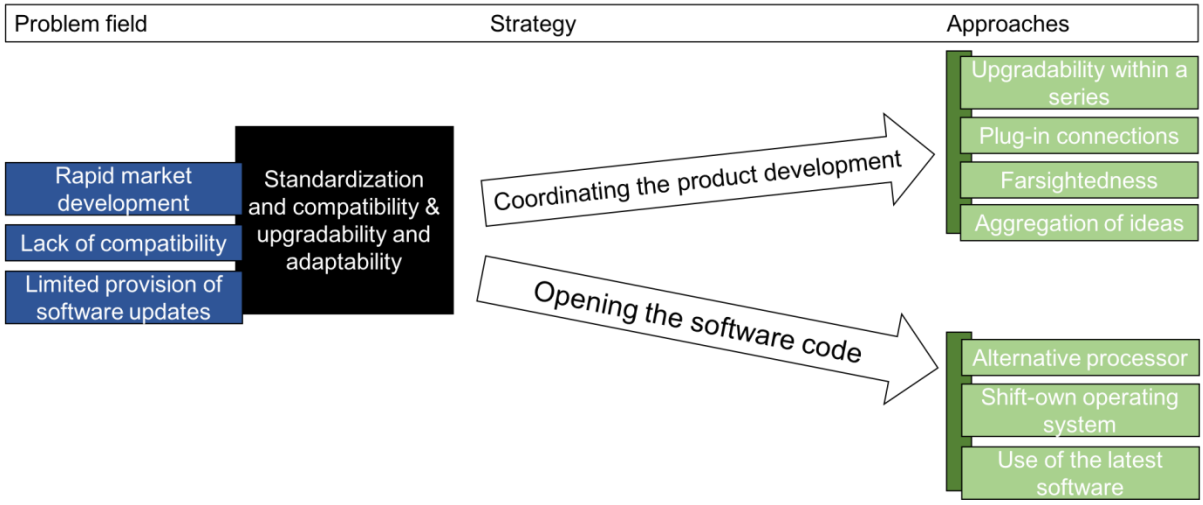
5.1.1. Problem field: Attachment and trust

Tackling the problem of lack of product attachment and building confidence in the company, Shift focuses on user's sense of achievement after an independent repair. The strategy which is pursued is called *building a relationship with the product*.



5.1.2. Problem field: Standardization and compatibility & upgradability and adaptability

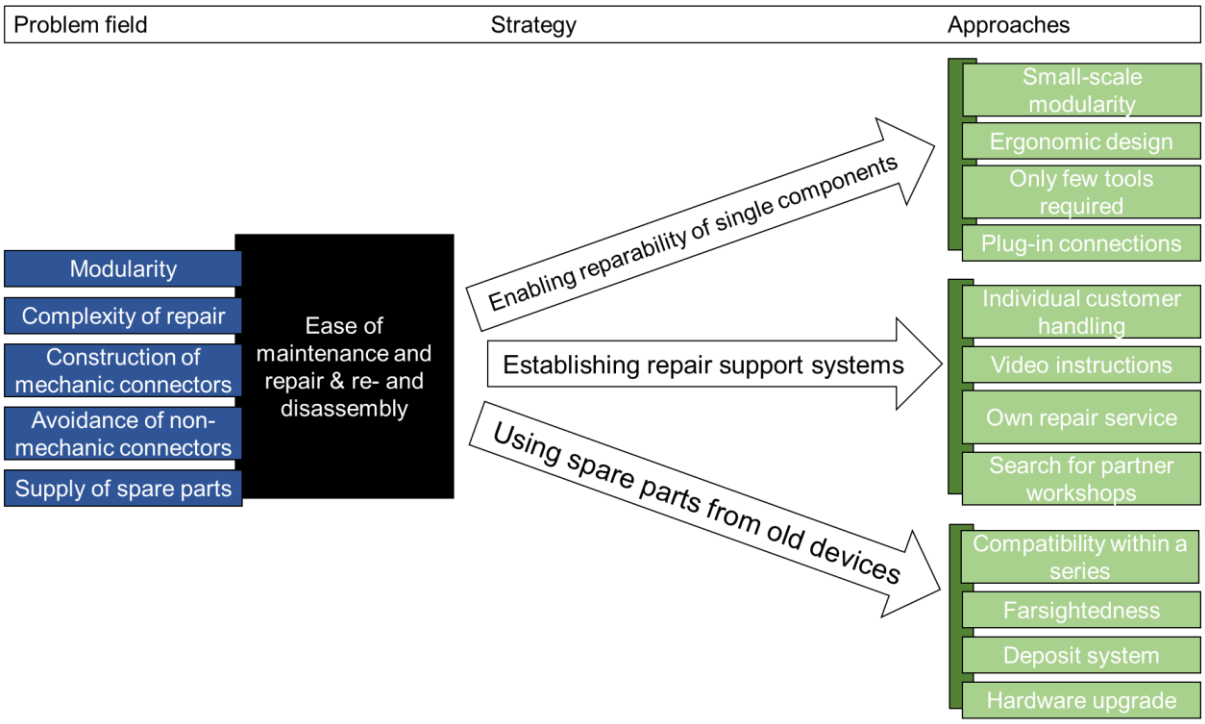
Rapid market development and lack of compatibility between smartphone components belong to the problem field of standardization and compatibility & upgradability and adaptability. The limited provision of software updates complements the problem field. To tackle this, Shift aims at c*oordinating the product development* through upgradability within a series, plug-in connections, farsightedness, and the aggregation of ideas. The strategy o*pening the software code* comprises approaches of an alternative processor and a Shift-own operating system as an alternative to the software of large corporations. The use of the latest software is also part of this strategy in the broadest sense.



5.1.3. Problem field: Ease of maintenance and repair & dis- and reassembly

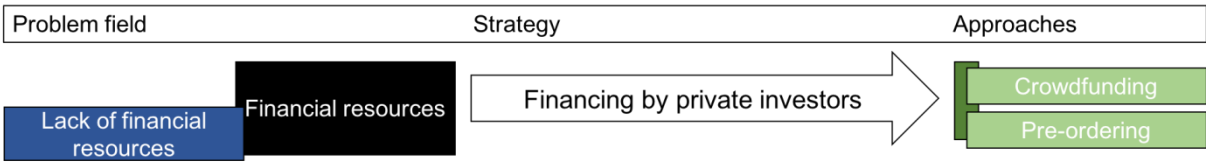
Aiming at ease of maintenance and repair & dis- and reassembly, the biggest challenge to overcome is modularity. This is accompanied by the selection of suitable connectors and the complexity of the repair. There is also the question of the supply of spare parts. With approaches of small-scale modularity, ergonomic design, requirement of only a few tools, and plug-in connections, Shift realizes a strategy of e*nabling reparability of single components.* Another strategy is e*stablishing repair support systems* through individual customer handling, video instructions, own repair service, and search for partner workshops. The supply of spare parts should be ensured through the strategy *using spare parts from old devices*. Especially compatibil-

ity within a series contributes to the realization of the deposit system and hardware upgrades, however, this requires farsightedness.



5.1.4. Problem field: Financial resources

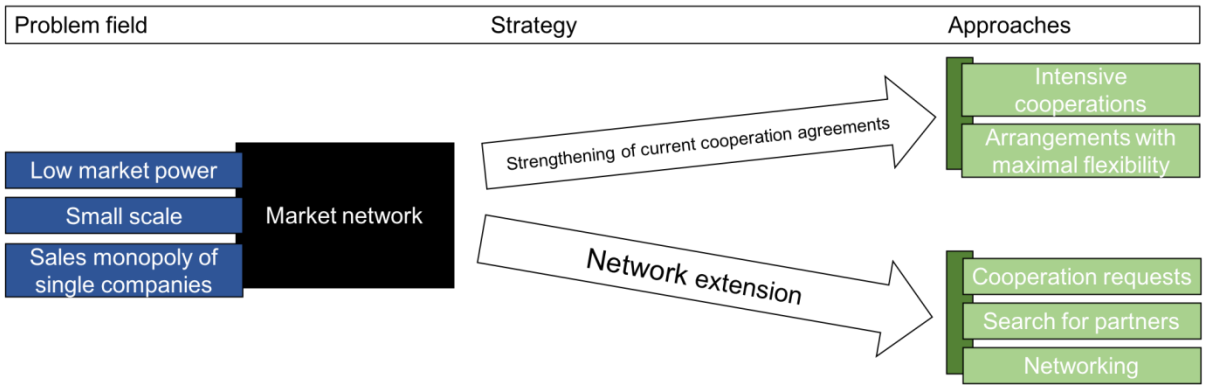
To deal with the problem of lacking financial resources, Shift chooses approaches that include crowdfunding and pre-ordering that contribute to the strategy *financing by private investors*.



5.1.5. Problem field: Market network

Shift pursues a *strengthening of current cooperation agreements* strategy through intensive cooperation and arrangements with a maximum of flexibility. Other approaches for the market network problem field are cooperation requests, search for

partners, and networking. These approaches belong to the *network extension* strategy.



5.2. Discussion of the findings

In this chapter, the strategies derived from the challenges and associated approaches are to be brought into connection with the current state of the literature. For a better understanding, the strategies are listed in Table 3 below with references to related literature. As the strategies are of different disciplinary character, this aspect is mentioned, too.

Table 3: Overview of strategies

Problem field	Strategy	Explanation	Literature
Attachment and trust	Building a relationship with the product	By the user's dealing with the smartphone and being able to change it himself through independent repair and understanding the technology behind it, a relationship to the product should be established and positive emotions should be connected with it.	Mugge et al. 2005; van Nes & Cramer 2006; Keyte 2015
Standardization and compatibility & upgradability and adaptibility	Coordinating the product development	In order to guarantee compatibility to a large extent, new product developments are coordinated and planned for the long term.	Umeda et al. 2005; Bakker et al. 2014
	Opening the software code	The software code should be disclosed in order to gain individual freedom and to ensure the long-term functionality of the software.	Proske et al. 2017
Ease of maintenance and repair & dis- and reassembly	Enabling reparability of single components	The smartphone's aesthetics, design and properties are intended to lower the inhibition threshold for repairing the smartphone. All circumstances are designed in such a way that the user's ability to repair is supported and single components can be replaced.	Schischke et al. 2017; van den Berg & Bakker 2015
	Establishing repair support systems	Service systems are being set up to support the smartphone repair.	Nissen et al. 2017
	Using spare parts from old devices	Aiming at long-term reparability, the supply of spare parts shall be ensured. Parts of discarded devices are utilized.	Nissen et al. 2017
Financial resources	Financing by private investors	The company's decision-making freedom should not be influenced by financial dependencies on commercial investors. The strategy pursues financing by "private" investors.	Schwienbacher & Larralde 2012; Belleflamme et al. 2010
Market network	Strengthening of current cooperation agreements	Existing cooperations are to be constantly strengthened and dynamically pursued.	Zajko 2017
	Network extension	The network to other companies and partners is to be successively expanded.	Pettersen et al. 2016; Dickel et al. 2018

5.2.1. Problem field: Attachment and trust

Strategy 1: Building a relationship with the product

Through a successful repair of a smartphone, which the user carries out himself, Shift hopes to increase consumers' emotional attachment to their products. The stronger the attachment, the more care take users of their devices, repair them and,

thus, extend their lifespan (Mugge et al. 2005; van Nes & Cramer 2006). A relationship with the product usually arises from feelings and memories that are connected to the device, as well as from the financial resources and the time spent on it (Grayson & Shulman 2000). If a user successfully carries out the repair of his smartphone, he has spent time (and probably money), on the one hand, and the user associates positive feelings with the device on the other.

However, the question arises as to whether such a high-level attachment can be established when the smartphone market is constantly subject to great innovation. This could be countered by providing more opportunities for consumers to physically engage with their devices, for example through modular products that users can upgrade and adapt themselves. In this way, more opportunities for positive emotional engagement are provided (Keyte 2015).

5.2.2. Problem field: Standardization and compatibility & upgradability and adaptability

Strategy 2: Coordinating the product development

Strategy 3: Opening the software code

In the case of Shift, no cross-series upgradeability could be achieved. With long-term planning Shift tries to make at least individual parts upgradeable. Upgradable products may create new business chances at later stages of a product life cycle, such as upgrading services, reuse of products, and remanufacturing of products (Tomiyama 1997). In order to meet the requirements of setting standards and ensuring compatibility, several manufacturers would have to cooperate in the long term. However, the coordination of product development with regard to compatibility and thus upgradeability is very difficult, especially in the ICT market.

In contrast to products such as refrigerators, ICT devices are of great interest and are subject to dynamic market conditions. In contrast to a smartphone, there are no major obstacles to designing a refrigerator for 20 years of use (Bakker et al. 2014b). The example of Shift confirms this assumption. It shows that the economically meaningful circular design strategy and the business model strategy depend on the product itself and on related market conditions.

The long-term supply of software updates is a problem for many smartphone manufacturers. An HTC representative says that for the respective update options for smartphones, the decisive criterion is which version delivers the best performance for the individual model. The factors involved are stability, speed, security and ease of use of the operating system. In some cases, the latest firmware is not always the most user-friendly choice. Thus, software updates are only available for a limited period of time (Frickel 2013).

To counteract these disadvantages of standardized software, Shift is aiming for a software variant with disclosure of the software code. It can be modified by the user (Proske et al. 2017). According to a statement by Fairphone B.V. on the subject of sustainable design, the unbundling of hardware and software can reduce the risk of premature aging of a smartphone (ibid.). Apart from the advantage of independent upgradability, personalization through having extended control also over the software and the operating system in particular, being able to adapt and adjust functionalities of modules or creating own modules contributes to higher product attachment, and thus, a longer product lifetime (Mugge 2017).

5.2.3. Problem field: Ease of maintenance and repair & re- and disassembly

Strategy 4: Enabling reparability of single components

Strategy 5: Establishing repair support systems

Strategy 6: Using spare parts from old devices

With the strategy of enabling reparability of single components, Shift demands a relatively high ability or willingness to repair from the users, but can thus avoid extensive housings of individual modules. According to Schischke et al. (2017), housings and universal connectors contribute to higher material consumption of high-scale modularity. The increased use of materials is only worthwhile, if the service life of the device and the individual modules is increased. However, there is a risk that the modules will be replaced very frequently in order to stay technologically up to date. This is called a “rebound effect” (Umweltbundesamt 2014).

The interchangeability of modules requires common interfaces (van den Berg & Bakker 2015). Here, the connection between modularity, compatibility and upgradea-

bility becomes clear. Farsightedness is a basic requirement. An additional aspect is the consumer's trust in the longevity of the smartphone. Assumed low product quality and short service life lead to low willingness to repair and thus short service life (Wieser & Tröger 2015).

Concerning hardware, there results the challenge of long-term supply. To servicing consumers for several years, possibilities of storage of spare parts or on-demand-production have to be discussed (Nissen et al. 2017). Shift chose the option of a deposit system. The advantage of this choice is that pre-owned parts can be reused and do not have to be disposed of. Moreover, this approach also brings immediate economic advantages, especially for a company like Shift with a low sales volume. Otherwise, risk remains if the equipment will actually be returned and how much time it takes. Referring to circuit boards, Krikke et al. (2004) point out the time needed for reverse logistics. The time period from when a user returns a part to when the part can be reused is much longer than it would take to reproduce spare parts. Nonetheless, the product category of smartphones and the low volume of spare parts for Shiftphones must be taken into account. For this reason, the example can be transferred to a limited extent only.
However, difficulties can also arise with regard to reproduction. Fairphone stopped supplying spare parts for the Fairphone 1 in mid-2017, four years after its launch. The demand was so low that there was no longer any profitable business. For further supplies, Fairphone refers to the community-marketplace, where users can buy spare parts from other users' obsolete smartphones (Fairphone 2017).
Examples like the challenging supply of spare parts demonstrate that a CE requires much more interaction and negotiation with other players in the value chain. Though, the resulting need for value chain coordination can be very challenging in case of small to moderately large enterprises (Nissen et al. 2017).

5.2.4. Problem field: Financial resources

Strategy 7: Financing by private investors

A challenge on the economic level is the initial investment. It means a long time of development without selling or having success. These investments need time to

amortize (Heinz 2012). Shift has opted mainly for crowdfunding and pre-ordering to be financially independent of large investors. Many other start-up companies also use crowdfunding for their early production phases (Schwienbacher & Larralde 2012). Cost reduction is usually the main reason for employing this strategy (Kleemann et al. 2008). As the revenues from crowdfunding/pre-ordering are used for product development and production, profits are shifted by one sales period. However, this gives Shift the advantage of being able to practice second-degree price discrimination and extract a larger share of the consumer surplus (Belleflamme et al. 2010).

Crowdfunding also serves to provide information and get public attention (ibid.). Beyond the status of the sponsor, users of crowdfunding can contribute to creating value for the company. This enables the company to reduce duration and costs of product development and to achieve higher customer acceptance (Schwienbacher & Larralde 2012).

5.2.5. Problem field: Market network

Strategy 8: Strengthening of current cooperation agreements

Strategy 9: Network extension

Shift is currently in a growth phase. Starting out in 2014, Shift has managed to "survive" the critical phase, which is considered to be the first two to three years of a business start-up, and can now continue to enlarge. This includes the development of strong sales and marketing, but also the expansion of the partner network to create new cooperation initiatives and to be able to stay innovative (Zajko 2017).

In addition to acquiring own networks, business incubators can contribute to network expansion. Internal networking with other incubator firms and external network resources facilitated by the incubator is perceived as a helpful supplement. However, in contrast to network resources acquired by the start-ups' own efforts, these incubator network resources are more generic in nature and provide limited idiosyncratic resources (Pettersen et al. 2016).

In contexts characterized by high uncertainty (Pfeffer & Salancik, 1978) and high innovativeness (Tether 2002), which are typical conditions for environmentally oriented firms (Hockerts & Wüstenhagen 2010; Mazzucato 2016; Schaltegger & Wagner

2011) like Shift, previous research indicates that the degree of collaboration with network partner increases. The complex and innovative solutions provided by environmentally oriented start-ups demand the more frequent communication of specific and complex know-how. According to this, environmentally oriented start-ups depend on networks to develop and sell sustainable innovations. These network activities are challenging but usually mandatory (Hansen 2014). However, Dickel et al. (2018) state that the network size depends on the internal or external environmental orientation of a company. External environmental orientation covers the extent to which managers believe external stakeholders expect that the firm fulfills environmental standards. In contrast, internal environmental orientation refers to managers' and employees' environmental values and norms (Banerjee 2002; Chan et al. 2012). Companies with a high level of internal environmental orientation place high demands on their suppliers; thus, such an orientation can be interpreted as a barrier that reduces the number of possible network partners (Dickel et al. 2018).

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6. Recommendations for practice and politics

From the discussion, recommendations for practice and politics have derived which are formulated in this chapter.

Since some accessories and tools are already available at the customer's premises, it is reasonable to request the desired accessories before sending the product. This way, resources for torx screwdrivers or power supplies can be saved.

When users of Shiftphones carry out repairs themselves, defective individual parts remain. In order to ensure professional disposal of those parts, it is recommended that Shift takes them back.

Especially in the area of spare parts supply, it would be advisable for Shift to cooperate with other (small) companies in order to achieve economies of scale and thus reduce the prices for customized products (Nissen et al. 2017). This would also contribute to the long-term supply of spare parts.

Aiming at gaining confidence in the long-term supply of spare parts and software updates, legally binding manufacturer guarantees for the supply are recommended. France enacted such a law in 2014 and can serve as a model in this case (France 2014).

To support the implementation of circular design approaches, tools or guidelines should be provided that make easy implementation possible and require only few resources and little time. Checklists, guidelines or databases are possible suggestions (Schulte & Hallstedt 2017).

Politics could also support pilot projects launched by companies with financial resources or facilitating access to risk capital funds (Bark et al. 2017; Vezzoli et al. 2015).

Aiming at countering the innovative speed of the ICT market and securing the return of smartphones, leasing offers should be considered. In the UK, Vodafone Red promises its customers the latest smartphone every twelve months. The used equipment is tested and then sold again, resulting in double added value. Such a performance business model is particularly suitable for higher-priced products such as smartphones, as they still achieve a high resale value after the first usage cycle (Rudolph 2018). Although the network operator Vodafone applies this business model in this case, it can also be transferred to manufacturers such as Shift.

7. Conclusion

During the implementation of a circular product design, Shift faces challenges that have to be dealt with. These challenges were assigned to the problem fields of product attachment and trust, standardization and compatibility & upgradability and adaptability, ease of maintenance and repair & re- and disassembly, financial resources, and market network. In dealing with these, Shift carries out various approaches, which could be summarized under certain strategies. Therefore, the hypothesis put forward at the beginning could be confirmed. The following nine strategies have been identified: (1) Building a relationship with the product, (2) Enabling reparability of single components, (3) Establishing repair support systems, (4) Using spare parts from old devices, (5) Coordinating the product development, (6) Opening the software code, (7) Financing by private investors, (8) Strengthening of current cooperation agreements, and (9) Network extension. As has become clear through the various arguments and connections, the strategies are of different disciplinary nature. This points to the complexity and multidisciplinarity of dealing with challenges resulting from the implementation of a circular product design.

Since the literature to date has only examined emerging challenges and few approaches, further studies should be conducted on more products in the ICT sector in order to enable comparisons. It would also be interesting to examine products that do not belong to the ICT sector to learn about strategic differences concerning product types and respective markets. In this way, the connection between circular product design and business models for a CE could also be established.

8. Bibliography

Accenture (2014): Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limits to Growth.

Angelis, R. De. (2018): Business Models in the Circular Economy. Cham: Palgrave Macmillan.

Bakker, C.; Wever, R.; Teoh, C. & de Clercq, S. (2010): Designing cradle to cradle products: A reality check. International Journal of Sustainable Engineering, Vol. 3, No. 1, 2–8.

Bakker, C.; den Hollander, M.; van Hinte, E. & Zijlstra, Y. (2014a): Products that last: Product design for circular business models. Delft: TU Delft Library.

Bakker, C.; Wang, F.; Huisman, J. & den Hollander, M. (2014b): Products that go round: Exploring product life extension through design. Journal of Cleaner Production, Vol. 69, 10–16.

Baldé, C. P.; Wang, F.; Kuehr, R. & Huisman, J. (2015): The Global E-Waste Monitor 2014. United Nations University, IAS – SCYCLE, Bonn.

Balkenende, A. R. & Bakker, C. (2015): Developments and challenges in design for sustainability of electronics. Advances in Transdisciplinary Engineering, Vol. 2, 3–13.

Banerjee, S. B. (2002): Corporate environmentalism: The construct and its measurement. Journal of Business Research, Vol. 55, No. 3, 177–191.

Bark, R.; Achimescu, A.; Neumann, C. & van Wijk, D. (2017): Supporting the circular economy transition: The role of the financial sector in the netherlands. Oliver Wyman.

Belleflamme, P.; Lambert, T. & Schwienbacher, A. (2010): Crowdfunding: An industrial organization perspective. Business, 25–26.

Bhamra, T. & Lofthouse, V. (2016): Design for Sustainability: A Practical Approach. UK: Gower.

Bitkom (2018): 124 Millionen Alt-Handys liegen ungenutzt herum. https://www.bitkom.org/Presse/Presseinformation/124-Millionen-Alt-Handys-liegen-ungenutzt-herum.html (Accessed: 25.05.18).

Bocken, N. M. P.; de Pauw, I.; Bakker, C. & van der Grinten, B. (2016): Product design and business model strategies for a circular economy. Journal of Industrial and Production Engineering, Vol. 33, No. 5, 308–320.

Bocken, N. M. P.; Short, S. W.; Rana, P. & Evans, S. (2014): A literature and practice review to develop sustainable business model archetypes. Journal of Cleaner

Production, Vol. 65, 42–56.

Bogner, A.; Littig, B. & Menz, W. (2005): Das Experteninterview: Theorie, Methode, Anwendung. Wiesbaden: VS Verlag für Sozialwissenschaften, 2. Auflage.

Bogner, A. & Menz, W. (2009): "The Theory-Generating Expert Interview: Epistemological Interest, Forms of Knowledge, Interaction," in Bogner, A.; Littig, B. & Menz, W. (ed.), Interviewing Experts. UK: Palgrave Macmillan, 43–80.

Bogue, R. (2007): Design for disassembly: A critical twenty-first century discipline. Assembly Automation, Vol. 27, No. 4, 285–289.

Botsman, R. & Rogers, R. (2010): What's Mine Is Yours: The Rise of Collaborative Consumption. New York: HarperBusiness.

Braungart, M.; McDonough, W. & Bollinger, A. (2006): Cradle to cradle design: Creating healthy emissions – A strategy for eco-effective product and system design. Journal of Cleaner Production, Vol. 15, No. 13–14, 1337–1348.

CEBIT (2018): Firmenprofil Shift GmbH. https://www.cebit.de/aussteller/shift-gmbh/R851847 (Accessed: 10.05.18).

Chan, R. Y. K.; He, H.; Chan, H. K. & Wang, W. Y. C. (2012): Environmental orientation and corporate performance: The mediation mechanism of green supply chain management and moderating effect of competitive intensity. Industrial Marketing Management, Vol. 41, No. 4, 621–630.

Mamadenkt (2018): Das SHIFTPHONE: Interview mit SHIFT-CEO Samuel Waldeck. https://www.mamadenkt.de/das-shiftphone-interview-mit-shift-ceo-samuel-waldeck/ (Accessed 18.04.18).

Dickel, P.; Hörisch, J. & Ritter, T. (2018): Networking for the environment: The impact of environmental orientation on start-ups' networking frequency and network size. Journal of Cleaner Production, Vol. 179, 308–316. https://doi.org/10.1016/j.jclepro.2018.01.058

Dießenbach, J. & Reller, A. (2016): "Das "Fairphone": Ein Impuls in Richtung nachhaltige Elektronik?", in Exner, A.; Held, M.; Kümmerer, K. (ed.), Kritische Metalle in der Großen Transformation. Heidelberg: Springer, 269–292.

Ellen MacArthur Foundation (2012): Towards the Circular Economy 1. Economic and Business Rationale for an Accelerated Transition.

Ellen MacArthur Foundation (2015): Growth within: A circular economy vision for a competitive europe.

Ellen MacArthur Foundation (2018): Case Studies. https://www.ellenmacarthurfoundation.org/case-studies/business (Accessed: 25.04.18).

European Commission (2015): Press release – Closing the loop: Commission adopts ambitious new Circular Economy Package to boost competitiveness, create jobs and generate sustainable growth. http://neurope.eu/wires/closing-the-loop-commission-adopts-ambitious-new-circular-economy-package-to-boost-competitiveness-create-jobs-and-generate-sustainable-growth/ (Accessed: 14.04.18).

European Commission (2018): Press release – Single-use plastics: New EU rules to reduce marine litter. http://europa.eu/rapid/press-release_IP-18-3927_en.htm (Accessed: 06.06.18).

Evans, C.; Renz, R.; McCullough, E.; Lawrence, S.; Pavlenko, N.; Brundage, S. S. A.; Hecht, J.; Lizas, D. & Bailey, P. (2011): Case Study on Critical Metals in Mobile Phones: Final Report. OECD.

Fabrycky, W. J. (1987): Designing for the Life Cycle. Mechanical Engineering, 72–74.

Fairphone. (2017): Why we had to stop supporting the Fairphone 1. https://www.fairphone.com/de/2017/07/20/why-we-had-to-stop-supporting-the-fairphone-1/ (Accessed: 28.05.18).

Flick, U. (2011): Qualitative Sozialforschung: Eine Einführung. Reinbek bei Hamburg: Rowohlt, 4. Auflage.

Flick, U.; von Kardoff, E. & Steinke, I. (2013): "Was ist qualitative Forschung?: Einleitung und Überblick", in: Flick, U.; von Kardoff, E. & Steinke, I. (ed.): Qualitative Forschung. Ein Handbuch. Reinbek bei Hamburg: Rowohlt, 13–29.

France (2014): Décret n° 2014-1482 du 9 décembre 2014 relatif aux obligations d'information et de fourniture concernant les pièces détachées indispensables à l'utilisation d'un bien (2014). https://www.legifrance.gouv.fr/eli/decret/2014/12/9/EINC1424543D/jo/texte (Accessed: 03.05.18).

Frickel, C. (2013): Warum Hersteller Technik so schnell veralten lassen. https://www.focus.de/digital/multimedia/tid-28934/fehlende-updates-und-hardware-fehler-warum-hersteller-technik-so-schnell-veralten-lassen_aid_895536.html (Accessed: 06.06.18).

Grayson, K. & Shulman, D. (2000): Indexicality and the Verification Function of Irreplaceable Possessions: A Semiotic Analysis. Journal of Consumer Research, Vol. 27, No. 1, 17–30.

Greenpeace (2017): 10 Jahre Smartphone: Die globalen Umweltfolgen von 7 Milliarden Mobiltelefonen. Washington.

Hagelüken, C. (2006): Recycling of electronic scrap at Umicore's integrated metals smelter and refinery. Erzmetall, Vol. 59, No. 3, 152–161.

Hansen, T. (2014): Juggling with Proximity and Distance: Collaborative Innovation

Projects in the Danish Cleantech Industry. Economic Geography, Vol. 90, No. 4, 375–402.

Heinz, S. M. (2012): Intelligent Product Design: An Exploratory Study on the Chances and Challenges of the eco-effective Cradle to Cradle Design Concept. Leuphana University Lüneburg: Bachelor thesis.

Hockerts, K. & Wüstenhagen, R. (2010): Greening Goliaths versus emerging Davids: Theorizing about the role of incumbents and new entrants in sustainable entrepreneurship. Journal of Business Venturing, No. 25, Vol. 5, 481–492.

Keyte, J. (2015): "Hardware hopes: Examining emotional connections to computers through creative story telling", in: Cooper, T.; Braithwaite, N.; Moreno, M. & Salvia, G. (ed.): PLATE conference - Nottingham Trent University, 17/19 June 2015. Nottingham: Nottingham Trent University, 166–172.

Kleemann, F.; Voß, G. G. & Rieder, K. (2008): Un(der)paid Innovators: The commercial utilization of consumer work through crowdsourcing. Science, Technology & Innovation Studies, Vol. 4, No. 1, 5-26.

Kraaijenhagen, C.; van Oppen, C. & Bocken, N. M. P. (2016): Circular Business: Collaborate and Circulate. Amersfoort: Circular Collaboration, 2nd edition.

Krikke, H.; le Blanc, I. & van de Velde, S. (2004): Product modularity and the design of closed loop supply chains. California Management Review, Vol. 46, No. 2, 23–39.

Kuckartz, U. (2014). Qualitative Inhaltsanalyse. Methoden, Praxis, Computerunterstützung. Weinheim: Beltz Juventa.

Lamnek, S. (2005): Qualitative Sozialforschung: Lehrbuch. Weinheim: Beltz, 4. Auflage.

Lewandowski, M. (2016): Designing the business models for circular economy: Towards the conceptual framework. Sustainability (Switzerland), Vol. 8, No. 1, 1–28.

MAXQDA (2017): MAXQDA: Software für qualitative Datenanalyse.

Mayring, P. (2015): Qualitative Inhaltsanalyse: Grundlagen und Techniken. Weinheim: Beltz, 12. Auflage.

Mazzucato, M. (2016): From market fixing to market-creating: a new framework for innovation policy. Industry and Innovation, Vol. 23, No. 2, 140–156.

McDonough, W. & Braungart, M. (2002): Cradle to Cradle: Remaking the way we make things. New York: North Point Press.

Meadows, D. H.; Meadows, D. L.; Randers, J. & Behrens, W. W. (1972): The Limits to Growth. New York: Universe Books.

Mestre, A. & Cooper, T. (2017): Circular Product Design: A Multiple Loops Life Cycle Design Approach for the Circular Economy. The Design Journal, Vol. 20, No. sup1, 1620–1635.

Mieg, H. A. & Näf, M. (2006): Experteninterviews in den Umwelt- und Planungswissenschaften: Eine Einführung und Anleitung. Lengerich: Pabst Science Publishers.

Mugge, R. (2017): "A consumer's perspective on the circular economy", in: Chapman, J. (ed.): Routledge Handbook of Sustainable Product Design. London: Taylor & Francis, 374–422.

Mugge, R.; Schoormans, J. P. L. & Schifferstein, H. N. J. (2005): Design strategies to postpone consumers' product replacement: The value of a strong person-product relationship. Design Journal. Vol. 8, No, 2, 38–48.

Nissen, N. F.; Schischke, K.; Proske, M.; Ballester, M. & Lang, K. D. (2017): "How modularity of electronic functions can lead to longer product lifetimes", in: Bakker, C. A. & Mugge, Y. (ed.): Conference Proceedings | 8-10 November, 2017 | Delft, NL. Amsterdam.

OECD (2015): Material Resources, Productivity and the Environment. Paris.

Osterwalder, A. & Pigneur, Y. (2010): Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. Hoboken: Wiley & Sons, Inc.

Osterwalder, A.; Pigneur, Y. & Tucci, C. L. (2005): Clarifying business models: Origins, present, and future of the concept. Communications of the Association for Information Systems, Vol. 16, No. 1, 1–43.

Patrignani, N. (2017): The Challenge of ICT Long-Term Sustainability. Visions for Sustainability, Vol. 7, 54–59.

Pettersen, I. B.; Aarstad, J.; Høvig, Ø. S. & Tobiassen, A. E. (2016): Business incubation and the network resources of start-ups. Journal of Innovation and Entrepreneurship, Vol. 5, No. 7.

Pfeffer, J. & Salancik, G. (1978): The External Control of Organizations. New York: Harper & Row.

Prendeville, S. M.; O'Connor, F.; Bocken, N. M. P. & Bakker, C. (2017): Uncovering ecodesign dilemmas: A path to business model innovation. Journal of Cleaner Production, Vol. 143, 1327–1339

Proske, M.; Schischke, K.; Sommer, P.; Trinks, T.; Nissen, N. F. & Lang, K. D. (2017): Experts View on the Sustainability of the Fairphone 2. 2016 Electronics Goes Green 2016+, EGG 2016, Berlin, 3–9.

Reller, A.; Bublies, T.; Staudinger, T.; Oswald, I.; Meißner, S. & Allen, M. (2009): The Mobile Phone: Powerful Communicator and Potential Metal Dissipator. Gaia,

Vol. 18, No. 2, 127–135.

Rudolph, C. (2018): Geschäftsmodell Circular Economy: Gegenwart und Zukunft der (erweiterten) Kreislaufwirtschaft. CSR und Geschäftsmodelle, 123–137.

Schaltegger, S. & Wagner, M. (2011): Sustainable entrepreneurship and sustainability innovation: Categories and interactions. Business Strategy and the Environment, Vol. 20, No. 4, 222–237.

Schischke, K.; Proske, M.; Nissen, N. F. & Lang, K. D. (2017): Modular products: Smartphone design from a circular economy perspective. 2016 Electronics Goes Green 2016+, EGG 2016, Berlin.

Schischke, K.; Proske, M.; Sommer, P. & Trinks, T. (2016): „Wie nachhaltig ist das Fairphone 2?“. Fraunhofer IZM, Deutsche Umwelthilfe, Berlin.

Schulte, J. & Hallstedt, S. (2017): Challenges and Preconditions to Build Capabilities for Sustainable Product Design. Proceedings of the International Conference on Engineering Design, ICED, Vancouver.

Schwienbacher, A. & Larralde, B. (2012): "Crowdfunding of small entrepreneurial ventures", in: Cumming, D. (ed.): Handbook of Entrepreneurial Finance. New York: Oxford University Press, 369–391.

Shift GmbH (2018): Shiftphones Homepage. https://www.shiftphones.com (Accessed: 29.05.18).

Shop Shiftphones (2018): Shift 6m (pre-order). https://shop.shiftphones.com/shift6m.html#product_tabs_description (Accessed: 13.05.18).

Steinke, I. (2005): "Gütekriterien qualitativer Forschung", in: Flick, U.; von Kardorff, E. & Steinke, I. (ed.): Qualitative Forschung: Ein Handbuch. Reinbek b. Hamburg: Rowohlt Taschenbuch, 319-331.

Stiftung Warentest (2013): Schon kaputt? Test, test 9/201.

Tether, B. S. (2002): Who co-operates for innovation, and why. Research Policy, Vol. 31, No. 6, 947–967.

Tomiyama, T. (1997): A manufacturing paradigm toward the 21st century. Integrated computer-aided engineering, Vol. 4, No. 3, 159–178.

Umweltbundesamt (2014): Rebound-Effekte. https://www.umweltbundesamt.de/themen/abfall-ressourcen/oekonomische-rechtliche-aspekte-der/rebound-effekte (Accessed: 05.06.18).

Umweltbundesamt (2016): Einfluss der Nutzungsdauer von Produkten auf ihre Umweltwirkung: Schaffung einer Informationsgrundlage und Entwicklung von Strategien gegen „Obsoleszenz. Dessau-Roßlau.

van den Berg, M. R. & Bakker, C. A. (2015): A product design framework for a circular economy. PLATE Conference, 365–379.

van Nes, N. & Cramer, J. (2006): Product lifetime optimization: A challenging strategy towards more sustainable consumption patterns. Journal of Cleaner Production, Vol. 14, No. 15–16, 1307–1318.

Vezzoli, C.; Ceschin, F.; Diehl, J. C. & Kohtala, C. (2015): New Design Challenges to Widely Implement “Sustainable Product-Service Systems”. Journal of Cleaner Production, Vol. 97, 1–12.

WBCSD (2010): Vision 2050: The new agenda for business.

Weetman, C. (2016): A Circular Economy Handbook for Business and Supply Chains: Repair, Remake, Redesign, Rethink. London: Kogan Page.

Wieser, H. & Tröger, N. (2015): Die Nutzungsdauer und Obsoleszenz von Gebrauchtgütern im Zeitalter der Beschleunigung: Eine empirische Untersuchung in Österreichischen Haushalten. Wien: Kammer für Arbeiter und Angestellte in Wien.

World Economic Forum; Ellen MacArthur Foundation & McKinsey & Company (2014): Towards the Circular Economy: Accelerating the scale-up across global supply chains. Genf.

Yin, R. K. (2009): Case study research: design and methods. Los Angeles, Calif.: Sage Publications, 5th edition.

Zajko, M. (2017): Challenges of scaling-up process for start-ups. Balkan Region Conference on Engineering and Business Education, Vol. 3, No. 1, 62–70.

9. Appendix

1. Enclosed to this document:
    a. Interview guideline (in German)
        i) Samuel Waldeck
        ii) Daniel Rauh
    b. Category system used for the content analysis
    c. German translation of quotes used in chapter 4

2. Available as supplementary material (upon request):
    a. Audio files recorded during interviews
    b. Transcripts
    c. MAXQDA file
    d. Codings form the content analysis

Appendix 1ai: Interview guideline (in German) – Samuel Waldeck

	Frage	Vertiefung
Person und Unternehmen	1. Welche Position nimmst du bei Shift ein?	
	2. Was sind deine Aufgaben?	
	3. Wie viele Mitarbeiter hat shift?	
Circular economy und circular design	1. Was verstehst du unter zirkulärem Produktdesign?	1.1 Wie kamt ihr zu dieser Idee?
		1.2 Warum?
	2. Mit welcher Motivation wird bei Shift ein zirkuläres Produktdesign	
Circular product design Merkmale	1. Warum habt ihr euch für ein modulares Smartphone entschieden?	1.1 Welche "besonderen" Einzelteile waren für die modulare Konstruktion
		1.2 Inwieweit waren die benötigten Teile auf dem freien Markt verfügbar? Warum nicht?
		1.3 Welche Herausforderungen bringt euer Status als kleines Unternehmen mit geringer Stückzahl mit sich? Warum?
	2. Wie seid ihr die Herausforderung von Kompatibilität angegangen?	2.1 Wie kombiniert ihr Weiterentwicklung und Standardisierung?
		2.2 Inwieweit sind die Geräte der shift-Reihe untereinander kompatibel?
		2.3 Wie genau funktionieren die „Hardware-Updates“? Warum habt ihr euch für diese Variante entschieden?
		2.4 Bestehen Kooperationen mit anderen Unternehmen?
	3. Worauf achtet ihr speziell, damit shiftphones einfach instand zu halten und zu reparieren sind?	3.1 Wie ist die Versorgung mit Ersatzteilen geregelt? Wie lange? Warum sind die Ersatzteile nur bei euch zu kaufen?
		3.2 Welche Herausforderungen treten bei der Bereitstellung von Software-Updates auf? Warum?
		3.3 Warum verfolgt ihr den Ansatz eines eigenen Betriebssystems (shift OS)?
		3.4 Warum habt ihr euch für Reparaturanleitungen per YouTube-Video entschieden?
	4. Wie werden beständige Materialien ausgesucht?	4.1 Worauf liegt der Fokus? Warum?
		4.2 Auf welcher Ebene treten am meisten Herausforderungen in Sachen Material auf? Warum?

Appendix 1ai: Interview guideline (in German) – Samuel Waldeck – continuation

Circular product design Merkmale	5. Welche Rolle spielen Kosten bei der Umsetzung eines Circular Designs?	5.1 Warum steigen/sinken die Kosten in bestimmten Bereichen?
		5.2 Warum habt ihr euch für die Anfangsfinanzierung per Crowdfunding entschieden? Warum Pre-Ordering?
		5.3 Wie variiert der finanzielle Aufwand der vorigen shiftphone-Generationen im Vergleich zum 6m(q)? Warum?
	6. Wie schafft ihr emotionale Verbundenheit zwischen Konsument und Produkt?	6.1 Wie schafft ihr Wertschätzung eurer Geräte?
		6.2 Was kann Transparenz von Partnern dazu beitragen?
		6.3 Welche Herausforderungen bringt Transparenz mit sich?
Zukunft	1. Verfolgt ihr aktuell ein nächstes Ziel bzgl. der Zirkularität eurer Produkte?	

Appendix 1aii: Interview guideline (in German) – Daniel Rauh

	Frage	Vertiefung
Person und Unternehmen	1. Welche Position nimmst du bei Shift ein?	
	2. Was sind deine Aufgaben?	
	3. Was verstehst du unter zirkulärem Produktdesign?	
Circular product design Merkmale	1. Warum verfolgt shift gerade die Strategie der Modularität? Welche Strategien wären für ein zirkuläres	
	2. Welche „besonderen“ Einzelteile sind für die modulare Konstruktion nötig?	
	3. Wie seid ihr die Herausforderung der „kleinteiligen Modularität“ (Zitat Samuel) angegangen? Welche Schwierigkeiten treten hier auf?	
	4. Wie gestaltet sich der Konflikt zwischen Modularität und	
	5. Welche Herausforderungen bringen mechanische Konnektoren mit sich?	5.1 An welchen Stellen sind mechanische Konnektoren (noch) nicht
		5.2 Für welche Alternativen habt ihr euch an diesen Stellen entschieden und
	6. Neben mechanischen Konnektoren: worauf kommt es außerdem an, dass ein Smartphone einfach auseinander- und wieder zusammenzubauen ist?	
	7. Wie werden beständige Materialien ausgesucht?	7.1 Worauf liegt der Fokus (Umweltverträglichkeit, Preis, Rezyklierbarkeit etc.)? Warum?
		7.2 Auf welcher Ebene treten die größten Herausforderungen in Sachen Material auf? Warum?
	8. Wie kombiniert ihr Weiterentwicklung und Standardisierung?	
	9. Welche Herausforderungen treten bei der Hardware-Upgradefähigkeit auf? Wie geht ihr mit diesen um?	
	10. Wie gestaltet sich die Zusammenarbeit mit der Abteilung „Reparatur“, um das Produktdesign an deren Ansprüche anzupassen?	
	11. Wie schafft ihr emotionale Verbundenheit zwischen Kunde und	
Know-how	1. Wie hast du dir Know-How zu Circular Product Design angeeignet?	1.1 Was war neu?
		1.2 Worauf konntest du zurückgreifen?

Appendix 1b: Category system used for the content analysis

First level	Second level	Third level
Attachment and trust		
	Lack of attachment	
		Sense of achievement of independent repair
	Confidence building between user and company	
		Individual customer handling
Standardization and comppatibility		
	Rapid market development	
		Compatibility within a serial
		Long-term thinking
	Low market power	
		Cooperation requests
Ease of maintenance and repair		
	Modularity	
		Small-scale modularity
	Complexity of repair	
		Ergonomic design
		Less tools required
		Video instructions
		Own reparation service
		Search for partner workshops
	Supply of spare parts	
		Deposit system

Appendix 1b: Category system used for the content analysis – continuation

First level	Second level	Third level
Upgradability and adaptibility		
	Rapid market development	
		Upgradability within a serial
		Hardware upgrade
	Lack of compatibility	
		Upgradability within a serial
		Hardware upgrade
	No disclosure of software code	
		Alternative software ship
		Shift-own operation system
Dis- and reassembly		
	Construction of mechanic connectors	
		Plug-in connections
	Avoidance of non-mechanic connectors	
Financial resources		
	Lack of financial resources	
		Crowdfunding
		Pre-ordering
Supply chain management		
	Small scale	
		Search for partners
		Intensive cooperations
	Sales monopoly of larger companies	
		Arrangements with maximal flexibiliy
		Networking

Appendix 1c: German translation of quotes used in chapter 4

Source	Original German quote
DR_40a	...vielschichtig[e]...
DR_40b	...wir versuchen da einfach auch über unsere Art, wie wir Produkte präsentieren, eine Verbundenheit und Verständnis entstehen zu lassen.
SW_54	Die Akkus sind natürlich nicht kompatibel, weil wir auch da eben immer versuchen das Optimum rauszuholen an Größe und Kapazität.
DR_36	Da ist es gut, wenn man sich frühzeitig überlegt: wo geht die Fahrt hin mit einem weiteren Produkt?
SW_20	...für uns war es beispielsweise keine Lösung eine Modularität zu wählen, wo wir ganze Modulgruppen tauschen. Das war für uns wichtig die Modularität wirklich auf einer ganz kleinen Ebene zu haben. Dass ich wirklich mit wenig Ressourcenverschwendung einzelne Teile entnehmen kann... Weil ansonsten dieser Nachhaltigkeitsaspekt auch gar nicht mehr so groß ist.
DR_12	Und so versuchen wir über das Produktdesign und da eben mit der Modularität sehr einfach Dinge darzulegen, die nachzuvollziehen sind durch den Nutzer […] sodass er sich dann auch wirklich traut.
SW_40	Dadurch kriegen wir immer wieder von Altgeräten Ersatzteile rein und können die dann wiederum an den Markt bringen.
SW_48	...sodass der Kunde selber entscheiden kann, welche Daten er bei sich lagernd haben möchte oder in welchem Bereich er dann die Google-Dienste nutzen möchte oder andere Dienste nutzen möchte, sei es Facebook oder Whatsapp. Da hat er seine Privatsphäre selber in der Hand, das ist uns wichtig in dem Bereich.
SW_68	Das hat jetzt nicht so viel mit Material zu tun, sondern mehr mit der Konstruktion. Das die eben möglichst klein sind, damit die Hauptplatine so filigran sein kann wie sie eben ist, aber trotzdem leicht zu reparieren sind.
SW_70	Also der Hauptteil der Kosten sind nicht Materialien, sondern Entwicklung. Das war für uns sehr aufwändig und das war auch ein Grund, warum wir nicht gleich mit einem modularen Gerät angefangen haben. Diesen Wunsch hatten wir schon von Anfang an ein Gerät so modular aufzubauen. Aber es wäre kostentechnisch für uns nicht realisierbar gewesen.
mama_denkt	Mit der Crowd zusammen ein Produkt zu entwerfen, ins Leben zu rufen und sich nicht von einem Investor reinreden lassen zu müssen, war großartig. Es war eine tolle Gelegenheit unabhängig eine Idee umzusetzen und mit den Kunden, die Interesse daran hatten, ein gemeinsames Produkt zu entwickeln.
SW_72	...je größer wir geworden sind [...], konnten wir dann eben auch die Sachen entsprechend umsetzen. Aber auch die Erfahrungen, die wir sammeln konnten.
SW_36	Aber die Partner, mit denen wir zusammenarbeiten, für die sind das sehr spannende Kooperationen. Weil die auch viel lernen dabei und unsere Ansätze auch sehr gut finden.
SW_38	...so größere Sachen wie Kamerachip-Hersteller und so, das sind halt Sachen, da muss man so spezialisiert sein, dass man irgendwie auch schon mit einem gewissen Standing im Markt sein muss. Da gibt es wenige so Start-Ups, die in dem Bereich sind.
SW_88	Und da haben wir aber einen Partner, mit dem wir einen sehr guten Umgang haben und der uns sehr viel selber machen lässt, mit dem wir da verschiedene Vereinbarungen getroffen haben, dass wir viel einfach selber umsetzen können.

10. Statutory Declaration

Hereby I declare that this bachelor thesis has been written only by the undersigned, solely with the support the indicated references. Furthermore, I assure that all quotations and statements that have been inferred literally or in a general manner from published or unpublished writings are marked as such. Beyond, I affirm that the work has not been used, neither completely nor in parts, to pass any previous examination.
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