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Closing Loops in the Circular Economy

A Make or Buy Analysis for the Smartphone Industry

Master's Thesis
Sustainability Science (M.Sc.)
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SUMMARY

Smartphones make intensive use of precious metals and so called conflict minerals in order to reach their high performance in a compact size. In recent times, sustainability challenges related to production, use and disposal of smartphones are increasingly a topic of public debate. Thus, established industry actors and newly emerging firms are driven to engage in more sustainable practices, such as sustainable sourcing of materials, maintenance services or take-back schemes for discarded mobile phones. Many of these latter efforts can be related to the concept of a circular economy (CE).

This thesis explores how CE-related value creation architectures (VCAs) in the smartphone industry contribute to slowing and closing resource loops in a CE. In order to analyze these new industry arrangements, transaction cost theory (TCT) is used as a guiding theory for a make-or-buy analysis. Combining TCT with the concept of a CE is a novel research approach that enables the empirical analysis of relationships between focal actors (e.g. manufacturers) and newly emerging loop operators (e.g. recycling firms) in the smartphone industry. Case studies of such VCAs are conducted with case companies drawn from the Innovation Network on Sustainable Smartphones (INaS) at Leuphana Universtity of Lüneburg and analyzed regarding their involved actors, partnerships, circular activities, motivation and perceived barriers.

Evidence from the conducted case studies suggests that asset specificity for circular practices increases for higher order CE-loops such as maintenance or reuse, therefore long-term partnerships between focal actors and loop operators or vertical integration of CE practices are beneficial strategies to reach a sophisticated CE. Similarly, circular practices that go beyond recycling require a strong motivation, either through integration in the focal firm's quality commitment or through business model recognition. It is further suggested that the circular design of products and services could reduce necessary transaction costs and thus overall costs of a circular economy.

Four different integration strategies for circular economy practices have been derived from the conducted case studies. These are: 1) vertically integrated loops, 2) cooperative loop-networks, 3) outsourcing to loop operators and 4) independent loop operators. This work thus provides evidence that circular economy activities do not necessarily have to be managed by focal actors in the value chain. Rather, circular practices can also be put forward by specialized loop operators or even independent actors such as repair shops.

Keywords: Smartphones, ICT, Circular Economy, Transaction Cost Theory, Sustainability, Corporate Sustainability

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ABBREVIATIONS

CE	Circular Economy
CSM	Centre for Sustainability Management
CSR	Corporate Social Responsibility
BD	Business Development
BM	Business Model
DFD	Design for Disassembly
EAR	Elektro-Altgeräte Register (National Register for Waste Electric Equipment)
e.g.	exempli gratia
ElektroG	Elektro- und Elektronikgerätegesetz (law on electrical and electronic devices)
EMF	Ellen MacArthur Foundation
i.a.	inter alia
ICT	Information and Communications Technology
INaS	Innovationsverbund Nachhaltige Smartphones
IPCC	Intergovernmental Panel on Climate Change
KrWG	Kreislaufwirtschaftsgesetz (law on ‘recycling economy‘)
OEM	Original Equipment Manufacturer
örE	öffentlich-rechtliche Entsorgungsträger (Public Waste Disposal Authorities)
p.a.	per annum
REE	Rare Earth Elements
TC	Transaction Costs
TCT	Transaction Cost Theory
UBA	Federal Environmental Agency in Germany
VCA	Value Creation Architecture
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
vs.	versus
WEEE	Waste Electrical and Electronic Equipment

1 INTRODUCTION

1.1 Problem Framing

Smartphones have become our daily companions and certainly provide an astonishing functionality, yet consumers know little about their inner parts, let alone what to do when they let us down. Due to their prevalence they have become a fascinating, but also challenging artefact for studying the implementation of a circular economy that aims towards a more sustainable development. The present thesis aims at identifying beneficial implementation strategies for circular economy practices on a macroeconomic level.

Information and communication technology (ICT) is a popular, fast moving consumption industry providing lifestyle goods, such as smartphones, with comparably short life times of 18-36 months on average (Suckling & Lee 2015; Valero Navazo et al. 2014; Wieser & Tröger 2015; OECD 2011). New smartphone models are presented by leading manufacturers on a yearly basis[1] and leading telecommunication providers commonly offer contracts which include a new smartphone every 12-24 months[2]. Today smartphones contain as many as 40-60 different materials, depending on performance and technological advances (Valero Navazo et al. 2014, 569; UNEP 2011b, 14). ICT is thus contributing significantly to growing volumes of electronic waste (e-waste) (Baldé et al. 2015).

Several sustainability issues relate to ICT and smartphones in particular. These include not only environmental problems such as growing e-waste volumes, environmental degradation related to extraction of rare earth elements (REE) or other minerals and hazardous production processes (OECD 2012; Lennerfors et al. 2015, 758; Greenpeace 2017), but also social issues related to so called conflict minerals (Behrendt et al. 2007; Walz et al. 2016) and unfair working conditions in assembly lines during production.

However, it can be observed that various actors, both within the smartphone industry and outside classical value chains of smartphones, engage in sustainable practices. These include efforts in taking back discarded mobile devices[3], providing publicly sourced repair manuals[4]

1 e.g. Apples product portfolio. For an exemplary detailed listing of release dates of new Apple hardware see http://buyersguide.macrumors.com/ (accessed on 04.11.2016).

2 All major German telecommunication provider offer or have offered the option of receiving a new phone every year or every two years, e.g. Telekom: https://www.telekom.de/unterwegs/tarife-und-optionen/smartphone-tarife. Vodafone recently withdraw an option that included a 12 months swap possibility: http://blog.vodafone.de/ueber-uns/jedes-jahr-ein-neues-smartphone-vodafone-nextphone/ (both accessed on 26.10.2016)

3 e.g. Telefonica with their joint recycling program with AfB gGmbH. See also: https://www.telefonica.de/verantwortung/umwelt-und-klima-schuetzen/ressourcenschutz/handy-recycling.html (accessed on 26.10.2016) and chapter 5 in this thesis.

4 e.g. ifixit.com who offer crowd-sourced repair manuals and spare parts for “nearly everything”. See also: https://www.ifixit.com/Info (accessed on 26.10.2016)

and even the emergence of new manufacturers who offer "fairer" smartphones[5] or smartphones that have modular design features[6].

Many of these efforts can be related to the concept of a circular economy. Geissdoerfer et al. (2017) define circular economy (CE) in their recent literature review as a "regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops" (Geissdoerfer et al. 2017, 766). Pioneers in the field of CE are Stahel & Reday-Mulvey (1976) who developed this concept as an industrial design strategy, i.a. for job creation. However, a CE also contributes, among other concepts, to a sustainable development through minimizing resource inputs and a relief of natural sinks. To create these impacts a CE requires a shift away from directional value-added chains towards value-added networks, which allow for material flows in multiple directions (EMF & McKinsey 2012). Three strategies to reach a CE can be distinguished: 1) adapt product design, 2) adjust business models and 3) building cascades of resource flows (Bocken et al. 2016; EMF & McKinsey 2012).

Building cascades of resource flows requires closed CE-loops which in turn introduce additional tasks for market actors along the value chain and opens the stage for new market actors (so called loop operators). Consequently, the question on whether to close CE-loops through own efforts or through the commission of specialized service providers arises. Further, Preston (2012, 15) mentions that implementing CE practices requires multiple actors to adjust their current practices and thus involves new company-to-company cooperation. This problem can be related to classical make-or-buy decisions which are among others based on transaction cost theory (TCT) (Williamson 1979; Picot et al. 1997; Klein 2005). The goal of this thesis is, to learn about and understand these different integration strategies on a macroeconomic level.

1.2 Research Aim and Research Question

As it has been outlined above, CE is a promising concept that receives increasing attention regarding implementation on a larger scale. All of the above mentioned strategies contribute to a CE, yet this thesis focuses mainly on approaches regarding building cascades and close resource loops. In literature and practice much has been discussed about circular designed products, in particular related to the cradle-to-cradle approach by McDonough & Braungart (2002). Few studies look particularly at service providers for loop operations. One of these

5 e.g. Shift GmbH who offer smartphones that are produced under fair working conditions. See also: https://shiftphones.com/downloads/SHIFT-report-2016-hq.pdf (accessed on 20.12.2016).

6 e.g. Fairphone who offer a phone of the same name that uses fair-sourced minerals and can be disassembled easily. See also Schischke et al. (2016) and https://www.fairphone.com/en/our-goals/ (accessed on 26.10.2016).

examples is a study by Riisgaard et al. (2016) who analyze drivers and barriers for repair shops in the smartphone industry. However, they do not take into account the relationship between focal companies (most visible from a customer perspective) and so called loop operators (service providers for loop operations). Therefore, there is little understanding of how exactly CE-loops are closed through market mechanisms (e.g. organizations) and which actors (and partnerships) are required for this.

The aim of this thesis is to analyze the company-to-company coordination forms that result from the transition to a circular economy. Accordingly, this thesis builds up-on classical make-or-buy analysis which is rooted in transaction cost theory and then applies these well-established tools from management literature on the new research focus of a CE. Combining classical TCT with contemporary research on circular activities within the smartphone industry is expected to produce new insights regarding the value creation architectures (Dietl et al. 2009) of a circular economy.

In line with the above developed research aim, this study focuses on the following research question:

> *How do different value creation architectures contribute to closing technical loops of the circular economy in the smartphone industry?*

In particular, this thesis:

- investigates market actors involved in circular practices
- explores characteristic patterns of value creation architectures that evolve around efforts to reach a circular economy
- addresses interactions between focal companies with loop operators
- analyzes functionalities of each value creation architecture and thus analyzes reverse cycling capabilities that are necessary to operate CE-loops and
- asks for obstacles and opportunities that are related to the observed VCAs

Hence a unique research framework is developed that combines CE approaches with TCT. It is used for five qualitative in-depth case studies on various companies within and outside of the value chain for smartphones. For this purpose, case companies are drawn from an ongoing research project on sustainable smartphones at Leuphana University of Lüneburg[7]. All of these companies are active in the private consumer sector (B2C sector), which is also a focus of this thesis.

7 The INaS-Project (Innovationsverbund Nachhaltige Smartphones / Innovation Network on Sustainable Smartphones) is part of the jointly managed research project eCoInnovateIT which includes besides Leuphana University Lüneburg, Carl von Ossietzky University of Oldenburg and University of Osnabrück. For further information, also see: http://ecoinnovateit.de/ (access on 27.11.2016)

1.3 Thesis Structure

Following the above stated research question this thesis begins with a detailed literature review and introduction of key concepts in Chapter 2. In order to understand the relevance of a transition to a more sustainable economy, the first section of the literature review serves to develop and outline a short, but holistic understanding of the concept of sustainability. It traces the development of sustainable development and introduces relevant literature of corporate sustainability. The second part of the literature review applies global sustainability challenges to the industry's context. This includes a review of major environmental and social challenges that arise from the intensive production and use of smartphones. Thereafter the concept of a circular economy is introduced on the basis of key literature. This chapter also presents an overview of different material loops necessary to implement circular economy practices. Finally, theoretical foundations of make-or-buy analysis are developed on the basis of transaction cost theory.

Based on this literature review, a conceptual framework is developed in Chapter 3, which combines the concept of a circular economy with approaches from make-or-buy analysis. Subsequently, an overview on the methodological approach is provided in Chapter 4. The conceptual framework is then used for a qualitative case study approach in the smartphone industry. The results are presented in Chapter 5, subdivided into five distinct value creation architectures which are presented in detail. A comparative analysis of the results is given in Chapter 6 and a continuum of four distinct integration strategies for circular economy practices is presented. Finally, the developed hypotheses from this research are discussed with regard to the existing literature. Lastly, suggestions for future research are presented.

2 LITERATURE REVIEW AND CONCEPTUAL FOUNDATIONS

2.1 From Global Sustainability Challenges to Corporate Sustainability

In order to increase the understanding of how specific sustainability challenges in the smartphone industry are related to the complex interdependencies of sustainable development, first some fundamental basics of sustainable development are introduced in this subsection.

Two of the major reference systems which are used in academic literature for classifying sustainability challenges and resulting goals, are the concept of *Planetary Boundaries* published by Rockström et al. (2009), and the *United Nations Sustainable Development Goals* adopted in 2015 (UN 2015). The first can be seen as a rather ecological approach, whereas the latter provides a global societal reference system.

Global sustainability challenges are closely related to accelerated change processes to our ecosystem that are brought about by humanity. It is argued due to this dominant impact of humans, that the current geological era is supposed to be renamed the Anthropocene era (Steffen et al. 2015)[8]. The understanding of potential limits to growth (Meadows et al. 1972) is not a new concept, however these limits reach a new momentum as the global population is growing and consumption is increasing (UNDESA 2015). One of the publicly most, intensive discussed impacts of human actions is global warming, which has accelerated rapidly in recent decades, very certainly through anthropogenic CO_2 emissions from fossil sources (IPCC 2014). Global warming is also one of the biggest challenges according to the concept of planetary boundaries (Rockström et al. 2009). This concept tries to give orientation regarding the world's 'carrying capacity' on an ecological level. Further ecological boundaries that are already trespassed according to this concept are biodiversity loss and global resource flows. Humans heavily rely on so called ecosystem services, which are provided by nature, such as natural flood protection through coastal forests and pollination services through bees (Costanza et al. 1997)[9]. The earth is a very complex ecosystem, which makes any prediction very difficult.

Additionally to this eco-centered view, a societal dimension must be added to the concept of sustainability as increased resource exploitation can be closely related not only to global and local environmental degradation but also to societal challenges such as growing resource inequality (Schaffartzik et al. 2014; UNEP 2011a). Our consumption levels have global impacts

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8 See also decisions of the International Union of Geological Sciences (IUGS) during the 35th International Geological Congress https://www.theguardian.com/environment/2016/aug/29/declare-anthropocene-epoch-experts-urge-geological-congress-human-impact-earth (accessed on 10.12.2016)

9 Calculations on the value of the worlds ecosystems by Costanza et al. (1997) are to be treated with some caution, nevertheless, their paper brought the topic of ecosystem service on the public agenda.

on working conditions in factories all over the world and our resource use has local effects on conflicts over resources. In contrast to the concept of planetary boundaries, the UN Sustainable Development Goals 2015 give orientation with a focus on a political and societal level and are sub-divided in 17 goals (UN 2015).

Due to the holistic approach of sustainability, a wide range of definitions for sustainability and sustainable development, which can be seen as the process of reaching sustainability, exist. However, the so called *Brundtland* definition is most commonly used and was published by the World Commission on Environment and Development in 1987:

> *„Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED 1987, Chapter 2, Paragraph 1)*

The Brundtland report has a clear anthropocentric focus and emphasizes human needs. The important notion of inter- and intra-generational justice results from this report and became an integral part of sustainable development. Inequality measures must be taken into account (UNDESA 2016), firstly because the effects of climate change have unequal consequence on different world-regions and secondly, because most effects of climate change are not yet observable and pose a potential threat for future generations.

We can state that the concept of sustainability is a normative concept, which combines ecological limits with a normative dimension of justice. This makes the objective of sustainability a societal process, which therefore must include all stakeholders within the society (Fischer et al. 2007; Lang et al. 2012).

One important discussion in academic literature asks of what exactly needs to be sustained. In literature and societal discourses, three dimensions of sustainable development are discussed, mainly the social, ecological and economical dimensions[10]. For these three dimensions, different configurations and relations are conceivable. Also the discussion of strong and weak sustainability results from this interplay of dimensions, which in turn asks for which kinds of capital are to be conserved in particular (Pearce et al. 1989 as cited in Neumayer 1999).

The triple bottom line approach considers all dimensions to be equally important and necessary for reaching sustainability (Elkington 1997). The notion of strong sustainability (Daly 2005) adds an order of priority, putting the environmental dimension first, thus limiting the development of the other dimensions. In contrast, weak sustainability assumes that capital stocks (e.g. natural capital and human made capital) can be substituted (Neumayer 1999). In

10 For an overview of the different concepts dealing with sustainability see also Hopwood et al. (2005, 41) and Michelsen & Adomßent (2014).

Figure 1 three commonly used graphical interpretations of above mentioned sustainability dimensions are displayed (Wu 2013).

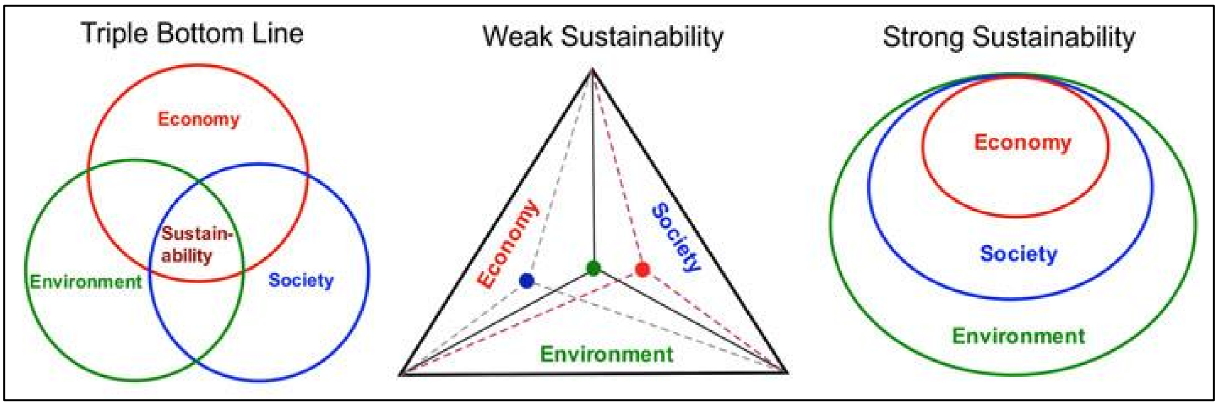

Figure 1: Different interpretations of sustainability dimensions. Source: Wu (2013, 1002).

A number of sustainability strategies supporting sustainable development can be derived from the Brundtland report. They include the efficiency, consistency and sufficiency strategies, which are summarized and clarified by Huber (1995).

The *efficiency strategy* aims at relative improvements (doing ”better”) of input/output ratios similar to financial efficiency. This strategy was originally formulated by Schaltegger & Sturm (1989) as eco-efficiency strategy and then further developed, among others, by Schmidheiny (1992) and Schmidt-Bleek (1994). The aim is to reduce required material and energy input, from 4 to 10 times, while maintaining current consumptions levels (Weizsäcker et al. 1995; Schmidt-Bleek 1994). One of the major problem to this strategy is the potential for rebound effects due to relocation processes (Huber 2000, 13). This is especially given when optimizing single products and use-scenarios while neglecting a systems perspective. Therefore a pure product-based viewpoint is counterproductive when striving for eco-efficiency improvements and a functional efficiency rationality must be added (Schaltegger & Sturm 1990).

In contrast the *consistency strategy* aims at a maximum effectiveness (doing things “different”). This in turn means a qualitative transformation process which is focusing on material flows and their compatibility with the natural metabolism (Huber 1994; Frosch & Gallopoulos 1989; McDonough & Braungart 2002; Jackson 1996). Renewable energy can be seen as an example for the consistency approach, because it imitates nature’s metabolism. The concept of a circular economy is closely related with this sustainability strategy and thus strategies and critiques are further outlined in Chapter 2.3. Other concepts related to this strategy are industrial ecology (Frosch & Gallopoulos 1989; Socolow 1994) and cradle-to-cradle (McDonough & Braungart 2002; Braungart & McDonough 2009).

The *sufficiency strategy* can be seen as complementary to technical oriented efficiency and consistency strategy. The aim of a sufficiency strategy is to encourage non-consumption behaviors (doing “less”) (Jackson 2005; Sachs 1993). Within German-speaking countries the concept of a post-growth economy (Postwachstumsökonomie) emerged around the economist Paech (e.g. Paech 2009). However, less extensive adjustments in consumption behaviors are also conceivable (e.g. slow-food, car-sharing, regionalization) (Schneidewind 2012). It is the least popular strategy in policy making, because it requires behavioral change of consumers and industry actors.

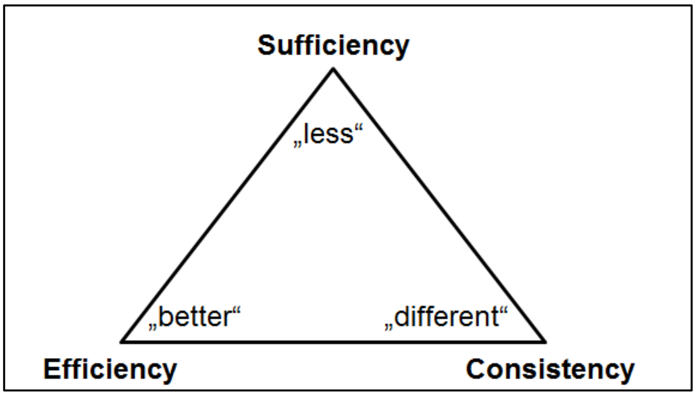

Figure 2: Interplay of different sustainability strategies (own presentation)

To which strategy a sustainability-oriented action can be assigned to, depends on the perspective (Diekmann 1999). It is important to note, that there is not a single strategy, which will lead to a sustainable development, but rather a combination of all strategies (see Figure 2).

Since the early 1990s a new research field of sustainability management has emerged due to the above developed discussion and the foundation of the World Business Council for Sustainable Development (WBCSD). This lead to a widespread adoption of the triple bottom line approach (Elkington 1997) and thus treating all three dimensions equally.

Hence, early concepts of integrating sustainability in the business sphere are of philanthropic nature and raised questions of profit appropriation (e.g. corporate citizenship). These concepts evolved in the 90’s to a more holistic concept of corporate social responsibility (CSR), which questions ways of profit generation (see e.g. "the pyramid of corporate social responsibility" by Carroll 1991). Corporate sustainability in contrast, shifts the attention away from inefficient end-of-pipe measures towards the core business of a firm (Schaltegger & Burrit 2005, 194). Crutzen et al. (2017) define corporate sustainability as “the strive for substantial improvements of ecological and social impacts of companies in line with planetary boundaries and societal goals like the UN Sustainable Development Goals by integrating social, ecological and economic perspectives in management” (Crutzen et al. 2017, 1291). Considering businesses as worthy problem solvers, not only as polluters, is key to this new perspective of corporate sustainability. Rethinking fundamental business concepts (e.g. business models and transfer of ownership) and product designs (see Chapter 2.3) is a challenging task, however, a necessary component for reaching a circular economy.

Demanding firms to challenge their core business practices is essentially connected to the concept of business models. The concept of business models tries to describe how firms function in a “scaled-down” version (Baden-Fuller & Morgan 2010, 157). In contrast to early streams of academic literature, a newly established notion of sustainable business models extends the view from only making profit to also creating other (non-monetary) positive effects or contributing to solve other (societal) problems. Schaltegger et al. (2016) recently dedicated a special issue of Organization & Environment to this research field. Sustainable business models are also strongly linked to the business case for sustainability, which aims at creating business value through engagement in environmental or social activities (Schaltegger et al. 2012). Schaltegger & Burritt (2015) identify four different kinds of business cases related to their ethical motivations, as seen in Figure 3.

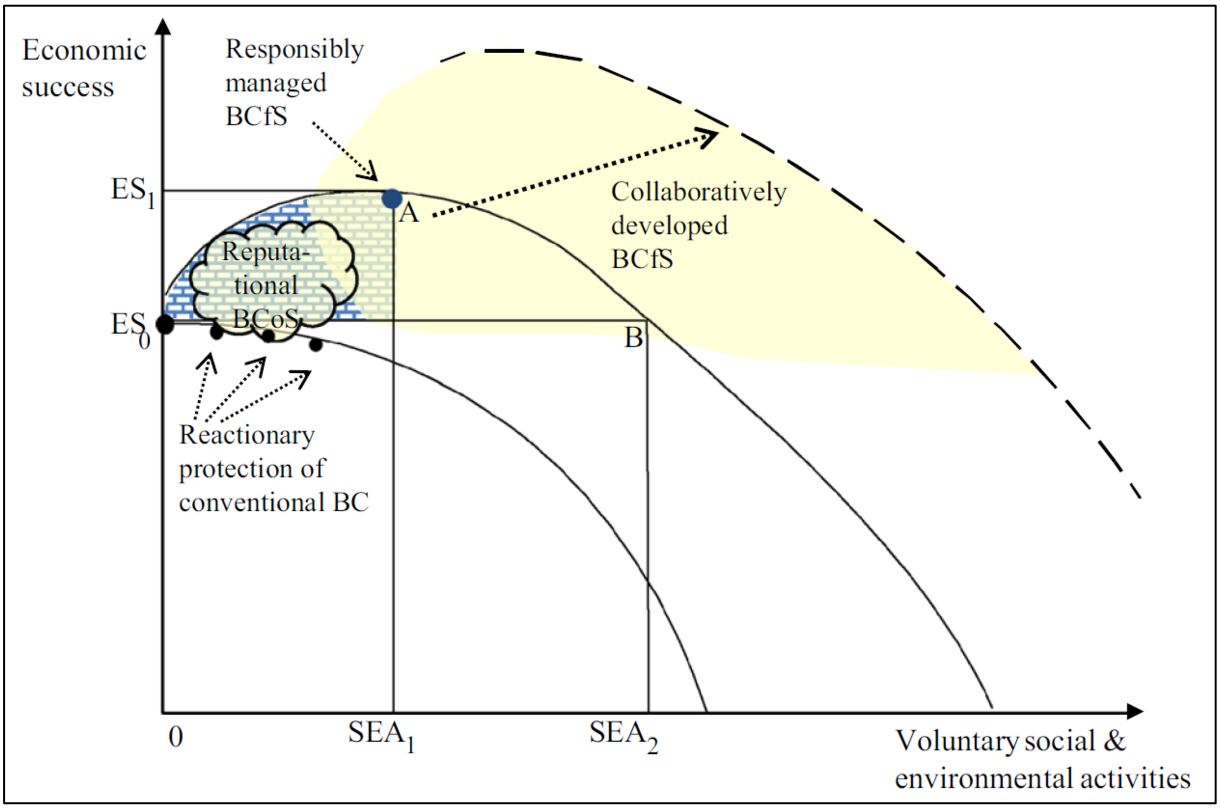

Figure 3: Positioning of different business cases related to their contribution to economic success and their voluntary sustainability activities. Source: Schaltegger & Burritt (2015, 11).

These include the reactionary business case which is basically implementing CSR activities on a compliance basis “only if they are […] necessary” (Schaltegger & Burritt 2015, 13). The reputational business case focuses on publicly beneficial CSR activities whereas the responsible business case *for* sustainability is going beyond compliance issues and includes voluntary actions. It basically sees sustainability as a source of new innovation and development potential. Lastly, the collaborative business case includes the engagement of various stakeholders in the development of future business fields (Schaltegger & Burritt 2015).

A circular economy increases the need for new business models in order to capture the values that result from such a transition. Bocken et al. (2016) develop business model strategies that enable “slowing, closing, and narrowing resource loops” (Bocken et al. 2016, 309), see also Chapter 2.3 for further details. Thereby small and large firms can contribute as problem solvers for environmental and social problems. Transformation processes initiated by the corporate world that aim toward circular economy practices can be characterized through an interplay of well-established corporations (Goliaths) and new market incumbents (Davids). Both influence each other and thus contribute to market transformation (Hockerts & Wüstenhagen 2010).

It can be concluded that firms engage in circular practices based on various motivations. These can be based on compliance, ethical motivations or based on economic considerations. Many of the above mentioned sustainability challenges can be related to the industry context of this study, as smartphones are a globalized product, which is a prime example for the complex system in that we live in. The relations of these challenges in an industry context to the smartphone industry are discussed in the following chapter.

2.2 Sustainability Challenges in the Smartphone Industry

A prominent example for a resource intensive consumer good is information and communications technology (ICT) and in particular, the smartphone (OECD 2011; Schischke et al. 2016). Additionally, sustainability challenges in the smartphone industry are numerous and subject to public debate (e.g. conflict minerals, electronic scrap, resource scarcity) (OECD 2012; Baldé et al. 2015; Dießenbacher & Reller 2016). These major sustainability challenges are represented along the value chain in Figure 4. Some of these sustainability challenges that are related to the scope of this study are further detailed in the following subchapters.

Public debate on these sustainability challenges has gained momentum in recent years. Examples are new market incumbents such as Fairphone, which could bring the topic successfully to the general public[11]. Raising awareness for sustainability issues in the smartphone industry was the general aim of the Fairphone initiative, whereas producing an

11 By actually producing a fair Smartphone and successfully positioning it in the market, Fairphone could significantly contribute to public debate, which is also reflected in the honor given to Fairphone founder Bas van Abel by the German Environmental Award (Deutscher Umweltpreis der DBU) in 2016. For this see also: https://www.dbu.de/123artikel36907_2418.html (accessed on 24.10.2016).

actual phone can be seen as a means to an end. The topic even influences the largest players in the smartphone industry, which is reflected in increased efforts of well-established market actors, such as Apple, who recently began to engage in sustainable practices with their Apple Renew Program[12].

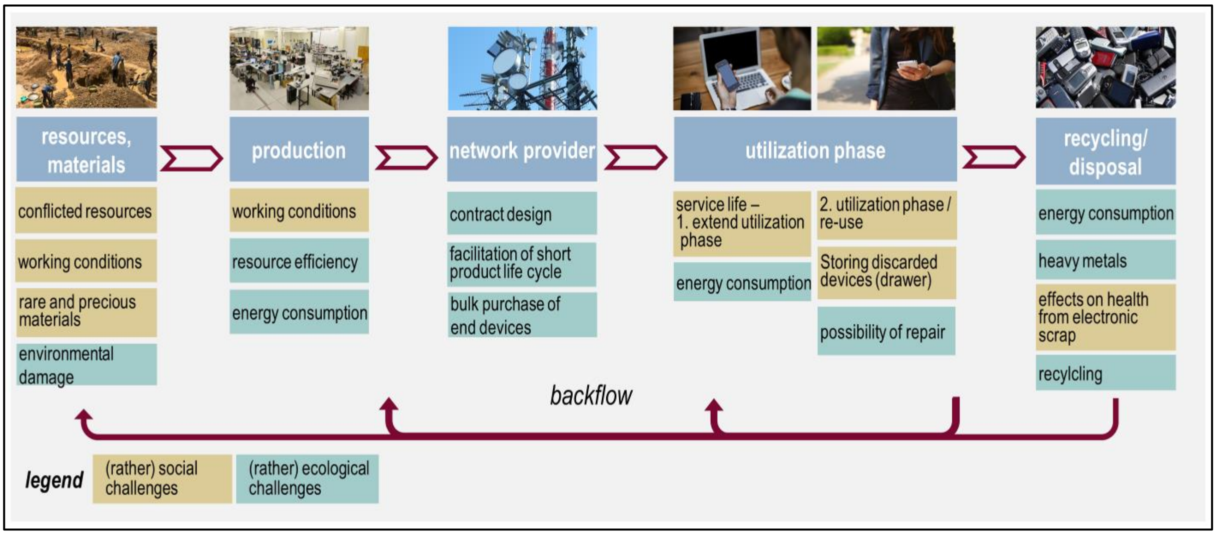

Figure 4: Sustainability challenges along a typical value chain for smartphones. Source: INaS Project, Leuphana University of Lüneburg[13]

This transformation process is accompanied by various research projects which are currently exploring the field of sustainable ICT. These include the innovation network on sustainable smartphones (INaS) at Leuphana University of Lüneburg[14] in which context this study was prepared. Additionally, a number of EU projects within the Horizon 2020 program[15] analyze the transformation processes.

An objection to the faith in technology can be observed in the smartphone industry. This is also represented in Moore’s Law which states that the number of transistors per integrated circuit chip doubles every 18 months (Moore 1965). This empirical law complied with reality in the last decades (Cavin et al. 2012). Although, against these steep efficiency improvements, our sharply increasing resource usage in the last decades may seem as contradictory, however, can be explained through rebound effects that have a causal link to ecological product efficiency gains (e.g. Patrignani & Whitehouse 2014). These rebound effects can be observed for example regarding energy consumption of ICT. Data analyzed by Koomey et al. (2011)

12 See also http://www.apple.com/recycling/ (accessed on 24.10.2016) and http://www.apple.com/environment/ (accessed on 24.10.2016).
13 Adopted from: http://www.leuphana.de/fileadmin/_processed_/csm_INaS_Partner_Wertschoepfungskette_3bf4236d81.png (accessed on 10.12.2016)
14 For more information see Chapter 1.2
15 For EU projects see for example the sustainablySMART project which is part of the EU Horizon 2020 program and supports circular economy approaches: http://cordis.europa.eu/project/rcn/198769_de.html (accessed on 24.10.2016).

shows: the efficiency of computations per kWh doubles every 1,57 years, but computing performance per device doubles at a similar rate (which corresponds to Moore's law) and as already mentioned so does the absolute number of devices. This in turn leads to an absolute increase in energy consumption. Therefore, solely relying on efficiency improvements through technological developments will not solve observed sustainability challenges.

2.2.1 Obsolescence in the use-phase

Smartphones have turned into fast moving consumption goods with short life times, which is partly due to incentives from telecommunication providers to renew devices on a regular basis. Some providers have promoted their contracts with the slogan "Every year a new smartphone"[16]. Meanwhile the absolute number of smartphones sold worldwide reached 1,400 million units per year in 2015 (Statista GmbH 2016) and the average lifetime of smartphones decreased to less than 3 years (Suckling & Lee 2015; Valero Navazo et al. 2014; Wieser & Tröger 2015)[17].

High levels of consumption can be explained with the concept of obsolescence. For consumer electronics different kinds of obsolescence can be distinguished. Different approaches to classify obsolescence can be found in grey literature and reports (Burns 2010; Cooper 2004; Wieser & Tröger 2015), including a very useful one by the German environmental protection agency (UBA 2016). They distinguish between material or mechanical, functional, psychological and economic obsolescence (UBA 2016, 64–65). All of these, plus the controversial 'planned obsolescence' can contribute to fast moving consumption styles for smartphones[18].

Functional obsolescence for smartphones can be observed through rapid developments in technology, such as processing power and data transfer rate of mobile networks and increased requirements for software applications. Current strategies of product development do not imply longevity or reparability and therefore represent material or mechanical obsolescence. Some key components such as the battery underlie a strong wearing, but cannot be replaced economically without additional tools. That's why the online-initiative iFixit assigns repairability scores for electronic devices, whereby smartphones regularly receive low scores[19].

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16 All major German telecommunication providers offer or have offered the option of receiving a new phone every year or every two years, e.g. Telekom: https://www.telekom.de/unterwegs/tarife-und-optionen/smartphone-tarife. Vodafone recently withdraw an option that included a 12 months swap possibility: http://blog.vodafone.de/ueber-uns/jedes-jahr-ein-neues-smartphone-vodafone-nextphone/ (accessed on 26.10.2016)

17 Some sources state the average life time of smartphones with 18 months actually considerably lower (OECD 2011).

18 However, some studies also suggest, that obsolescence is the result of fast moving consumption styles, which in turn are results of societal pressure and influence from advertising (Wieser & Tröger 2015).

19 For their repairability scores and method of calculation see also: https://de.ifixit.com/smartphone-repairability (accessed on 25.10.2016)

Among other things the short life times of smartphones are undesirable due to major environmental impacts in the production phase. A meta study by Suckling & Lee (2015) of 11 life cycle reports on different smartphones and their GHG emissions states that most impacts result from the early life cycle stages (white area in Figure 5). More precisely 74% of direct emissions result from the manufacturing of smartphones. However, in a conference paper Judl et al. (2012) draw attention to the increasing share of cloud based computing and its resulting benefits and impacts. According to the meta study of Suckling & Lee (2015) this can double the impact during the use-phase (black area). Nevertheless, main GHG-emissions still result from the production-phase, which supports the importance of prolonged use-times, rather than buying a new phone every year.

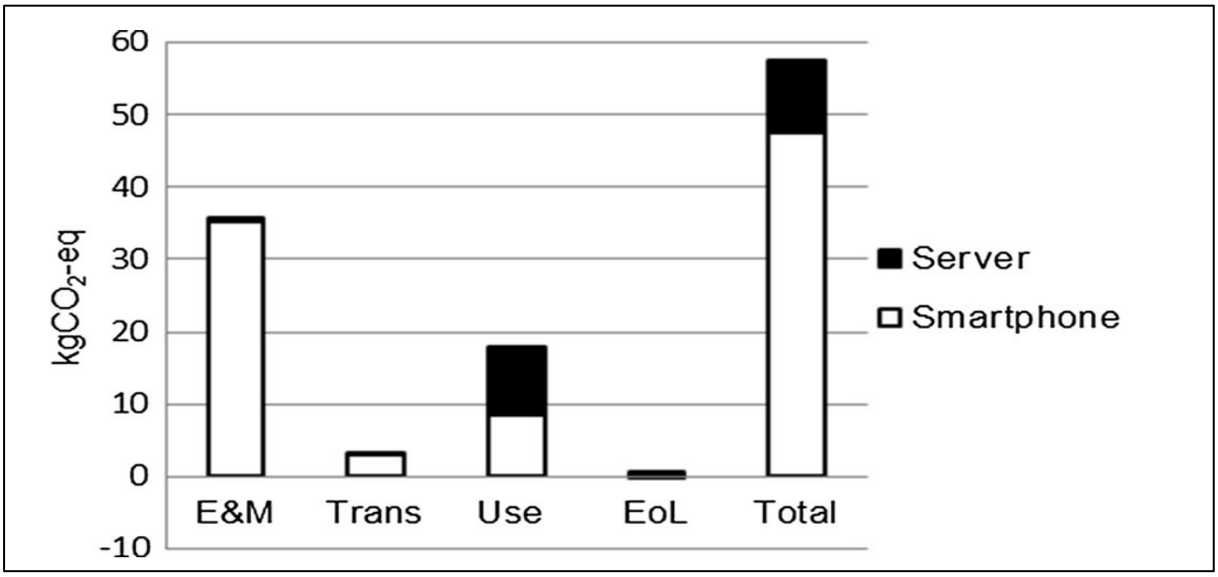

Figure 5: GHG emissions of typical smartphones in kg per unit by life cycle stage (extraction and manufacturing, transportation, use and end of life). Source: Suckling & Lee (2015, 1185).

2.2.2 Resource scarcity in production and sourcing

In order to continuously improve functionality for smartphones, hardware has to reach high levels of sophistication. Today smartphones contain 40-60 different materials, depending on performance and technological advances (Valero Navazo et al. 2014, 569; UNEP 2011b, 14). Many of these materials are, to date, not fully recyclable due to technological or economic reasons (see Chapter 2.3). High performance combined with low weight and small size can only be reached by the use of precious metals, such as rare earth elements (REE) and other so called technology metals (Li et al. 2010; Reuter 2011). A comprehensive overview of technology metals used in electrical equipment and their related scarcity measures is given by Behrendt et al. (2007). Scarcity is understood here as measured either by price, price volatility, scarcity of reserves, scarcity of reserve bases or concentration of reserves (Behrendt et al.

2007, 19). For a classification of the different reference systems, precisely reserves, reserves bases and resources see also USGS (1973).

Additionally to a limited availability of resource, intensive resource usage can lead to geopolitical as well as ecological and social problems due to their geographically unequal distribution. According to OECD (2011) many technology metals are extracted in politically or economically unstable countries and their mining contributes to armed conflicts within or between countries (see also: Walz et al. (2016)).Therefore, these minerals are also called conflict minerals (Behrendt et al. 2007). In this context conflict minerals are defined as tin, tantalum, gold and tungsten (Walz et al. 2016, 25). A prominent case is the mining of Tantalum, used for high-performance capacitors in ICT, which led to the Coltan Crisis[20] in the Democratic Republic of Congo (Hayes & Burge 2003).

The mining of technology metals such as REE is to some extend linked to other metals or minerals such as copper or uranium (Schüler et al. 2011). Environmental risks related to the mining processes include CO_2 emissions due to high energy requirements, radioactive waste from waste refining processes, and land-use especially for open pit mines and large water consumption. A good overview of these environmental risks from REE mining, separation and refining processes is given in Schüler et al. (2011). These environmental risks are of particular importance as illegal, small scale mining is ubiquitous in sourcing countries.

Nevertheless, other minerals or technology metals are also sourced under pre-industrial conditions, resulting in environmental degradation and poor working conditions. One example is cobalt, which is a transition metal and crucial for high-performance lithium-ion batteries[21]. Complex supply chains make backtracking of actual sources very difficult and even the social enterprise Fairphone has difficulties to guarantee conflict free smartphones (Schischke et al. 2016).

However, while the use of technology metals is inevitable in electronic equipment with today's performance requirements, a promising approach is to foster their recycling.

2.2.3 Recycling of Waste Electrical and Electronic Equipment

Smartphones and other electrical and electronic devices turn into waste at the end of their use-time; they are then commonly described as Waste Electrical and Electronic Equipment (WEEE). Once these valuable metals listed above are used in smartphone production, only a small share of materials can be recycled. This is because these metals are used in very low

20 Coltan is an acronym for the columbite-tantalite ore which contains niobium and tantalum (Behrendt et al. 2007).

21 An investigative research by the Washington Post newspaper, published in September 2016, gives vivid insights in the pre-industrial-like mining of cobalt-containing rock in the Democratic Republic of the Congo: https://www.washingtonpost.com/graphics/business/batteries/congo-cobalt-mining-for-lithium-ion-battery/ (accessed on 27.10.2016)

quantities and for alloying purposes which makes recycling technically complex and not always economically feasible (Bleher & Schüler 2016; Reuter 2011). Additionally, only 5-16% of sold smartphone reach a recycling plant at their end-of-life phase according to OECD (2011, 52) and a study by the German Öko-Institute (Buchert et al., 71).

Low collection rates, landfilling and shredding of electronic scrap without previous separation leads to a global dissipation of critical metals. This in turn leads to an overall reduction in concentration of virgin material, which in turn makes recovering more difficult (Bleher & Schüler 2016; Huber 1995). In Germany 21.6 kg of WEEE are produced per capita per year, one of the highest rates in the world according to the Global E-Waste Monitor 2014 (Baldé et al. 2015, 67). Therefore, collection rates must be increased significantly to reach a sustainable consumption.

Many REE are currently not recovered, as retrieval from WEEE is focused on the five to eight most valuable metals (Valero Navazo et al. 2014). The main processes for recovering virgin materials from e-waste are pyro-metallurgy, hydrometallurgy and electrometallurgy processes (UNEP 2013). Recovered metals include mainly copper, nickel, tin, lead, antimony, silver, gold and palladium (in order of weight; per ton of mobile phones) (Valero Navazo et al. 2014). Recycling companies work on further increasing recovery rates, but not every technology that is currently available is also economically feasible and according to Chakhmouradian & Wall (2012) less than 1% of rare earth elements are recycled worldwide at this time. Therefore, new recycling technologies are necessary to extend material recovery to less valuable resources.

However, there are also some physical limits to recycling. These limits depend on product design, disassembly and separation methods and on thermodynamics (Reuter 2011). Due to imperfect separation and liberation, currently most recyclates do not meet the same physical properties of virgin materials (UNEP 2013). This is why some scholars refer to “downcycling” rather than recycling or upcycling (e.g. Kümmerer 2016, 81).

Complex products such as smartphones with a heterogeneous composition of materials and unfavorable material and component connection types are therefore very challenging to recover in their individual components. Hence, rare earth elements and other technology metals, which are inevitable for smartphones, are a vivid example for the wastefulness of linear economic systems.

Hence, recycling efforts for smartphones are definitely necessary and creditable, however, not sufficient to reach a sustainable consumption of ICT. Further efforts for extended use strategies are necessary.

2.2.4 Economic supply chain risks

From an economic perspective it is also important to note that our current consumption life style not only has significant environmental and social impacts but also ignores imbedded value of waste streams.

E-waste collected in official take back schemes globally and treated for recovery has a value of roughly € 48 Billion annually, most of it captured through the recovery of valuable metals such as gold and copper (Baldé et al. 2015, 9). An Ellen MacArthur Foundation (EMF) report suggests that pure material value of each discarded phone is around $ 3 (EMF & McKinsey 2012, 39), resulting in up to $ 500 million loss on not-recycled mobile phones in Europe per annum.

Simultaneously, firms that rely on the supply of technology metals have to deal with volatile resource prices. Most REE and other technology metals used for mobile phone production are not necessarily rare in absolute numbers, but their availability is limited to a few countries: e.g. 85-98% of all rare earth reserves are found in China (Alonso et al. 2012, 3406; OECD 2011). This can lead to severe supply chain risks and political dependencies. This could be observed in 2010 when China reduced exportation of some REE without further notice (see e.g. Bleher & Schüler 2016). Future demand for REE is hard to predict as it depends on technological developments and available recycling technology.

2.3 Circular Economy as a Conceptual Lens

As it was pointed out in the previous chapters, increased consumption and intensive resource use leads to environmental, social as well as economic problems that cannot be solved by looking at product-centered solutions only (e.g. recycling) and call for a more holistic perspective considering different systematic parameters.

Therefore, current discussions in academic literature extend the perspective from a pure product-based focus to a holistic system-perspective (Ny et al. 2006). Life-cycle orientation is fostering such a system-perspective and is also claimed by environmental management norms (ISO 2015). Such an extended perspective is important as it turns out that recycling, as an end-of-pipe measure, is not enough to stay within ecological limits and further transformation is needed (Reuter 2011). Additionally, product-focused approaches for increasing sustainability performance favor rebound effects. Extending the perspective to product-service systems and new business models opens up the opportunity for new sustainability potentials (Hansen et al. 2009; Mont 2002). Going even one step further, the concept of a circular economy provides the opportunity to incorporate a system-perspective on a level beyond the single company (Tukker 2015). Consequently, the concept of a circular economy seems to be a promising approach to further advance our economy on a holistic basis.

2.3.1 From linear to circular

In a linear economy the goal is to optimize value-added chains for a single product or industry. Linear economic systems focus on increasing sales in order to grow and therefore focus on optimized production (e.g. robots, automation, economies of scale) and optimized business processes (e.g. lean management), rather than product optimization for longevity of products (Stahel 1984). This “fast-replacement” system leads to environmental deterioration on the input and output side (Stahel 1984, 73). It is designed linearly except for the notion of reverse logistics, which originates in take-back systems for recall campaigns (Fandel & Reese 2005; Ferguson & Souza 2010). Reverse material flows are thereby commonly associated with costly processes, product failure or disposal costs (Guide & van Wassenhove 2009). The current linear system widely ignores the finite availability of other resources, as well as the finite intake capacity of natural sinks (see Figure 6 below).

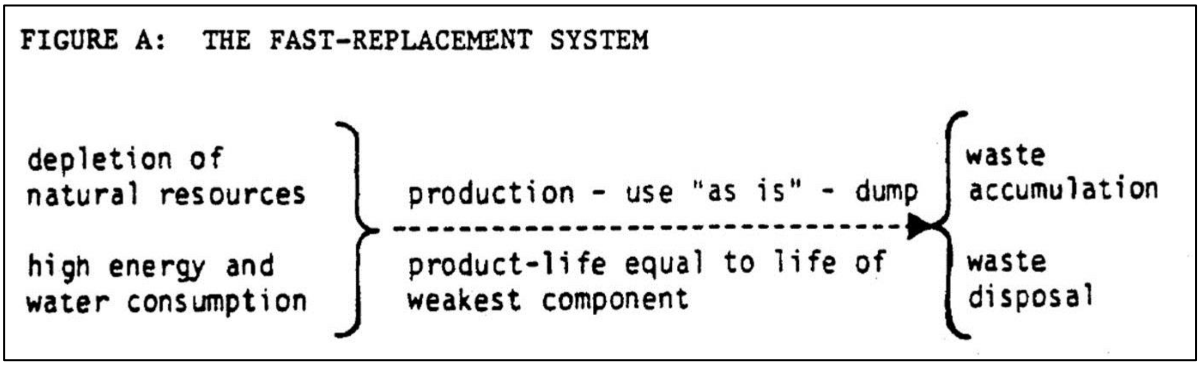

Figure 6: Linear production model according to Stahel. Source: Stahel (1984, 73)

An economically viable concept to overcome the linear economic system is the implementation of a circular economy (CE). The concept of a CE aims at multi-directional material flows in a system with the goal of closing material loops on different levels (Stahel 1991; EMF & McKinsey 2012). With the implementation of CE-loops, technical and biological nutrients can circulate and be reused along the lines of nature’s metabolism (McDonough & Braungart 2002; EMF & McKinsey 2012). The goal is to implement an industrial system where resources flow in circles and leakage is minimalized. Such a “spiral-loop” system displayed in Figure 7, in comparison to the linear system, consists of four additional loops: 1) reuse, 2) repair, 3) reconditioning and 4) recycling (Stahel 1984, 74).

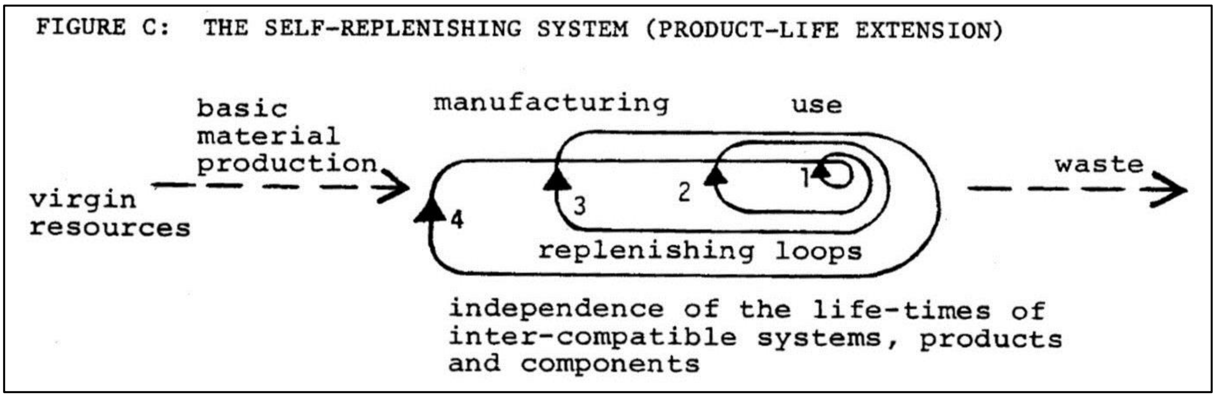

Figure 7: Economic alternative: spiral-loop system with minimized material in- and outflow. Source: Stahel (1984, 74)

This leads to an industrial design concept that is restorative and regenerative by design, meaning that waste is eliminated through anticipated design and material flows are kept as pure as possible (EMF & McKinsey 2012; Braungart et al. 2007). CE can be understood as an application-oriented concept to reach a more sustainable development (Fleig 2000). However, implementing a CE requires major shifts, not only regarding product design, but also from business model perspectives for the implementation of reverse loops (EMF & McKinsey 2012).

The theoretical background of a CE lies among others in ecological economics, environmental economics and industrial ecology (Ghisellini et al. 2016). The aim is to use nature as a role model to learn (e.g. bio mimicry (Nachtigall 1997)) and adapt material flows accordingly (McDonough & Braungart 2002).

Different schools-of-thought regarding the concept of a circular economy have been developed over the last decades, including but not limited to: Performance Economy (Stahel 1984; Giarini & Stahel 2000), Cradle-to-Cradle (Braungart et al. 2007; McDonough & Braungart 2002), Blue Economy (Pauli 2010) and Industrial Ecology (Huber 2000; Frosch & Gallopoulos 1989). These schools-of-thought all have different emphasizes and backgrounds.

The Ellen MacArthur Foundation (EMF) combined these different perspectives and published a number of business-oriented reports on the CE (EMF & McKinsey 2012; EMF & McKinsey 2013; EMF & McKinsey 2014; EMF et al. 2015). This thesis builds mainly on the reports by the EMF due to their practical implications. Nevertheless, other academic literature is used to underpin this approach.

2.3.2 Strategies for a CE

Basic CE strategies include product design strategies for circularity and longevity, business model adjustment for product-life extension and intensification, and a set of organizational design strategies for closing cycles and building cascades (Bocken et al. 2016; EMF & McKinsey 2012). These strategies are further detailed as follows (see also Table 1).

Table 1: Selection of beneficial strategies to reach a circular economy. Based on Bocken et al. (2016, 309ff.) and EMF & McKinsey (2012, 58).

CE strategy	Details
Product design	- Consider material selection and material purity - Lasting designs, overcome obsolescence - Modularization and improved (automated) disassembly
Business model adjustment	- Shifting from consumers to users (and prosumers) - Development of product-service systems and performance based business models (increase service share) - Retain ownership of materials - Encourage sufficiency
Building cascades	- Establish (industry wide) collection systems - Increase collection rates - Enable information sharing across industries (industrial symbiosis) - Improve material recovery quality

In order to increase recycling capability, *product design* should always consider available recycling technologies and allow for single-origin separation of material flows (Stahel 1991; Pötzschke 1991). Different product design strategies focusing on the initial product development phase and focusing on design for sustainability or design for circularity are discussed in literature and in practice.

A very popular approach is the eco-design approach, which is mainly developed at TU Delft and published by Stevels (2007) in a comprehensive book. The eco-design approach is also published by the UNEP and includes the design for environment strategy wheel, which became a popular tool in industrial design (Brezet & van Hemel 1997). A CE specific approach is design for disassembly (DFD). The DFD approach contains three principles summarized by (Lowe & Bogue 2007, 287):

- careful selection of materials,
- design of modules and
- selection of connectors.

These principles are further detailed in DFD design rules, which include the creation of modular design, minimized use of different materials, use of mechanical joints and design for automated disassembly (Lowe & Bogue 2007, 288). Another approach on a materials chemistry level is “benign by design”, which includes catalyst design and design for single-origin separation (Anastas & Warner 1998 as used in Kümmerer & Schramm 2008). A very specific approach for the case of mobile devices which takes into account circular characteristics is a design guideline that was developed in a master’s thesis by Poppelaars (2014). All of those approaches take into account circular thinking and by doing so assure functioning loops that are more than merely efficiency improvements.

Product design strategies on their own, however, are not enough to reach a CE. Therefore, a second important element is *business model adaptation*. This approach is also strongly interlinked with the idea of sustainable business models presented in Chapter 2.1. Stahel, who is a pioneer of this concept, already created a strong link between ownership-based economies and pure performance based products and business models (Stahel & Reday-Mulvey 1976; Stahel 1984). Based on (Stahel 2010) and his idea of a performance economy which is not based on ownership or physical sales of products, Bocken et al. (2016) present a comprehensive overview on the strongly interlinked adaption of business models. They suggest six types of business model innovations to slow and close resource loops (Bocken et al. 2016, 313). These include *access and performance* based models such as product service systems (PSS), that, designed as sustainable product service systems (SPSS), can decouple usage from ownership and therefore enable prolonged life times and resource recovery (Tukker 2015). Another promising business model, especially for the smartphone industry, is focusing on the reuse loop by offering *extended product value* through remanufacturing or collection and resale (Bocken et al. 2016).

Following the building blocks logic of EMF & McKinsey (2012) the third element necessary to implement a CE successfully is closing loops and building cascades of usage. Closing loops can be seen as a new and additional task for market actors, which is mostly associated with the end of a value chain, but with impacts along the entire value chain. These CE-loops are further analyzed in the following section.

2.3.3 Material loops in a CE

Integral parts of a CE are material loops that allow for resources to flow in multiple directions along the value chain. A popular representation of the CE-concept that displays this circular material flow is the so called butterfly-diagram (see also Figure 8) published by the Ellen MacArthur Foundation (EMF) together with McKinsey (2012, 24). It combines the two basic strategies of slowing and closing resource loops (Stahel 1991; Bocken et al. 2016) and divides the industrial system in a biological nutrient and technical nutrient perspective, building on the cradle to cradle approach by McDonough & Braungart (2002)[22.]

22 This dualism is a simplification, as in reality no strict separation of biological and technical nutrients is possible. In earlier publications McDonough & Braungart (2002) call intermediate goods “monstrous hybrids”, later on they weaken this wording to “complex products” Braungart & McDonough (2009). This highlights the importance of handling material selection carefully through circular design strategies.

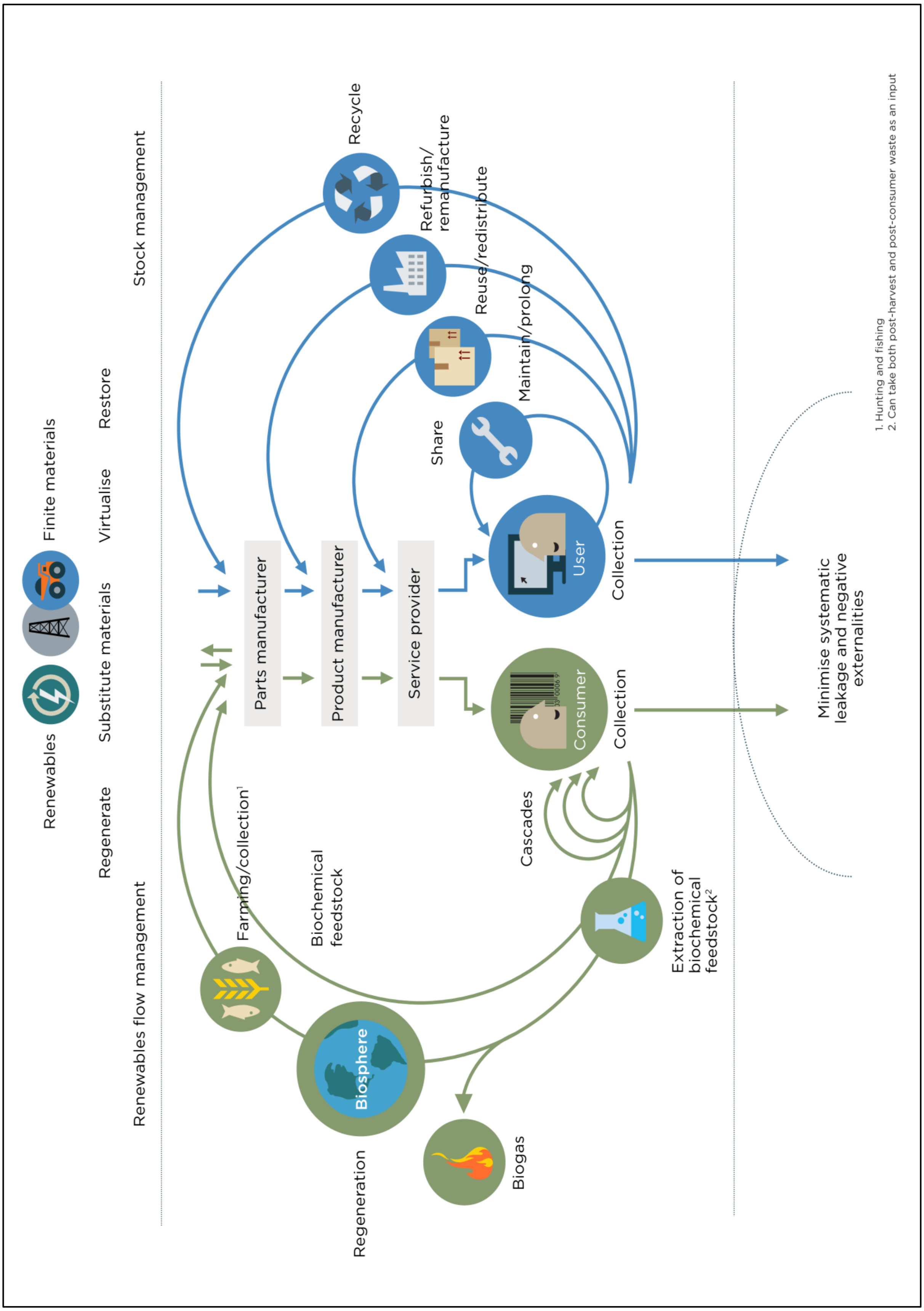

Figure 8: The so called butterfly diagram, representing the concept of closed loops within a circular economy. Source: EMF & McKinsey (2012, 24).

The notion of cascading resource flows is an integral part of a circular economy, thereby acknowledging thermodynamics and limits of a CE. Cascading materials means to use the same material stocks in decreasing quality for different applications (e.g. using timber to produce: 1. furniture; 2. paper; 3. recycled paper; 4. cardboard; 5. home insulation and 6. lastly as a fuel (Stahel 1984, 80)).

This thesis focuses on strategies for closing technical nutrient cycles, which include maintaining, reusing, refurbishing and recycling (EMF & McKinsey 2012). In literature and practice a number of different terms and concepts exist for these so called reintegration strategies. Thierry et al. (1995) published an article introducing an 'integrated supply chain' and material recovery options in a practitioner's journal for business managers. Alternative definitions are available from legal sources (e.g. KrWG) and industry associations (e.g. VDI). An overview of these technical CE-loops is given in the table below. The biological cycles, are not further considered in this thesis.

Table 2: Product recovery options as defined by (Stahel 1984), Thierry et al. (1995), and EMF & McKinsey (2012):

CE loop	Strategy	Product recovery	Level of Dis-assembly	Quality Requirements	Resulting Product
Maintenance	Slowing loops	Repair / maintain	Product level	Restore product to working order	Fixed or replaced by spares
Reuse/ redistribute	Slowing loops	Reuse	N.A.	Functioning product	Second, third, ... life
Refurbish/ remanufacture	Closing loops	Re-furbishing	Module level	Inspect all critical modules and upgrade to speci-fic quality level	Some modules repaired/replaced with potential upgrades
		Remanu-facturing	Part level	Inspect all modules and parts and upgrade as new quality	Used or new parts combined into new product with potential upgrade
		Cannibali-zation	Part level	Depends on purpose	Some parts reused; remaining product recycled or disposed
Recycle	Closing loops	Recycling	Material level	Goal: No down-cycling of materials	Materials reused to produce new parts

This thesis uses the following terminology based on the sources from Table 2.

The first CE-loop considers all activities that contribute to maintaining functionality of a product. These include scheduled maintenance without previous breakdowns and repairs after a product failure occurred. Common techniques include fixing or replacement of worn components or other damages without transfer of ownership.

Within the reuse loop products change owners with no upgrading and only minimal aesthetic refurbishing. This is also called redistribution or remarketing and can ideally lead to consecutive use phases by different users with diminishing demands.

There are a number of different definitions regarding the third loop. Refurbishing can be considered as maintaining a device's functionality through an exchange of entire modules. Remanufacturing includes exchanges of single parts that in some cases even lead to an upgrade of functionality. Compared to the previous reuse loop both include a thorough inspection of all parts respectively modules. However, remanufactured goods can be considered as A-grade goods, or 'as new', because a subsequent warranty is likely to cover the entire product. The notion of cannibalization refers to the process of separating used products in high-value parts ready for later reuse and low-value or irreversible broken parts for material recycling.

In contrast to the other strategies mentioned above, the goal of recycling is not to maintain the functionality of a good but to recover the materials that were used to make the good. Recycling requires a separation of all materials in a highest possible purity. EMF distinguishes functional recycling which recovers material for its original purposes, downcycling with loss of quality and upcycling which increases material's quality or functionality. However, there is a limit to recycling, especially for smartphones (see Chapter 2.2.3).

In general the CE-loops follow an explicit order from the inside to the outside (top to bottom in Table 2), meaning that products should be maintained as long as possible and thereafter refurbished or recycled (Stahel 1984). This strategy not only has the highest saving potentials regarding material and energy use, but also regarding the embedded monetary values. These savings decrease with the outer loops. Recycling is the least preferable strategy considering thermodynamics (Jackson 1996, 12; Reuter 2011) and imbedded monetary values (EMF & McKinsey 2012). This is also generally in line with the European Waste Framework Directive and the resulting waste management hierarchy (European Commission, Article 4).

2.3.4 Legal perspective and critique of a CE

In the political landscape many initiatives support a CE, both on national and international level. Germany has adopted a law in 1996 which carries the term 'Kreislaufwirtschaft' in its name (KrWG 2012)[23]. However, this term can be translated as 'circular economy' or 'recycling economy'. The latter being more appropriate because of its main focus on the waste sector (KrWG 2012). This is because the German KrWG defines a 'recycling economy' as the

23 Gesetz zur Förderung der Kreislaufwirtschaft und Sicherung der umweltverträglichen Bewirtschaftung von Abfällen (KrWG).

prevention and recovery of waste (§3 KrWG 2012). Nevertheless, the law also obligates product development which enables for multiple use and take-back of products (§23 KrWG).

Similarly, many earlier publications on circular economy in German speaking countries originated in the waste sector. They focused on the one hand, mainly the material flow recovery strategies and on the other hand, the interruption of harmful substance flows instead of avoiding them in the first place (Pasckert 1997, 148). Therefore, CE-approaches that originated in the waste sector can be seen as an end-of-pipe approach, whereas more recent approaches are following a more holistic view.

Since the year 2005 ElektroG[24] is the German implementation of the European Commission WEEE directive, which regulates the take back of electrical and electronic devices. According to §6 ElektroG all distributing companies, including producers and dealers, are obligated to install a ‘clearing house’ which coordinates take back processes of WEEE. Resulting costs of return processes are converted to the individual distributing company through their market share. Additionally, distributing companies have the possibility to introduce individual collection systems (§12 ElektroG). Based on this self-governing possibility for the handling of WEEE a number of service providers emerged in the market to offer their services to distributing companies.

The European Commission is also working on a comprehensive CE strategy with several initiatives. Circular economy is seen as new growth potential and is also included in the Horizon 2020 program that includes € 600 million of funds (European Commission 2015). Several political reports address the benefits of a CE for Europe (Reichel et al. 2016). However, in the European Union a circular economy is also promoted due to its high potentials for future growth. The concept of a circular economy is compatible to our common neo-classical economy, as it is promoted by some actors as enabling a decoupling of growth and resource use.

The dispute between different sustainability strategies is an ongoing debate in academic literature. An example is the debate between scholars who follow a sufficiency strategy and related de-growth approaches with consistency and related circular economy approaches (Paech 2005). This discussion is related to a debate between relative decoupling of resource use and growth vs. absolute decoupling. It is outlined among others by Rammelt & Crisp (2014) in their article in the very critical Real-World Economics Review journal. The circular economy approach is often criticized to give further growth-incentives to the economy, rather than providing a way out quantitative growth.

24 Gesetz über das Inverkehrbringen, die Rücknahme und die umweltverträgliche Entsorgung von Elektro- und Elektronikgeräten (ElektroG).

It is also argued that a CE is only an ideal state that can never be fully reached, due to technical challenges such as dissipation of materials through small particles, material losses due to diffusion, corrosion or erosion (Huber 1995). Even if all technical challenges, such as recovery of smallest units could be solved, there is no such thing as a perpetual motion machine (Reuter 2011; Jackson 1996). Therefore, other sustainability strategies such as eco-efficiency of sufficiency should be combined with a CE approach (e.g. Bocken et al. 2016; Huber 1995; Paech 2005).

2.4 Transaction Cost Theory as a Theoretical Lens

As it was shown in the previous chapter the circular economy is a promising concept to overcome sustainability challenges in the smartphone industry. Further, it can be considered that closing technical CE-loops constitutes to additional tasks for current market actors that are mostly positioned along linear value chains. This chapter looks at so called *make-or-buy decisions* as a theoretical concept to analyze the relationships and in particular coordination forms within a value chain that emerge due to the transition to a CE.

The foundations for make-or-buy decisions can be found within the concept of *new institutional economics* (NIE) which is studying the institutions that govern and structure our economy. NIE is considered a standard framework to study such institutional arrangements (Klein 2005). It emerged out of the critique on neoclassical theory and their assumptions of perfect markets and maximizing utility. As response to this critique NIE assumes non-perfect markets, asymmetric distribution of information and uncertainty (Fischer 1993). NIE presents alternative coordination forms to market-coordination and builds on coordination processes (Klein 2000). A good overview on the historic development of NIE is given in Fischer (1993, 29–42) and Klein (2000). Approaches to operationalize NIE are property rights theory, principal agent theory and transaction cost theory (Fischer 1993; Picot et al. 1997). For a detailed understanding of make-or-buy decisions transaction cost theory (TCT) is selected as a basic framework. TCT has proven to be most appropriate for explanations of different kinds of transaction arrangements and other theories within NIE rather focus on property rights related to goods or the principal-agent relationship.

2.4.1 Fundamentals of Transaction Cost Theory

According to Coase (1937) the reason for existence of firms are the transaction costs of markets. All attempts of coordination between market actors produce transaction costs. Such costs can include research, consultation, negotiation and quality control expenses (Picot 1991, 344). Up to a certain point firms can minimize transaction costs through internalization due to their efficient hierarchical organization, which is mostly based on facilitated information flows within firms (Fischer 1993). Therefore, the central question of transaction cost theory is whether a certain task is more efficiently organized within a firm by hierarchical means or left to market forces (Geyskens et al. 2006). Following this argumentation, according to transaction cost theory, the firm's boundaries are determined by the relative transaction costs between external and internal interchange (Klein 2005; Picot et al. 1997). Thus, the framework developed by Coase is not only suitable for explaining the existence of a firm, but also its size and scope.

The considerations developed above result in two main forms of coordination: market-based forms and hierarchical forms within firms (Williamson 1981). However, these two coordination types can be seen as limiting a continuum between market coordination on the one side and hierarchical coordination on the other (Picot 1991; Picot et al. 1997). Between these two extremes, other so called intermediate forms (e.g. cooperation, value-adding networks) are emerging[25] (Williamson 1991; Borys & Jemison 1989 as cited in: Fischer 1993, 107). The resulting continuum and exemplarily coordination forms are presented in Figure 9.

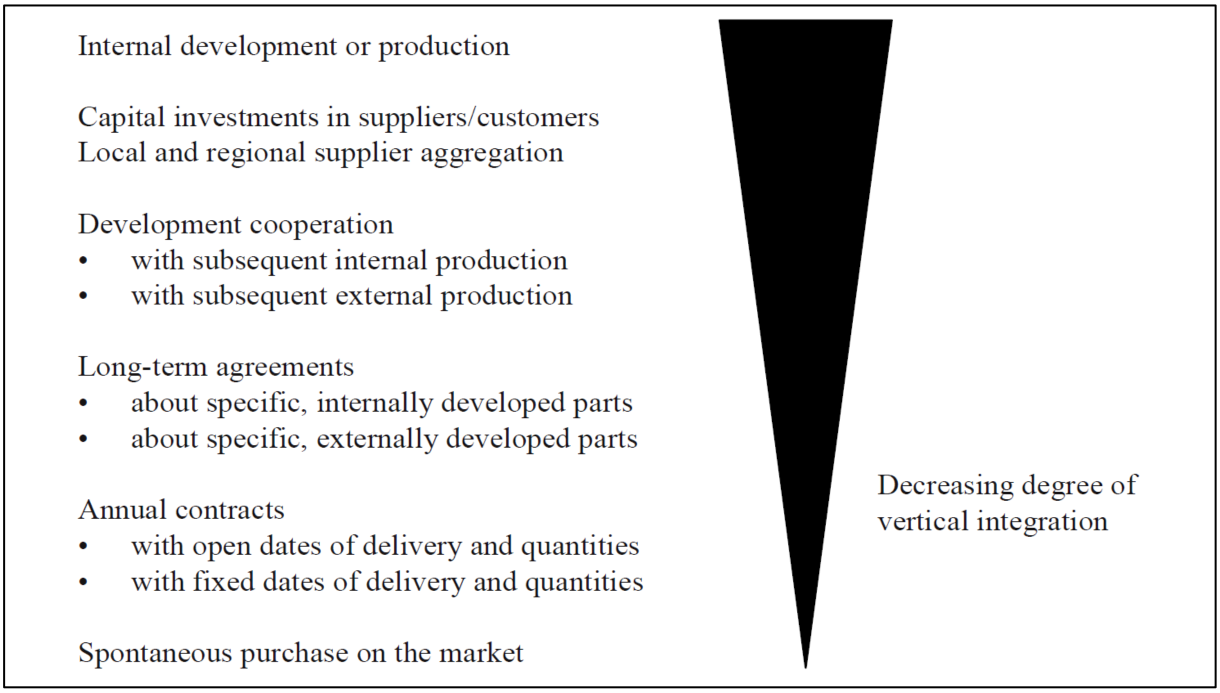

Figure 9: Exemplary forms of coordination along a continuum between markets and hierarchies. Source: Picot (1991, 340) as cited in Picot et al. (1997, 45).

However, these forms of coordination are subject to continuous change processes due to market and technology based developments. An example is the rapid development of ICT at the end of the 20th century and their contribution to the development of transaction costs. Picot et al. (1997) discuss the role of ICT on transaction costs and propose a general decrease of transaction costs through the use ICT which in turn can lead to new coordination types. One

25 Benger (2007) adds with traditional coordination another type, which, however, only relates to traditional forms of behavioral patterns (e.g. religion, family relations) and can be excluded from this analysis.

resulting effect is when the boundaries of a firm vanish and it becomes increasingly difficult to see a firm as a closed structure (Picot et al. 1997). Therefore, more complex forms of coordination are sometimes referred to as network-forms of coordination (Benger 2007, 26; Blecker & Liebhart 2006; Powell 1990), which illustrate the complexity of relationships between firms.

2.4.2 Make-or-Buy analysis

Transaction cost theory is the predominant framework for explaining make-or-buy decisions in empirical studies. This is because TCT and Williamson's coordination types can be closely related to make-or-buy decisions, as the latter "depend on the relative costs of internal versus external exchange" (Klein 2005, 436). Moreover, make-or-buy analysis is commonly used to analyze the structure of a firm within its context (Geyskens et al. 2006). Historically major applications for make-or-buy decisions were found in production, especially in the automobile industry (e.g. Bigelow & Argyres (2008), Walker & Weber (1984)). Additionally, these make-or-buy decisions are especially interesting at the beginning and end of a value chain (Schneider et al. 1994), as the competencies of the central firm are diminishing. Therefore, make-or-buy analysis is an ideal instrument for an application to organizational structures of a circular economy.

If transaction costs for a certain good are reaching a point where no more transaction takes place, markets are no option for coordination and a firm must *make* the good themselves (Schneider et al. 1994). This is especially true for goods with a high asset specificity, high levels of uncertainty and strategic relevance (Picot 1991). On the other hand, when transaction costs are low and the market is functioning well, which is applicable for standardized goods, outsourcing or *buy* decisions are facilitated (Picot 1991). Hybrid forms where transaction costs are reduced through cooperation (e.g. long term contracts, ownership structures) with market actors until an agreement can be reached correspond to *ally* decisions (Sydow & Möllering 2004). For such intermediary coordination types Picot (1991) also emphasizes an equity investment as an effective means for reduction of transaction costs through long term relationships.

Make-or-buy decisions therefore depend not only on bounded rationality and opportunistic behavior but also on the cost drivers of transactions. These are mainly asset specificity, uncertainty, and transaction frequency (Williamson 1979; Picot 1991). These influencing factors are to be analyzed for all corporate tasks (e.g. R&D, purchasing, production, sales, etc.), following Picot (1991). However, other non-market effects such as legal and technological developments, degree of innovation, quality requirements and a company's own strategy are increasingly recognized as being important factors (Picot et al. 1997; Picot 1991;

Fischer 1993). A comprehensive overview of all influencing factors is given in Schneider et al. (1994) and Fischer (1993). The most important influencing factors are further specified below (see also Table 3). An illustrative representation of Williamsons resulting 'organizational failure framework' is given in Picot et al. (1997, 43) (see Figure 10).

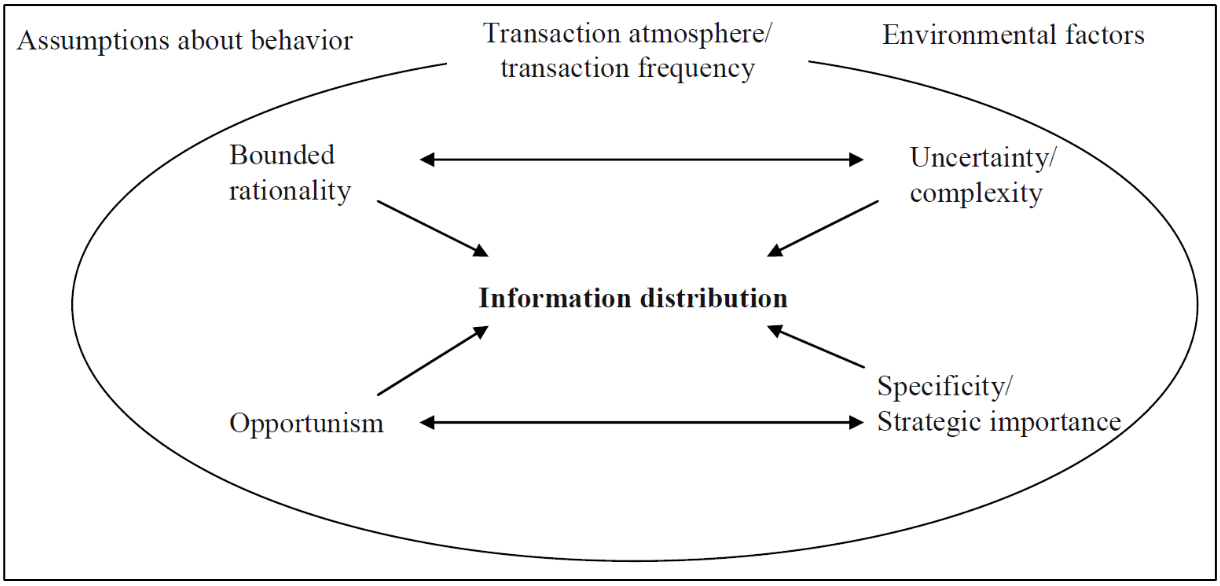

Figure 10: Organizational failure framework based on (Williamson 1975). Source: Picot et al. (1997, 43).

The most commonly discussed influencing factor in academics is asset specificity under which can be understood investments that are taken specifically for performing a certain task. Specific investments (e.g. in highly specialized production lines) can only be used for a single task and are thus immobile, unspecific investments (e.g. in office equipment) on the other hand are multi-functional (Fischer 1993). Therefore, not necessarily the product itself differs from a standardized one in the market, but the production or the process for delivering the service differs significantly. These addressed investments can include investments in machines, but also in employees, contractual arrangements or site specific investments (Picot et al. 1997; Fischer 1993; Schneider et al. 1994). Specific investments can be exploited through opportunistic behavior (Picot et al. 1997, 44) and should therefore not be based on short-term relationships, but rather an integrated one (e.g. hierarchical or cooperative integration).

Strategic relevance is another important influencing factor. It is highlighted by Picot et al. (1997) with reference to a company's core competencies. Core competencies should always be carried out internally through hierarchical organization. Also strategic decisions may be related to the current position of the product or task in the life-cycle. In early stages of the life-cycle higher strategic relevance may occur as associated with higher specificity (Schneider et al. 1994). Later on, specificity is lost due to standardization and buy-decisions are encouraged.

One more influencing factor is uncertainty which is based among others on information-asymmetry. This uncertainty is expressed in imperfect contracts, which in turn result from imperfect information (Fischer 1993, 95). The occurrence of uncertainty is especially true for contracts that are part of highly specific investments which may not be overlooked fully from beginning and can therefore be considered complex (Picot et al. 1997, 44). Uncertainty can occur, for example, when there are quality or quantity risks, no norms or standards exist or it is a novel good with limited experience (Schneider et al. 1994, 74).

Two additional influencing factors are less of a subject of debate in literature, but nevertheless equally important. On the one hand this is transaction frequency, which is one of the three critical dimensions named by (Williamson 1979). However, it is mostly related to economies of scale and amortization rates (Fischer 1993) and generally speaking, transaction costs decrease with higher frequency. On the other hand, this is the transaction spirit, pointed out by (Picot et al. 1997) which includes the underlying values as well as “social, legal, and technological” circumstances (Picot et al. 1997, 45).

Table 3: Influencing factors on make-or-buy decisions. Based on: Picot (1991), Powell (1990), Williamson (1979), Geyskens et al. (2006), Fischer (1993), Schneider et al. (1994), Picot et al. (1997).

Variable	Description	Types
Asset specificity	- Critical determinant of TC - Investments to a unique task - Degree of locked-in relationships - Know-how requirements - Quality demands	- Site specificity - Physical asset specificity - Human asset specificity - Time specificity - Procedural asset specificity
Strategic relevance	- Core competencies - Life-cycle evolution	- Products - Services
Uncertainty	- Forecasts - Agreement adjustment - Volume, change in quality - Missing standards and norms	- Environmental uncertainty * volume uncertainty * technological uncertainty - Behavior uncertainty
Transaction frequency	- Supporting dimension - Economies of scale	- Ratio of fix and variable costs
Spirit	- Values and norms	- Social, legal and technological conditions

It should be noted that transaction costs are very difficult to monetize (Fischer 1993). However, the goal of a make-or-buy analysis is to compare different options, which is frequently done through interviews of decision-makers regarding influencing variables.

TCT is also criticized for focusing heavily on the assumptions of opportunistic behavior and efficiency gains. These, however, may not always hold true in the real world, as decisions are not always explained rationally. Ghoshal & Moran (1996) for example claim that TCT does not consider the social context and trust issues within the organizations environment. Fischer

(1993) summarizes the critique on TCT in three aspects. These include a unilateral view of coordination forms from a cost perspective, lack of operationalization and lack of consideration of power phenomenon (Fischer 1993, 124). Despite this critique, TCT is a commonly used theory to study organizational arrangements on a macro level. In this thesis it is used as a guiding theory for explaining the arrangements that occur out of circular economy activities of different market actors in the smartphone industry.

2.4.3 Make-or-buy decisions in the value chain

A wide range of definitions to value creating structures exist in the academic literature. However, within the scope of this master thesis it should be sufficient to define value chains as a cooperation of independent organizations to create products and services through value added activities (Reese 2016, 5). Value chains are thus the sum of all value added activities from resource extraction to end product. However, the beginning and end of a value chain remain unclear (Schneider et al. 1994), as it is a matter of defining the system boundaries.

This discussion is also closely related to the notion of vertical integration, which is part of internal processes and strategies mostly influenced by Porter (1980). However, these intra-firm value chains should not be confused with the inter-firm organization. By contrast, a value chain according to Porter (1985, 48) is “a system of interdependent activities” within a firm that are linked to each other. The emphasis lies here on the internal linkages between primary and supporting activities that form a value chain within a firm.

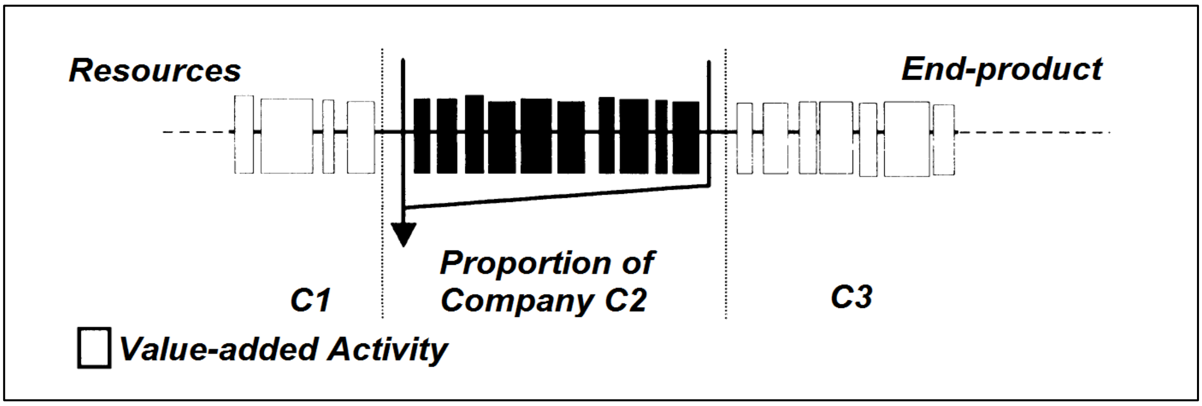

Figure 11: Structure of a simplified value chain with involved companies C1-C3. Source (originally in German): Schneider et al. (1994, 13).

The graphical presentation of value chains is always an idealized one; because in real life the world is more complex and added value is produced through value-added processes within complex value-added networks (Benger 2007, 94ff.; Ritter & Gemünden 2003, 694ff.). Additionally, in the real world many activities are carried out simultaneously and interdependencies exist. For this master’s thesis, however, value chains inspired by Schneider et al. (1994, 13ff.) are used to display the connection of a focal actor with other dependent actors (see Figure 11). This simplification increases clarity and practicality. These value chain maps display on a schematic scale, the successive value added activities from resource extraction to end product that are necessary to make a product or deliver a service. They are kept on a very rough scale, nevertheless, they allow for high transparency in strategic networks and offer a holistic overview on activities from a focal actor’s perspective (Schneider 2015). These inter-firm value chain maps, however, should not be confused with Porters framework of internal value chains (Blecker 1999).

Classic examples for make-or-buy decisions can be found in the automobile industry (Bigelow & Argyres 2008; Dietl et al. 2009; Walker & Weber 1984). Typically, relations between automobile manufacturers and suppliers are analyzed by means of this theory. Core competencies with high specificity, such as combustion engines or chassis are made by the OEM (Original Equipment Manufacturer). For other key components long-term contracts are established with strategic suppliers or development partnerships are preferred which can be related to ally-decisions or hybrid forms. Standard components such as tires are bought off-the-shelf from suppliers, as they involve no transaction-specific investments (Powell 1990).

3 CONCEPTUAL FRAMEWORK

Combining the conceptual basis of a circular economy with the theoretical framework of make-or-buy analysis is a novel research approach. It enables an empirical exploration and in-depth analysis of how resource loops are closed from an inter-organizational perspective and what kind of value creation architectures could emerge. The resulting conceptual framework is presented in this chapter. It is developed in an iterative process between theory and first empirical observations in the field (e.g. at the first INaS-workshop).

The term value creation architecture (VCA) which is used to describe this framework is taken from an article in an applied management journal by Dietl et al. (2009). The concept of VCAs "describes the structure and relationships of all the value-adding activities that are carried out by various actors and companies to bring a particular product or service to market" (Dietl et al. 2009, 26). Similarly as in supply chain management the analysis starts from the focal actor, who links the production and distribution side (Dietl et al. 2009; Gemünden et al. 1996; Seuring & Müller 2008). A focal actor is defined as "those companies that usually (1) rule or govern the supply chain, (2) provide the direct contact to the customer, and (3) design the product or service offered" (Seuring & Müller 2008, 1699). Thus the concept of VCAs can be seen as an applied concept of the closely related TCT discussed in the previous chapter 2.4.

In the context of the smartphone industry focal actors can therefore be related to manufacturers or network-providers. According to Dietl et al. (2009, 28) VCAs differ regarding three main variables: make-activities of the focal actor, buy, or ally activities outsourced to suppliers and relationship characteristics between these. Market actors who offer services that are related to closing loops in the smartphone industry are called "loop operators". These loop operators are specialized in processes necessary to close these CE-loops. This may include reverse logistics, data deletion, maintenance and refurbishing activities.

The conceptual research framework mostly follows an outside-in approach which means that focal companies in the value network are analyzed indirectly, i.e. from the outside[26]. Usually contracts are subject of investigation for make-or-buy analysis (Fischer 1993, 42), however, in the scope of this thesis an inspection of contracts was not feasible. Nevertheless, some information about the contractual relationship could be collected. Consequently, no direct statements can be made about the situation within large smartphone manufacturers or telecommunication providers.

26 This is not an ideal situation for performing a make-or-buy analysis, which generally produces statements from a focal actor's perspective. Nevertheless, this is a reasonable approach in the context of time and resource constraints of this master thesis as access to large focal companies was not available.

The resulting conceptual framework is presented below in Figure 12. It assumes a linear value chain that reaches from resource extraction to collection of used devices. The analytical perspective of a make-or-buy analysis is maintained and presented by the grey shaded area and the glasses icon. Classical linear value added activities are of successive nature and can be of different scope and size (icon: white rectangle). Additionally, circular activities in form of technical CE-loops are drawn from EMF & McKinsey (2012, 24). These circular activities are mostly associated with the end of the value chain, related to the user or post-user (e.g. collection) phase (EMF 2016). Circular activities are displayed through arrows pointing backwards. Rectangular fields with a question mark are associated with these newly established circular activities. Question marks present placeholders that are going to be filled within this research by colored rectangles depending on the observed coordination form.

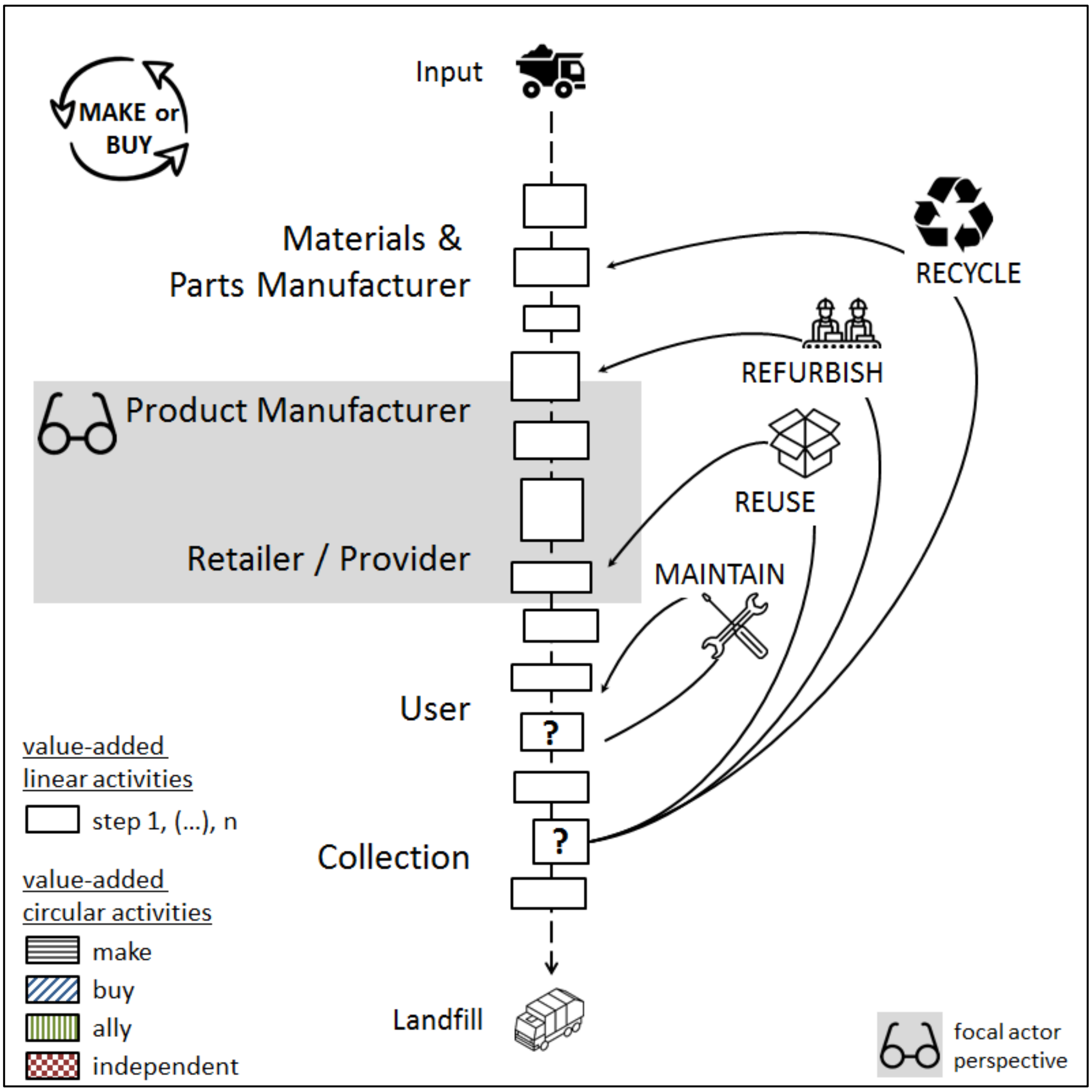

Figure 12: Conceptual framework for analyzing circular value creation architectures: Combining CE with make, buy or ally analysis. Source: Own representation.

While the above framework is subject to empirical analysis, it also serves as a basis for sampling cases for an empirical case study (see also Chapter 4.2.1). Three possible value creation architectures can be identified from theory. Applying TCT and Williamson's general coordination types to a CE environment leads to the first three possible VCAs presented in Figure 13 below. Firstly, it is expected that a VCA exists that integrates circular economy practices and in particular loop operators in a vertical manner. This means that a focal company in the value chain decides to "make" or coordinate circular economy loops internally (VCA 1). Secondly, theory suggests that focal companies can decide to outsource their loop operations and thus engage in a "buy" coordination. To do so a large focal firm (focal actor) commonly commissions a service provider (loop operator) to provide services that lead to closed material loops (VCA 3). Following Williamson (1991), it is further possible that focal firms engage in hybrid forms of coordination. This would include a VCA that consists of a relationship which is commonly characterized as "ally" coordination and includes close partnerships between focal companies and loop operators to close CE loops (VCA 2).

In addition to these VCAs that closely relate to TCT, a number of independent market actors that have no direct relationship (e.g. contract, partnership) to focal actors in the value chain can be observed in the field. Examples for such independent loop operators may be repair shops or second hand marketplaces for electronic equipment. They form the fourth possible VCA for this thesis which is characterized through independent market actors (VCA 4).

Figure 13 below gives an overview of the preliminarily identified possible VCAs. The selection of possible case companies is based on these theoretically and practically deducted VCAs (see Chapter 4).

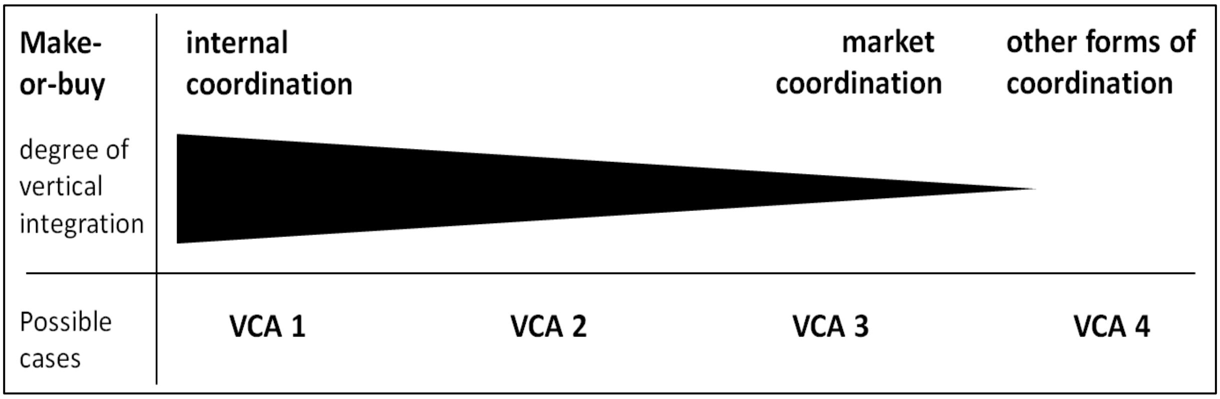

Figure 13: Preliminary identified cases based on TCT, plus one extreme case

4 METHODOLOGY

4.1 Research Design

The proposed preliminary framework is used for a qualitative multi-case study approach in order to analyze the contributions of different value-creation architectures for closing loops in a circular economy. A qualitative research design is chosen in order to increase the understanding of closing CE-loops in the field and to cope with the still novel research of circular economy implementations (Flick 2011). In the following Figure 14 the utilized research design for this thesis is presented.

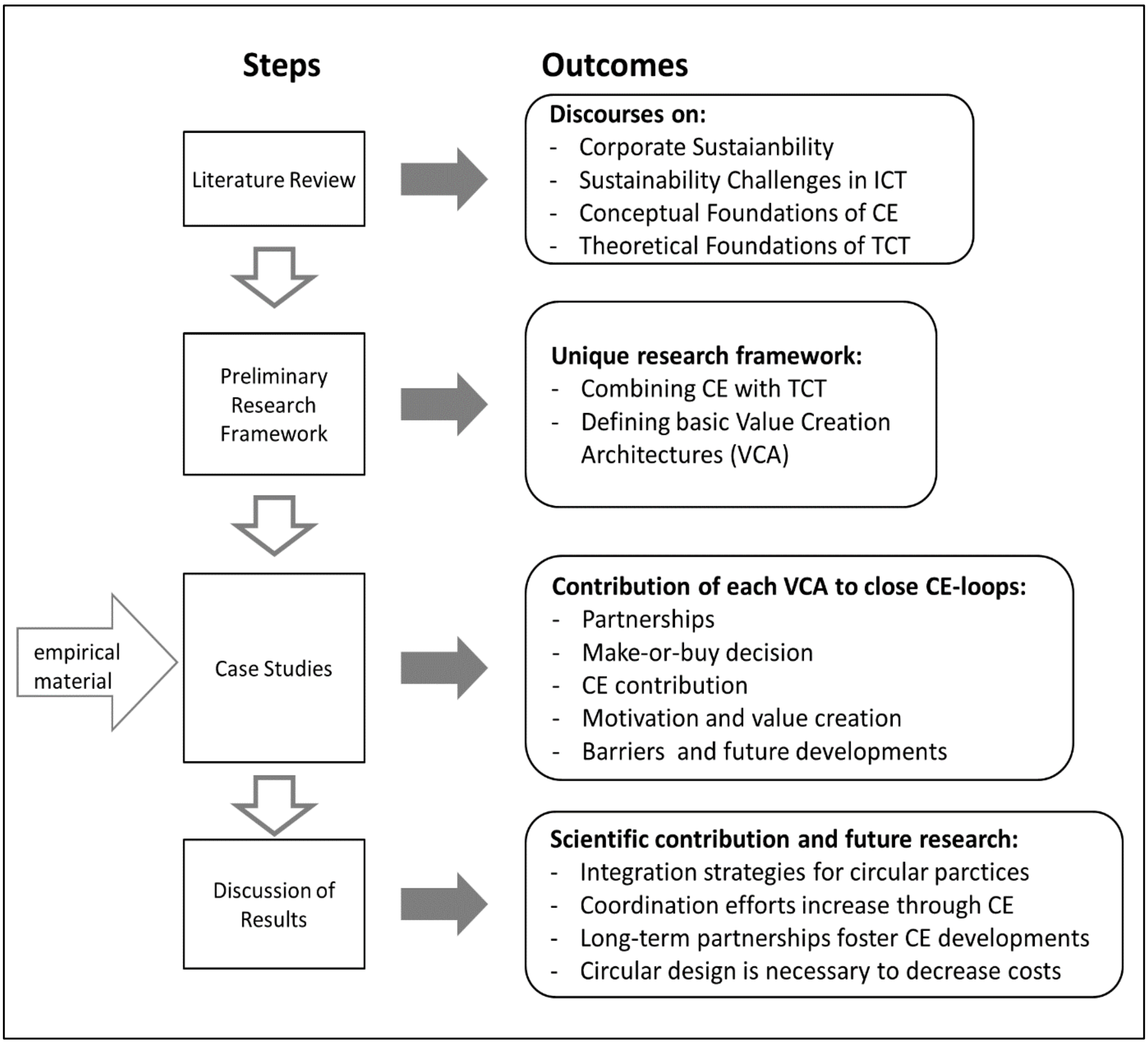

Figure 14: Utilized research design for this thesis

4.2 Case Study Approach

For each VCA a multi-source case study on selected companies and company networks drawn from INaS participants is conducted. Case studies are prepared in line with the principles formulated by Yin (2009).

Case studies are commonly used to understand real life contexts. According to Yin (2009, 18) they are especially suitable for extensively investigating contemporary phenomenon where system boundaries are unclear. Therefore, a case study's primary aim is to learn and understand, rather than to prove something (Stake 1995). Case study research can be understood as a holistic approach for research design, data collection and analysis (Yin 2009). The aim of this study is to understand the complex phenomenon related to closing CE-loops but also to produce context dependent hypotheses for further research. In-depth case studies are particularly useful for such an approach (Flyvbjerg 2006), however, they require significant resources.

Nevertheless, there are also some frequently discussed limits to qualitative case study research. For example, they are seen as an inferior methodological approach compared to large quantitative data samples, especially regarding validity and reliability. However, Flyvbjerg (2006) responds to this critique and misunderstandings about case study research in his well cited article that they are method to learn and understand about context dependent real life problems. In order to prevent critiques, Yin (1981) stresses the importance of building on a clear conceptual framework when producing a case study. Therefore, in the following paragraphs the case sampling strategy, data collection and data analysis approach are presented.

4.2.1 Case sampling strategy

Case sampling is based on the above developed conceptual framework in order to create a predictable and smooth structure (Yin 1981). The aim is to select cases that help us to maximize our learnings, and they don't necessarily have to be representative of a population (Stake 1995). Therefore, case sampling was conducted along the principles of Yin (2009, 91 f.) by operationalizing criteria from theory. These selection criteria for case companies include engagement in activities related to closing loops of a circular economy and active or passive relationships to other firms along the value chain. Further, as this thesis is related to a bigger research project, select case companies are part of the partner network from the ongoing "INaS" research project at Leuphana University of Lüneburg (see also Chapter 1). All selected case companies are situated within the smartphone industry and are located in Germany.

For each coordination structure resulting from TCT and the above developed conceptual framework at least one matching company was selected. This means that a pre-study allocation of companies was performed on the basis of first observations in the field. In this way it was ensured that all coordination types developed in Chapter 2 could be analyzed. All selected case companies are also part of a bigger organizational structure which is subject to analysis. Nevertheless, in this thesis the analysis starts at a single company level for practical reasons and therefore, the chosen process can be described as an outside-in approach, which tries to draw conclusions from an outside perspective (see also conceptual framework).

Purposely, additional to the three cases which are closely related to theory, an extreme case was selected which does not explicitly fit to the selected theory but subserves to challenge the preliminary framework and produce most valuable insights (Flyvbjerg 2006).

4.2.2 Data collection

Data was collected from various sources (see Table 4) between August and December 2016. Whereby the initial prepared conceptual framework was used for guiding data collection (Yin 2009). Collected Data included on the one hand personal interviews with company representatives at a management-level and with industry experts, extended site visits and photographs in order to gain insights into a company's situation (Lamnek 2010). On the other hand, data collection included publicly available information such as websites, press-releases, company brochures, product flyers and printed material to compensate the modest amount of conducted personal interviews.

Table 4: Overview of data sources

Data Type	Details	Documents
Semi-structured interviews	7 Semi-structured interviews	Transcripts, protocols
Site-visits	4 Site-visits	Photos, field notes
Workshops	2 Workshop participations	Official documentation
Secondary sources	Brochures, websites, etc.	PDFs, digital print outs

If possible, interviews were conducted face-to-face in order to increase legitimacy and to have the opportunity to also include a site visit. Interview partners were chosen from management-level or company-owner level to increase validity (Yin 2009). Compared to rigid questionnaires, qualitative interviews allow to move from observing to understanding the case and its embeddedness in the system (Hopf 2013). To allow for flexibility and react to interviewees accordingly a semi-structured interview questionnaire was developed building on the literature review and preliminary framework (Flick 2011)[27]. Personal interviews were conducted between September and October 2016 and recorded with a portable audio recorder (see also Table 5). Transcripts[28] of each interview were produced using simplified rules that are summarized by

27 The semi-structured interview questionnaire is available in the appendix.
28 All transcripts are available in the digital appendix and upon request

Kuckartz (2007, 43) and enable for continuous reading and focus on the content of the material (Mayring 2010). Contact to case companies and industry experts was established through staff members of the INaS-Project at Leuphana University of Lüneburg, who can therefore be seen as facilitator and gate keeper.

Table 5: Formal characteristics of interview-material

Code	Company	Interviewee Position	Type	Duration	Documents	Site visit?
AF	AfB gGmbH	CSR-Manager/ BD	formal, skype call w/ video	00:52:00	Transcript	No
BI	binee UG	CEO	informal, tele-phone interview	00:20:00	Protocol	No
SP	Shiftphone GmbH	CEO	formal, face-to-face	01:16:00	Transcript	Yes
TQ	Teqcycle GmbH	Key-Account Telekom / BD	formal, face-to-face	00:55:00	Transcript	Yes
indi_1	akkutauschen UG	CEO	formal, face-to-face	00:58:00	Transcript	Yes
indi_2	iPassions GmbH	CEO	formal, face-to-face	00:43:00	Transcript	Yes
exp_1	RITTEG Trade + Consulting	CEO	formal, face-to-face	00:47:00	Transcript	No

All cited online sources or other publicly available information that are used in addition to the conducted interviews are presented with a direct link to the source and corresponding access dates. During two workshops, which were part of the INaS-Project further material and information on case companies was collected. During the first workshop first contacts were established to interview partners, in order to further develop the research proposal. In the second workshop in December 2016 final results of this study were presented to experts in the smartphone industry in order to collect feedback and to increase validity.

Table 6: Attended workshops within the INaS-Project

Code	Workshop	Topic/Aim	Date	Location	Documentation
W_1	“Sustainable Product Design and Supply Chain”	- Project kick-off - Eco-Design - Value Chains	23.06. 2016	Leuphana University of Lüneburg	Full documentation available form INaS-Project team
W_2	“From devices to solutions using PSS”	- PSSs as facilitator for a circular economy	02.12. 2016	Leuphana University of Lüneburg	Full documentation available form INaS-Project team

4.2.3 Data analysis

A structured content analysis was performed to analyze the material. Content analysis is a very common technique in social science to analyze qualitative data, due to its systematic approach (Kuckartz et al. 2007). Structured content analysis (Mayring 2010, 92) is a central form of content analysis and aims at structuring the collected material according to a systematically developed category system Mayring (2010). It aims at a typification of the material, which means that particularly extreme attributes and characteristics that contribute to theory are of interest. The procedure for a structured content analysis described by Mayring (2010, 100) is followed. However, due to constraints related to the nature of this master's thesis, the procedure is simplified (e.g. no verification through intercoder-reliability).

The category system used for this approach is developed based on deductive logic but open to emerging aspects from the empirical material, leading to a combined approach which is in line with the explorative nature of this research (Mayring 2010)[29]. The content analysis is carried out with computer-aided software (MAXQDA 2016).

The resulting analysis and interpretation of the material is discussed with other researchers in the INaS project on a continuous basis in order to increase transparency and reduce biases. Such a "communicative validation"[30] (Mayring 2010, 120) is reached through interaction of researcher and research object and is a quality criteria for content analysis. Preliminary results of this research were also presented in form of a working paper at the Research Colloquium on Innovation & Value Creation (I+VC) 2016.

29 The category system is available in the digital annex
30 Own translation from the German term „kommunikative Validierung"

5 RESULTS

In this chapter the analyzed cases are described in detail. This includes an analysis of involved actors, factors that influence the make-or-buy decision, addressed resource loops from a circular economy perspective, the focal actor's and loop operator's motivation and finally the perceived barriers and possible future development paths that are mentioned by the analyzed actor. In total, five separate cases that are related to the B2C sector in the smartphone industry were observed. They are analyzed in detail in the following subchapters (see Table 7).

Table 7: Overview of presented cases in Chapter 5

Case	Value Creation Architecture	Analyzed actor	Coordination type
Case I	Vertical Integration of CE-loops	Focal company (smartphone manufacturer)	Make
Case II	Closing CE-loops through Hybrid-forms of Coordination	Loop operator	Ally
Case III	Engaging a Service Provider to Close CE-loops	Loop operator	Ally/buy
Case IV	The legal Case regarding CE-loops	Industry expert	Buy
Case V	Emergence of independent loop operators	Independent loop operators (repair shops)	Independent

5.1 Case I: Vertical Integration of CE-Loops

This first case describes a value creation architecture that primarily involves Shift GmbH as a vertically integrated smartphone manufacturing company from Germany. Due to their small market share, they use standard components for their smartphones which limit modularity and reparability. Nevertheless, a number of circular activities are offered directly through Shift.

5.1.1 Involved actors

This value creation architecture is dominated by Shift GmbH as a focal company. Shift is a small German smartphone manufacturer from Hessen who uses crowdfunding to gain market access. They position themselves as a fair smartphone manufacturer with close contact to their customers. Their "shiftphones" are produced in China; however, during the interview it was emphasized that Shift's CEO personally monitors fair working conditions during assembly. Shift is generally highly vertically integrated in order to guarantee transparency and flexibility for their customers. They can be described as a very flexible start-up company that can quickly adapt to new market situations and most activities are personally overlooked by the CEO.

They see their customers also as their partners in the development of a more sustainable smartphone. Most of Shift's products are brought to the market via crowd-funding campaigns where potential customers have the chance to engage in the product development and express their expectations.

Further partnerships relevant for their circular activities are currently developing. This is especially necessary to fulfill the legal requirements for take-back of electronic devices. Shift is planning to work together with an environmental NGO and specialized loop operator regarding the recycling loop (similar to VCA 3.1 in this chapter).

Shift mentions that they are generally open to work together with other partners in order to intensify their CE practices. However, so far such cooperation has not been established.

> *"We are already looking for workshops that can and want to carry out repairs for us". (SP, 47)*

The small-scale smartphone manufacturer Shift is the focal actor in this VCA which does not involve specific loop operators (see Table 8 for a summary).

Table 8: Overview of involved actors and their tasks for Case I

Actor	Details	Tasks and responsibilities
Focal actor	Smartphone manufacturer	Contracting authority, mostly communication with end-user
User	Shift customers	Can engage in the product development via crowd-funding campaigns
Further partners	Disassembly and recycling company	Processing of devices in the "recycling loop"

5.1.2 Factors influencing the make-or-buy decision

Shift is generally very vertically integrated, not only regarding CE-loops. For example, they are currently planning to open their own manufacturing site in China to increase transparency and control the supply chain. It is a strategic decision to be very much vertically integrated and therefore be able to retain flexibility and transparency which could not be achieved otherwise. Being in close contact with their customers is a unique selling point of Shift.

At the same time this vertical integration strategy leads to an extensive support structure such as offering a maintenance service for their smartphones which requires a very complex process that includes intensive coordination with their customers. This also results from the general complexity of their smartphones which use standard components and thus are not designed for repairability (see also section 5.1.5).

> *"Our customers get in touch with us and mention a defect. Then we have a personal consultation for everyone. Then we listen to them and then we give advice and tell to do it this or that way. And also tell them about the videos [on YouTube]. And then we talk further and decide which part is needed". (SP, 15)*

Outsourcing their customer support is not only strategically unwanted, it also led to potentially high transaction costs due to complex coordination efforts. Very specific knowledge about customer behaviors and the product itself are necessary to offer maintenance or refurbishment activities. Due to the complexity of repairs, such a partner workshop would need to be in close contact with Shift.

Therefore, another factor for a vertical integration of circular economy practices is that Shift so far could not find appropriate partners that correspond to their expectations. In the interview it became clear that it does not always making sense to work together with partners for closing CE-loops. Shift wants to take back their phones themselves, in order to reuse them in the best possible way.

> *"Oh maybe we do not know these partners yet. Generally, we are open to work together with others also. […] Regarding repairs this would actually be useful, because we also reach our limits sometime. […] It increases the more number of units we sold. Eventually we won't be able to manage it anymore". (SP, 47)*

One of the major reasons for internalizing their additional services around their circular economy activities is that Shift can offer them more cost efficiently than professional loop operators. Shift is still a start-up company and thus has a cost efficient internal structure.

> *"Only the main problem is that we cannot find service companies who would be willing to work for as little money as we currently do. […] And also when you have partners, they have massive overhead costs and this and that and expensive insurances. I do not know what else there is, what is absolute necessary". (SP, 95)*

The most relevant influencing factor for Shift's make-or-buy decision is probably their underlying values and norms. The spirit of Shift is to be close to their customers and act as a sustainable smartphone manufacturer. This VCA can therefore be described as *make coordination* (see Figure 15 below).

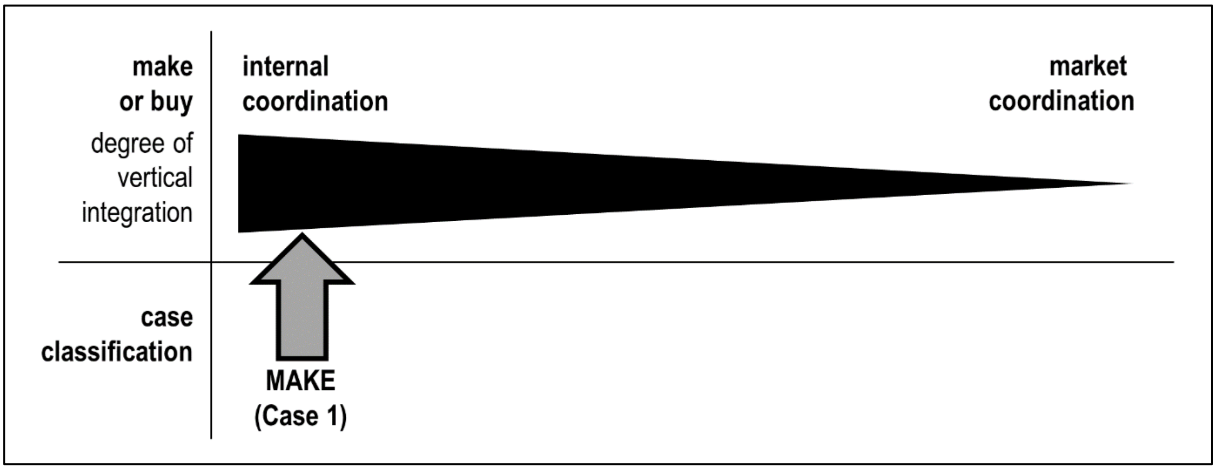

Figure 15: Classification of Case I in Williamson's coordination types

5.1.3 Addressed CE-loops

In this VCA three CE-loops are directly addressed through the manufacturing company Shift. These loops include 1) maintenance, 2) reuse and 3) remanufacturing/refurbishing. They communicate these activities in a recently released report as follows:

> *"All of these fields we cover ourselves with SHIFT and process them with our small team in-house. We operate a small repair-workshop, a second-hand market and try to reuse most of our parts ourselves". (Shift-Report 2016, 11)*

Table 9: Contribution of Case I to closing or slowing resource loops of a CE

CE-Loop	Coordination	Details
Maintain	In-house	Spare parts availability for everyone Repair manuals on YouTube and through a wiki Repair services if required
Reuse	In-house	Used phones can be returned (deposit) Development of a second-hand market Reduced prices for social organizations (used phones)
Refurbish	In-house	Used phone parts are reused Returned phones repaired and resold
Recycle	Loop operator	For own phones: very little experience For other phones: cooperation with loop operator

One of the first CE-loops offered by Shift for their customers was a maintenance service for their devices. Unlike other smartphone manufacturers Shift offers a wide range of original spare parts directly through their service team. The service team also assists with YouTube videos that explain the repairing-process[31] and through written repair instructions on their

31 For their YouTube channel see also: https://www.youtube.com/channel/UC8g1DFrAPbTVRBZ_N-YfcLA (access on 10.11.2016)

website[32]. Additionally, a repairing service is offered for customers who don't want to repair their phone themselves.

> *"Look, basically, you can get even every single cable or sticker. Everything is basically available as a spare part". (SP, 23)*

However, Shift does not actively promote these additional services. For example, spare parts and their repair-services are not offered directly on the company's website or in their online shop. This may be due to their personally-oriented communication approach with customers.

> *"We do not have these in our shop, because most of the times it would be too complex and most people would not know which part it would be". (SP, 15)*

The reuse loop is the second most important CE-loop for Shift. Two measures were implemented in order to increase return rates of used smartphones. Firstly, users can upgrade their phone which means that when a new version is brought to the market, customers have the option to trade-in their old phone. Secondly, Shift recently implemented a deposit system which includes a 22 Euro deposit when buying a Shiftphone.

> *"Reuse works like this, people can either upgrade [their phone] and send us their old one, or they say they need a completely different one and want to send their current [phone] back". (SP, 33)*

> *"We desire, that a SHIFTPHONE is never just thrown away, as it contains valuable resources and parts that we want to reuse again. This is why we introduced a 22 EUR deposit on out devices this year". (Shift-Report 2016, 11)*

The returned phones are then sold for a reduced price in the second-hand market. According to the conducted interviews the demand for used smartphones that do not include the latest functionality is high. Shift directly sells these used devices in the secondary market or for a reduced price for example to social institutions. However, these second-hand devices are not yet sold on their website.

> *"We have sufficient inquiries from people, who want an old one. They say it does not need to be the newest Android version, essential for is only WhatsApp". (SP, 35)*

The refurbish-loop is not yet as well-developed as other CE-loops, because few smartphones are returned in a bad condition. Nevertheless, Shift has an interest in broken but returned phones in order to use them in further processes of refurbishing and repairing. They are seen as a valuable resource for their operations.

32 For their own wiki-page see also: http://de.shiftphones.com/wiki/SHIFTPHONES (access on 10.11.2016)

> *"But our phones we want definitely back… We need them ourselves. Since we can do that best ourselves, reuse and recycling. Because we know our phone best and we know where something is coming from". (SP, 11)*

Lastly, the recycling loop is only recently becoming relevant for Shift. This has to do with their legal duties as a manufacturing company. For compliance reasons they also start to implement similar systems as described in cases 3 and 4 and thus do not integrate them vertically.

> *"Here we would work together with someone. Well for our own things we do the recycling ourselves. But we also accept other phones, now". (SP, 11)*

In general, it can be observed that Shift deals with the CE-loops from the inside to the outside, meaning that higher order loops (e.g. maintenance) become relevant first. In practice it also turns out that they become relevant in this sequence, because smartphones first require small maintenances and then larger repairs or exchange. This is also reflected in Figure 16 which summarizes VCA 1.

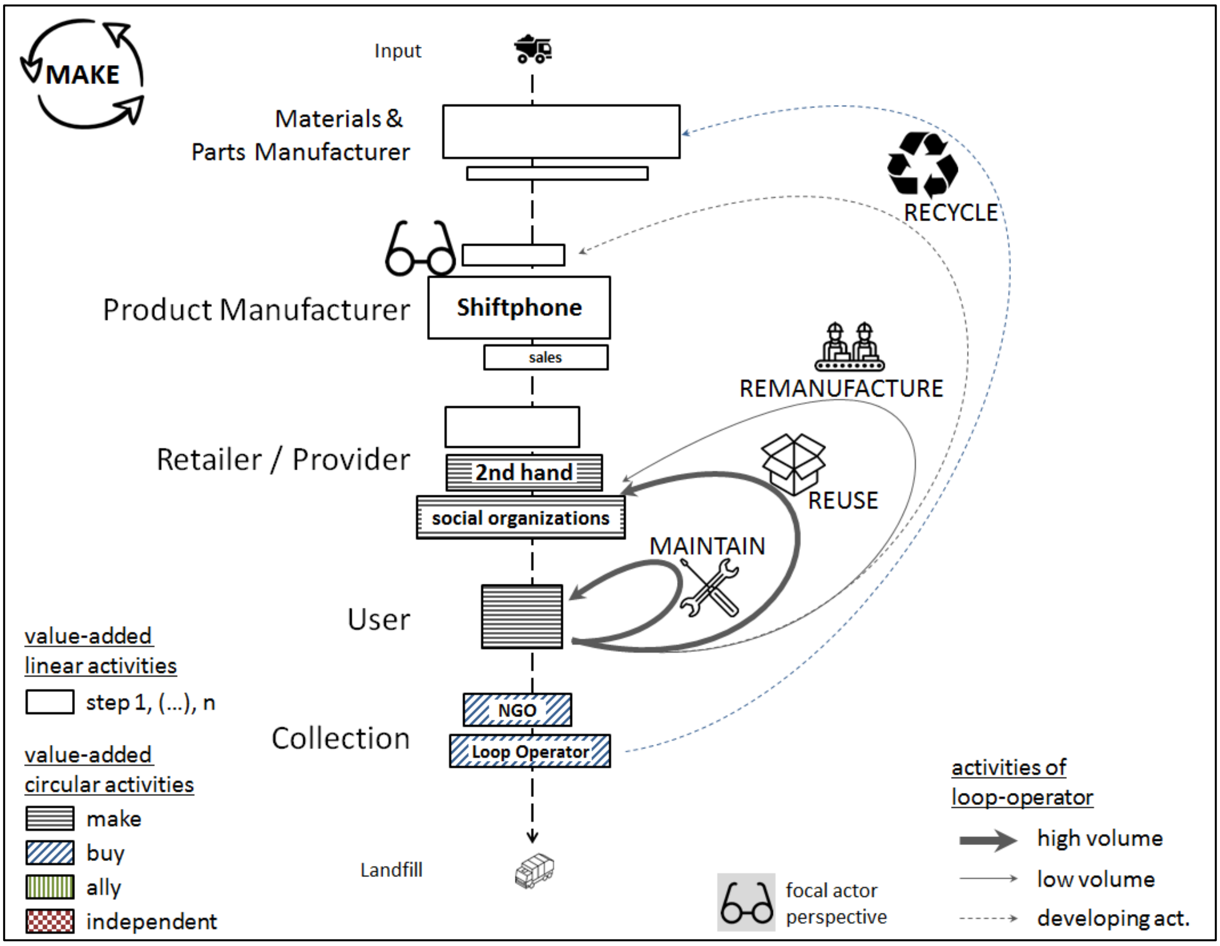

Figure 16: Schematic representation of VCA 1 which is dominated by a "make" solution and coordinated through a smartphone manufacturer

5.1.4 Motivation and value creation

The interview material has revealed that circular activities are not seen as a unique selling point for Shift. Most of the CE-loop operations are available upon request only and no advertising about repair options or take-back possibilities can be observed on the company's website. Generally, many of Shift's additional services are offered as part of their support commitment to their customers. Table 10 summarizes the motivation of Shift.

Table 10: Motivation for closing or slowing CE-loops

Motivation	Details
Intrinsic	Strong intrinsic motivation Protection of natural resources Fair working conditions
Quality-oriented	It is a self-evident logic to offer services regarding CE-loops It is part of the quality approach

A strong intrinsic motivation and customer oriented motivation can be observed. Also a high intrinsic motivation from the company's CEO can be observed regarding the protection of natural resources.

> *"Then we check how can we do it best, in which way do we save most resources, how do we best care best about the environment, how do we care best about people." (SP, 63)*

According to the interview material, Shift closes these CE-loops out of an intuitive and logic integration into their service offerings. Shift emphasizes that it should lie in the nature of a manufacturing company to offer all services necessary to satisfy their customers. Therefore, the approach followed by Shift can be described as quality-driven.

> *"These loops we just did them all intuitively. Without thinking about it before, it just developed by itself. Because we realized: To do it well we have to deal with them." (SP, 13).*

However, no clear business model was developed around these loop activities. Basic support requests are also not charged for and there is no clear pricing available for extended services such as repairs. For example, it is unclear which services are free of charge (e.g. consultation for assistance in repairs) and which services are offered in a cost-covering way.

> *"This [support] we offer for free. One does not need to pay for it. It is a service that we offer. This means we should calculate this in our sales offer." (SP, 55)*

5.1.5 Barriers and future development

The main challenges for Shift are high efforts associated with their offered customer support and maintenance of Shiftphones. Offering a comprehensive maintenance service is complex and time consuming, as users need very specific instructions. Therefore, the service can currently only be offered to customers in Germany. Cooperating with an external loop operator is generally desired by Shift; however, it is associated with potentially high transaction costs (see also subsection 5.4.2).

A promising approach to simplify coordination efforts associated with CE-loops would be to increase modularity, however currently Shift uses standard components for their smartphones in order to decrease costs. Modular components require major development efforts which cannot be achieved alone by such a small manufacturer as Shift.

> *"And this is the real reason why we need modular phones. Which are built in a way, that one [customers] cannot destroy anything. Even when you open it. And this we have not reached yet. R&D would have been too expensive, we would not have managed". (SP, 89)*

Therefore, modularity is seen as a way to reduce service costs that arise from offering CE-loops. This modularity is not required for every component, but for key-component families. Such a modularity would also include simple and practical connectors, both for electronic and mechanic elements.

> *"We believe that we can only manage it, when we have reached modularity, so that everyone can repair it themselves". (SP, 91)*

The case presented is following a vertical integration strategy for circular practices. Shift dominates the VCA and offers circular services, including maintenance and remarketing, as part of their commitment to quality.

5.2 Case II: Closing CE-Loops through Hybrid-Forms of Coordination

This case is characterized through a VCA which includes close cooperation between a focal company in the value chain (telecommunication provider) and a service company for reverse logistics (loop operator). Together they offer two models for collecting used mobile devices. One of them is realized in cooperation with an environmental NGO and aims at public collection of mobile devices. It is designed similar to the take-back system described in VCA 3.1[33]. However, additionally they offer a buy-back program specifically designed for used

33 For more information on the first model which aims at a public collection see also: http://www.handysfuerdieumwelt.de/home/ (accessed on 17.12.2016)

smartphones with higher remarketing-values. This second program is designed for the B2C sector also and subject to analysis in the following chapter.

5.2.1 Involved actors

A large German telecommunication provider, Telekom Deutschland GmbH (Telekom for short), is the focal actor of this value creation architecture because they represent the most visible actor from an end-user perspective. Telekom is representing the business operations in Germany with around 13,000 employees and their brands T-Mobile, Congstar and T-Home[34]. All involved firms and other actors are listed in the Table 11 below.

Four years ago Telekom founded together with Teqport Services GmbH[35], an experienced service provider for take-back process of business IT, a reverse logistics specialist for mobile devices. This was Teqcycle Solutions GmbH (short: Teqcycle) who now manages most of Telekom's return activities for used smartphones in the B2C sector. It is therefore defined as a loop operator in the further analysis. Teqcycle receives around 60% of all collected mobile devices from Telekom. Other operations include activities in take-back of business IT in the B2B sector. They see themselves as a managing authority for Telekom's return processes.

> *"One can say that we are the one who manages processes, logistics and ensures that all security criteria are complied with". (TQ, 3)*

The smartphone-user is also a key actor in this VCA. The buy-back offers provided by Telekom are not limited to their own customers, but purposely opened to the general public.

Another important partner for Telekom is a recycling company, specialized for e-waste recovery. It is located in central Germany and is also affiliated with Telekom through a share-holder relationship[36]. Upcoming WEEE in the system is diverted to this recycling specialist.

> *"We basically work together with a partner close to Göttingen who recycles devices according to the DIN standard. This means that resources and components are recovered where economically feasible and data privacy is guaranteed". (TQ, 71)*

The service offered by Teqcycle and Telekom in this VCA aims at smartphone users who want to sell their used mobile devices and potentially want to upgrade to a newer version. Telekom offers two systems to accommodate this. The first one aims at all smartphone users, regardless their affiliation to Telekom. However, Telekom customers receive a 10% premium when they

34 See also annual report 2015, p. 8: http://www.geschaeftsbericht.telekom.com/site0216/fileadmin/15_AR/PDF_DE/telekom_gb15_gesamt.pdf (accessed on 17.12.2016)
35 See also https://www.teqport.com/ for more information on this founding partner (accessed on 17.12.2016)
36 See also: http://www.electrocycling.de/unternehmen (accessed on 15.12.2016)

choose a voucher option. The buy-back system offers fair prices that are calculated according to the condition of the device[37].

Table 11: Overview of involved actors and their tasks for case II

Actor	Details	Tasks and responsibilities
Focal actor	Telecommunication provider, for some activities also manufacturers	Contracting authority, mostly communication with end-user
Loop operator	Reverse logistics specialist	Process management, logistics, data deletion and valuation
User	All smartphone users in Germany	Smartphone users can sell-back their used device and receive cash or a Telekom voucher
Further partners	Disassembly and recycling company	Processing of devices in the "recycling loop"

The second model offered in cooperation with Teqcycle is related to Telekom's brand Congstar which aims at younger customers. Here the customers have the option to swap their smartphone every 12 months, however, only if they sell back their old device[38]. All required processes for this service are also managed by Teqcycle in the background.

5.2.2 Factors influencing the make-or-buy decision

This section is looking conceptually at the underlying factors that influenced Telekom in their make-or-buy decision regarding closing loops for mobile devices. However, the analysis of these influencing factors is based on the perspective of Teqcycle as a loop operator.

Table 12: Classical influencing factors on transaction costs for case II

Influencing factors	Type	Case characteristic
Specificity	Site specificity	Specialized site for processing returned devices
	Physical asset specificity	Specific investments in tools for: data deletion, repair/refurbish activities
	Human asset specificity	Loop operator is reverse logistics specialist, low qualification compared to core workforce at Telekom
Uncertainty	Agreement adjustment	Long-term agreements, but organic development of future products and services
	Volume, change in quality	Fast growing market, high potential, currently niche market, loop operator employs flexible work force
Frequency	Economies of scale	High fix costs for assets, capacities for higher volumes

37 See also: https://www.telekom.de/hilfe/geraete-zubehoer/handyankauf and https://telekom-online-takeback.teqcycle.com/ (both accessed on 17.12.2016)

38 See also https://www.congstar.de/handys/handytausch-option/ for more information (accessed on 17.12.2016).

On basis of the interview with Teqcycle and participation in a site visit it can be concluded that the offering requires very specific assets. These include a "production" site where returned mobile devices are processed efficiently. In addition, Teqcycle uses specialized tools for required testing, data deletion and refurbishing activities. Although, the work force necessary to process returned mobile devices do not need a high qualification, they do need a different qualification than for example a Telekom sales team. This includes specific experience to correctly assess the market value of used smartphones (see also section 5.2.3).

From the perspective of Telekom, taking back used mobile phones is not only a rather new activity but also a contrary one to selling mobile devices. It therefore includes considerable uncertainties, such as its acceptance in the market. Telekom does not have the flexibility to change their business model; therefore, the engagement in CE-loops is reached through the employment of a loop operator. Uncertainties in the contractual relationship between Telekom and Teqcycle are reduced through a long term and partner-like relationship.

> *"We are what a big firm cannot manage: A big firm equals a huge tanker. They have their business and the tanker runs straight ahead and probably is very successful. But you cannot tell this tanker: tomorrow you have to do the opposite and run in a different direction". (TQ, 63)*

Additionally, Telekom could save considerable amounts of money through externalizing processes related to reverse logistics.

> *"We help Telekom by providing processes that they could do themselves, but it would be much more expensive and cost intensive if they would do it themselves". (TQ, 49)*

> *"Telekom has saved 3.5 Million EUR compared to old and own processes in the last year. This is actually a useful decision to outsource such things". (TQ, 51)*

In addition to these classic influencing factors, further factors can be taken into account when assessing a make-or-buy decision. In the beginning of their collaboration an exclusivity-contract between Telekom and the loop operator was agreed upon. Although this exclusivity is no longer valid, Telekom is still one of the most important customers of Teqcycle. As already mentioned, Teqcycle is an affiliated company and 20% of their shares are held by Telekom. This increases influence and encourages long term relationships.

> *"Telekom is an investor in our company and holds 20% of our shares". (TQ, 25)*

This long term relationship can also be observed in the close cooperation between Teqcycle and Telekom to develop further activities and business models for taking back discarded mobile devices. The idea to buy back used smartphones emerged out of the first project of a public collection campaign.

As part of this work [public collection of mobile phones] the idea was further developed to also buy-back mobile phones. For this we also cooperated with Telekom intensively, also. (TQ, 3)

According to Teqcycle, strategic considerations are another important factor for Telekom to externalize their loop operations. Currently the service of offering a take-back scheme for mobile devices can be considered as a secondary activity. From Telekom's point of view, it is not relevant for the further development of their core business activities.

"And this [take-back processes] is a typical marginal issue; it never has the importance within Telekom to operate this economically". (TQ, 51)

"This is not their core business. Their core business is to sell telephone connections". (TQ, 53)

The dominant coordination form observed in this VCA is thus similar to a *hybrid or ally coordination* (see Figure 17 below).

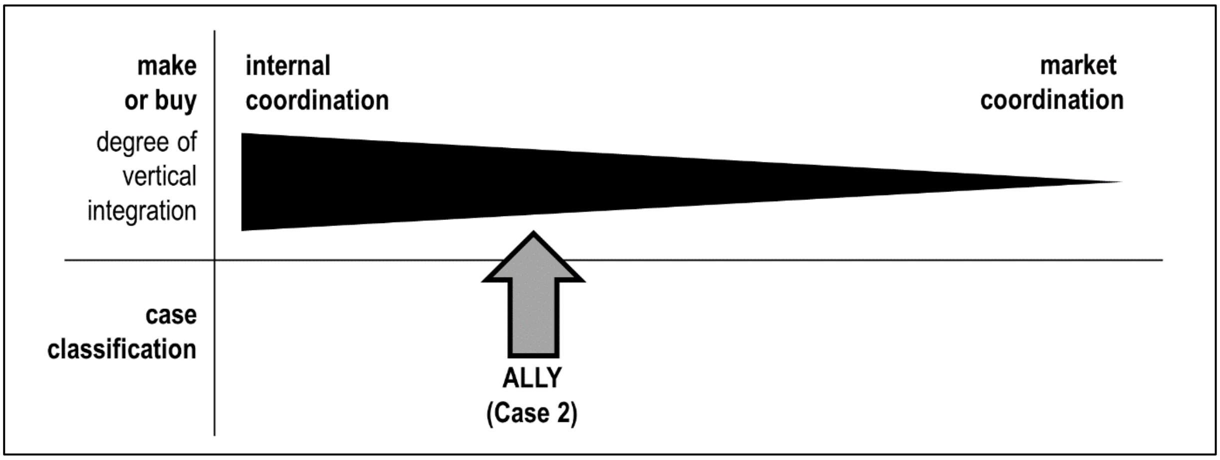

Figure 17: Classification of Case II in Williamson's coordination types

5.2.3 Addressed circular economy loops

From the perspective of a circular economy it is important to note, that through the close cooperation between Telekom and Teqcycle higher-order loops such as reuse can be operated. For Teqcycle it is also economically desirable to buy back used smartphones, because it includes considerably higher margins than solely managing material recycling activities.

Once customers have decided to sell-back their old smartphones through one of the provided platforms all devices reach the reverse logistics facilities of Teqcycle. The loop operator runs their own facility with 5-10 employees for these return processes in southern Germany. The following valuation and refurbishing process are shown in Figure 18 below.

In the first step, all mobile devices go through an accurate valuation process. If it is economically feasible to resell the device, it is either refurbished or directly sent to a data deletion station (forensic data deletion). The process of thoroughly deleting all personal data from the previous owner is a unique selling point of Teqcycle. Afterwards the smartphone is prepared for its second use-phase.

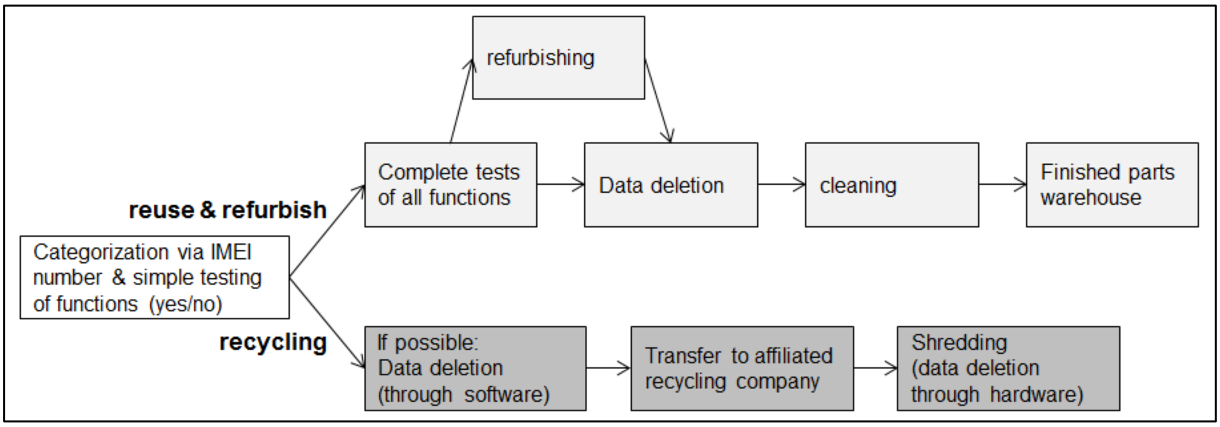

Figure 18: Loop operator's process for choosing the right loop for each mobile device

If a reuse of this particular mobile device is not economically viable (because it is out of date or damaged) all data is deleted nonetheless. If no software based data deletion is possible then a data deletion is guaranteed through a certified shredding process.

Through this multi-stage valuation process an optimal recovery of inherent values from an economic and ecological standpoint is reached.

> *"This [valuation process] requires very individual and detailed considerations. This means that we have appropriate systems for that". (TQ, 83)*

> *"The process works like that. The device is first connected [to our system], then all functions are checked. Then all components are checked. Then the device is going through a data deletion and finally the device is refurbished in a first step. But this just consists of polishing and a minimal appreciation". (TQ, 83)*

The valuation of smartphones requires significant market knowledge. This is because in the second-hand smartphone market, some defects are more vital than others. Display cracks are for example an exclusion criterion, whereas scratches are acceptable. This knowledge of defects on the market-value of smartphones heavily relies on the experienced sales team from Teqcycle who developed their industry-experience through their long-standing activities in this field.

> *"When a certain device is appearing in this process, for which our sales people made the experience that it can be sold better, if for example the flashlight is functioning. But*

the flashlight is not functioning. Then the process is stopped and the device taken out for repairs". (TQ, 83)

Table 13: Contribution of Case II to closing or slowing resource loops of a CE

CE-Loop	Priority	Condition of mobile devices	Handling process	Whereabouts
Reuse	first	Good condition	Data deletion, cleaning	Batch-sale to B2B customers
Refurbish	second	Minor hardware defects: e.g. screen, battery, scratches, minor component defects	Depends on: level of wearing, economic considerations, spare parts availability	In-house refurbishing section
Recycle	third	Major hardware defects, no data deletion possible	Disassembling valuable components, shredding	Handover to affiliated recycling company

As mentioned above, the main goal of this VCA is to addresses the reuse loop for mobile devices, in particular smartphones (see Table 13 above). To increase the margin, smartphones are treated thoroughly and restored where necessary and economically feasible. This also means that for heavy defects, which also influence the market value considerably, a refurbishing process was implemented. Refurbishing in this context refers to a process that includes repairs in such a way, that they can be sold as A-grade devices. The interview partner underlined, however, that considerable differences can be observed in the repairability of different smartphone brands (also see subsection 5.2.5).

"Refurbish means to recondition a device in that way that it can be resold as A-quality". (TQ, 33)

Finally, the remarketing process of smartphones is realized through batch-sales to B2B customers, who sell these devices in second-hand markets all over the world. An in-house auctioning platform is used to sell these batches to approved retailers only. This should prevent illegal exportation of second-hand mobile devices in developing countries. This risk is also minimized thorough the sale of high-value devices (e.g. smartphones), which have a considerably higher use value than their inherent material value.

"This means that we carry out on-site visits. We perform random checks in order to check if everyone complies with the rules. Everyone who buys our products has to sign that he is not doing it [illegal exportation]". (TQ, 35)

Interestingly some devices are also sold with considerable defects to Chinese companies, who can refurbish them in China with considerable lower labor costs.

"This can also be a trading partner in China who refurbishes these devices locally, because it is cheaper as in Germany, and then resells them". (TQ, 35)

The reuse value of some devices, however, is too low for remarketing and in some cases an obligatory software-based data deletion is not possible. In these cases, a small share is sent to Electrocycling GmbH for material recycling.

Generally, the valuation process for the loop-decision can therefore be understood as complex, due to the various options that need to be considered. It requires considerable experience with the market and logistic capabilities. This knowledge enables Teqcycle to operate the reuse loop with high volumes (see also Figure 19 below).

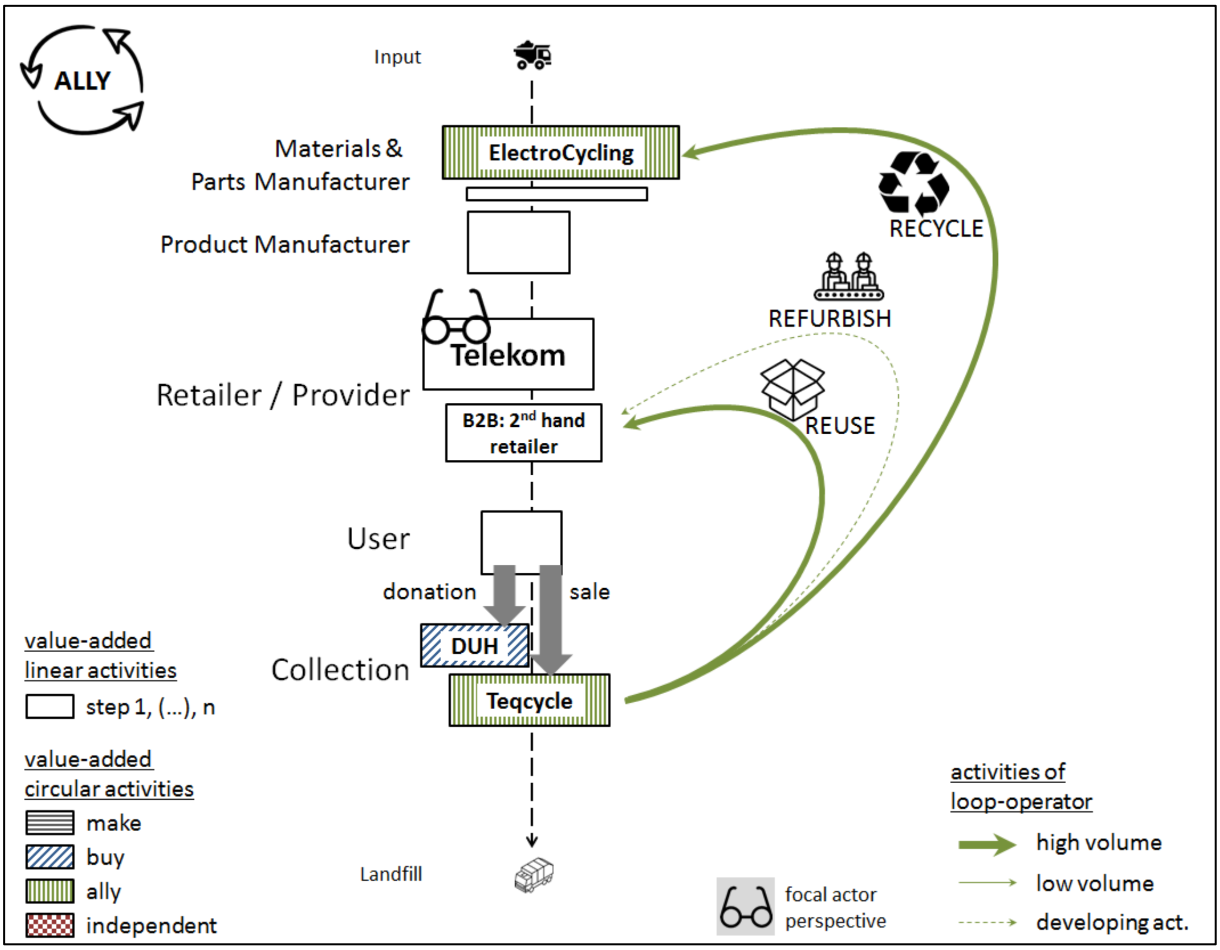

Figure 19: Schematic representation of VCA 2 which is based on an “ally” relationship between the focal actor and their loop operators

5.2.4 Motivation and value creation

According to the interview with Teqcycle the motivations for Telekom to engage in these circular activities are numerous. Telekom and Teqcycle originally operated together a similar system than observed in VCA 3. It was designed for the public collection of discarded mobile devices. This original project was a measure to increase Telekom’s social responsibility and thus their public image.

"It also has to do with their image. Such a big company, they have somewhat 40 million customers, and then you need to cover this subject". (TQ, 17)

Nevertheless, engaging in circular activities also provides other benefits such as customer awareness and increased customer traffic in Telekom stores. But also it increases customer retention through an incentive to buy a new phone. Trading in an old phone can reduce the sales price of the new phone considerably, which makes it a perfect sales argument for the salesman and therefore a major motivation for Telekom to engage in circular practices is to boost sales of new smartphones.

"For Telekom we now do both, fulfill legal compliances and boost business". (TQ, 43)

An evolution of their motivation and business model can be observed parallel to the further development of their circular economy practices. In the beginning it was mostly CSR-driven, similarly to VCA 3, however, now it is also driven from an economic perspective to boost sales. This makes Telekom's and Teqcycle's partnership more robust as a continuously profitable business model was developed.

Teqcycle's business models are designed in a way that normally the principal (e.g. Telekom) receives a provision for each smartphone. This provision is something around 10% of the buy-back price of the smartphone. Teqcycle in turn makes its margin out of the difference between buy-back price and remarketing price, less operating costs (reverse logistics, data deletion and refurbishing).

"In these full packages [which include buy-back], it is typical that our customer receives a financial offer from us". (TQ, 79)

5.2.5 Barriers and future development

In the future, a growing market for second-hand smartphones is expected, not only in emerging markets, but also in Europe. Therefore, Teqcycle wants to further develop their engagement with Telekom, but also with other national telecommunication providers in order to find ways to increase total take-back volumes.

"But it will never be their core business. For this the market must fundamentally change". (TQ, 55)

Teqcycle does not expect that telecommunication providers are going to take over these loop activities in the future. Therefore, they want to further develop their engagement with telecommunication providers with the goal of setting up a more automated process of take-back in order to increase collection rates (similar to the one offered by Congstar). A promising approach for this is to link the sales of new smartphones with a buy-back option. For this, a closer collaboration between Telekom and Teqcycle is necessary. In a first step this model is tested in the B2B environment.

> *“The salesman offers his Telekom-package and then also says: Oh by the way I can also get you some money for your old device”. (TQ, 81)*

Some major challenges for Teqcycle, and thus also for Telekom, are low collection rates for mobile devices and associated low capacity utilization. According to the interview partner this requires patience, because changing the customers’ behavior requires time. Teqcycle and Telekom must convince smartphone users through financially attractive offers and transparency.

> *“It is difficult to collect enough stuff. Selling it is no problem at all”. (TQ, 115)*

> *“For this you need patience. We need the patience until humanity realized that resources are lost forever”. (TQ, 105)*

Another major barrier that is conceived especially by Teqcycle are complex repair processes and non-availability of necessary spare parts for some smartphone models. For their activities regarding repairing and refurbishing smartphones Teqcycle must fully rely on their experience gained through “learning by doing”, as official repair manuals are missing. This is preventing Teqcycle as a loop operator from further developing their refurbishing loop through which they could increase their reuse rates for smartphones.

> *“For some [models] it is not worth it, and for some it is just not possible”. (TQ, 85)*

This second case is thus characterized by a close cooperation between focal actor and loop operator and an engagement in multiple CE-loops.

5.3 Case III: Engaging a Service Provider to Close CE-Loops

This third VCA is based on the voluntary collection of discarded mobile devices from end-users on behalf of a large telecommunication provider. It is analyzed from the perspective of AfB gGmbH who acts as a loop operator for collecting mobile devices in the B2C sector. The legal basis for this voluntary collection through third parties is given in §12 ElektroG (see also chapter 2.3).

5.3.1 Involved actors

This value creation architecture consists of a number of actors, each having their own role and tasks. An overview of the most important actors is given in Table 14.

Telefónica Deutschland Holding AG (short: Telefonica) is one of the largest telecommunication providers in Germany. They represent the most visible actor in this VCA and can therefore be described as the focal actor.

AfB gGmbH can be described as a service company for reverse IT logistics which is situated at the end of the value chain with a main focus on processing post-consumer electronic devices. With a total of 260 employees and 12 years of experience their main offers include data deletion and remanufacturing processes for business IT (B2B). They also operate retail stores for used IT products in many German cities. In the B2C sector, AfB cooperates together with Telefonica for collecting and processing discarded privately owned mobile devices at about 600 locations (e.g. mobile phones, smartphones and tablets). This activity was developed upon request and exclusively for Telefonica and is subject of analysis in this chapter.

AfB and Telefonica teamed up with NABU a large German NGO from the environmental sector in order to increase legitimacy for their collection activities from an end-user's perspective. NABU is responsible for communication with end-customers and public relations. This NGO is a key partner which is situated between AfB and the user along the value chain. For end-users the incentive to bring their mobile device to collection is given through the cooperation with NABU.

Other partners are recycling companies, in this case Belgium based *umicore S.A*. Mobile phones dedicated for the recycling loop are shredded in-house at AfB in order to guarantee data deletion. This shredded material is brought to an umicore recycling plant in Belgium without use of an intermediary.

Table 14: Overview of involved actors and their tasks for case III

Actor	Details	Tasks and responsibilities
Focal actor	Telecommunication provider	Internal coordination, marketing, provision of staff
Loop operator	Reverse logistics specialist	Logistics, data deletion and valuation of collected mobile devices
Further partners	- NGO - recycling plant	- Communication, increase credibility - Process shredded mobile devices

Mobile phone users can hand in their discarded devices at collection points within Telefonica's retail stores. These collection points are labeled and linked with the activities of the environmental NGO.

AfB as a loop operator ensures a responsible recovery according to the principles of a CE. The loop operator's main role is the provision of return logistics which includes the installation of return boxes in-store; pick-up services through a parcel service; sorting and valuation of mobile devices and preparation of recycling or reuses processes. Similar to the previously discussed VCA, a certified data deletion process is crucial for the collection and reuse of smartphones.

The role of the NGO is diverse. Most importantly they are responsible for the communication with end-users and create attention and awareness for the possibility of returning mobile devices. Additionally, the NGO can easily communicate environmental topics through its trustworthiness as a NGO in the environmental sector. In return Telefonica donates 1.60€ for each mobile phone collected to this NGO for the support of an environmental project[39].

Most mobile devices collected through this scheme are further processed in the recycling loop (see also section 5.3.3). AfB calculates to make a profit through offsetting logistic costs with earnings from reuse and inherent material values of mobile devices. However, reliable data is not available so far (see also section 5.3.4).

The entire collection process is also described in detail in the following Figure 20 on page 59[40].

5.3.2 Factors influencing the make-or-buy decision

The partnership between AfB as a loop operator and Telefonica as focal actor in the value chain is based on the agreement that AfB is provisioned as the only firm in Germany to collect mobile devices for Telefonica. Telefonica is utilizing AfB's return network, infrastructure, knowledge and experience in collecting mobile devices. Therefore, AfB can be characterized further as an external service provider and loop operator.

> *"Our customer, our principal is Telefonica Germany. They told me or have commissioned and qualified our organization as the only one in Germany to collect mobile phones in Germany. This is my customer". (AF, 16)*

According to the interview material, the relationship is based on long-term contracts. Both, AfB and Telefonica cooperate closely to offer their return services and within the VCA each actor is responsible for their own specialized area. Telefonica is also supporting this VCA through internal provision of personnel and strategically through a participation of the sustainability department.

39 For more information on the NABU environmental protection projects supported through the collection of mobile phones see: https://www.nabu.de/umwelt-und-ressourcen/aktionen-und-projekte/alte-handys-fuer-die-havel/ and https://www.nabu.de/umwelt-und-ressourcen/aktionen-und-projekte/alte-handys-fuer-die-havel/19366.html (accessed on 01.11.2016)

40 This diagram represents an offer of Telefonica Germany for their business customers. It displays a take-back service that Telefonica offers for philanthropic activities at their customers location. Nevertheless, the system is the same for B2C collection at stores owned by Telefonica Germany.
Source: https://www.o2online.de/assets/blobs/business/pdf/handyrecycling-prozess-business-englisch-pdf/ (accessed on 15.11.2016)

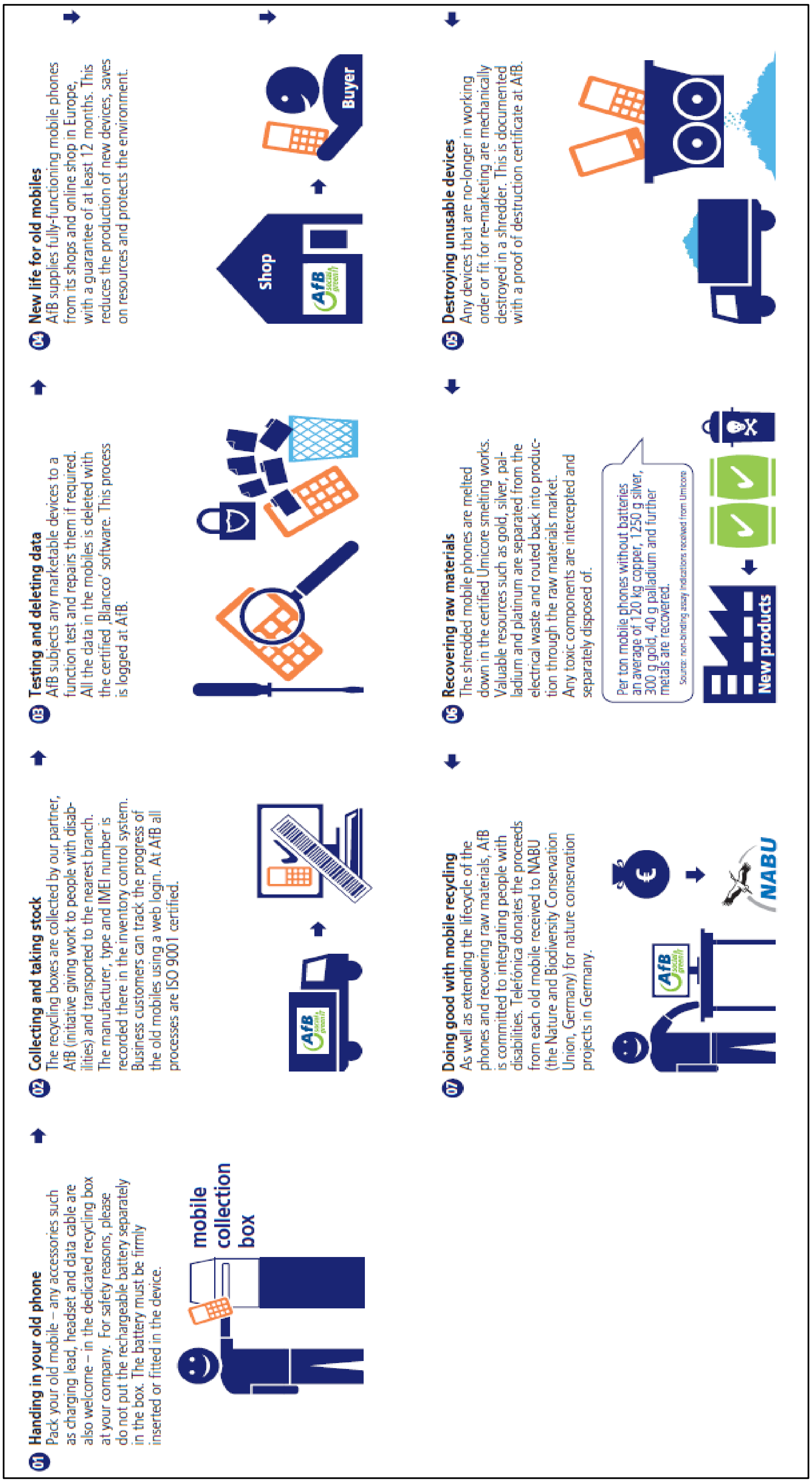

Figure 20: Representation of take-back process for discarded mobile phones (extracted from corporate website of Telefonica). Source: See footnote 39 on page 58.

Therefore, it can be concluded that Telefonica has not fully outsourced their loop operations, but remains some areas of activity. This indicates a hybrid coordination form.

> *"But I can tell you, in the background they go all hands in. You really have to say, they have commissioned one person who is working full-time on this subject. Wages and salaries […] Telefonica supports in many ways". (AF, 28)*

Nevertheless, Telefonica's main business remains in selling mobile phones and corresponding network access. Collection of mobile phones is a secondary activity, and therefore partly outsourced. This is a strategic decision of Telefonica which is based on their general spirit and goals. It is expected that this influence the make-or-buy decision strongly.

In general, the relationship between AfB and Telefonica can be characterized as fair and based on partnership. Due to AfB's experience in collecting discarded IT, they are an optimal partner for Telefonica to reduce their costs related to such take-back schemes.

> *"We would not have been involved in this market, the collection of mobile phones, it would not be our market. We are specialized on corporate IT". (AF, 50)*

> *"There are process costs of course, which we have halved on this basis of these quantities, we had to simplify this process. And in this way we can offer it free of charge for our end-customer and for Telefonica eventually". (AF, 26)*

Because an environmental NGO is also part of this VCA to communicate that end-users should return their discarded mobile devices. This also indicates also that engaging in circular activities is an activity with high asset specificity.

In conclusion, the partnership between Telefonica as a focal actor and AfB as a loop operator can be characterized as a hybrid form of coordination, because of long-term contracts, close partnership and exclusivity agreements. However, in comparison to case two it is positioned slightly right towards market based coordination because of a missing equity investment. The positioning along Williamson's continuum is shown in Figure 21.

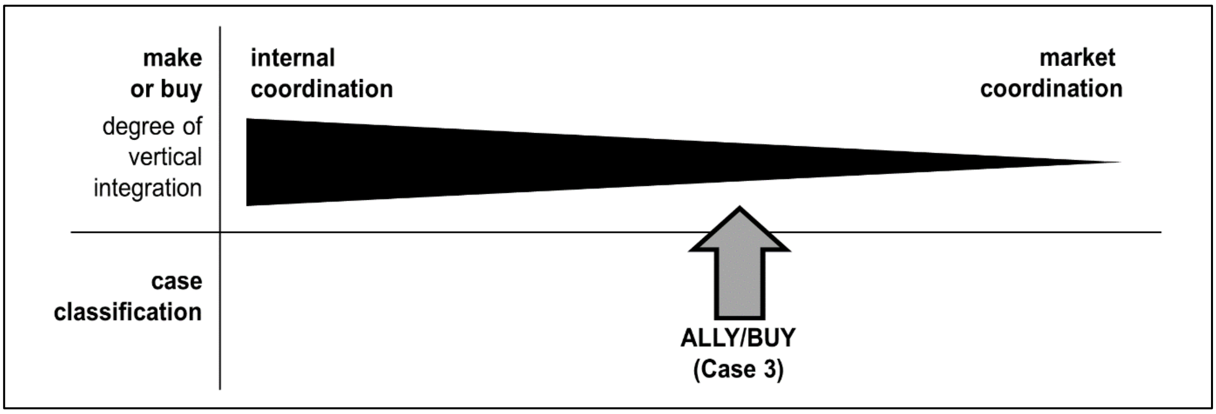

Figure 21: Classification of Case III in Williamson's coordination types

5.3.3 Addressed CE-loops

In 2015 the consortium of Telefonica, AfB and NABU collected around 46,000 phones[41]. This is around one sixth of AfBs total volume of processed IT[42]. Once a phone reaches the AfB collection centers there are two options for AfB to proceed with the collected mobile devices (see also Figure 20).

If the mobile device's value is too low for remarketing (e.g. Nokia 6210, broken smartphone), or if no software-based data deletion is possible it is mechanically destroyed and recycled. Due to the primary collection in shops, around 95% of all mobile devices are currently valued too low for reuse. In order to guarantee the data deletion process, AfB sends these devices into a shredder (without battery). Shredded material is thereafter delivered to a recycling plant of umicore S.A.

> *"It means that currently we are collecting most devices out of draws, they are donated. […] Of course we try to further develop, because we have experiences from the B2B business". (AF, 22)*

Mobile devices with a higher re-use value (e.g. most functioning smartphones) are remarketed in AfB-owned online or offline shops. However, more valuable smartphones are currently underrepresented, probably because users know of their value and do not throw them into collection boxes. Therefore, this section corresponds to roughly 5% of collected devices only. These phones go through a software based data deletion process and are afterwards sold in secondary markets. AfB operates 17 shops in Germany where all of their second-hand devices are sold. Generally, AfB offers full transparency for their processes and guarantees no exportation of electronics outside the EU.

AfB has an interest in collection a bigger share of mobile devices with a higher reuse value, because their business model is based on the resale of smartphones and other IT devices. Therefore, AfB currently also develops in-house refurbishing activities in order to increase remarketing shares. Refurbishing is actually AfB's key competence in other IT markets (e.g. with Futjisu). However, AfB faces similar challenges to Teqcycle regarding the upscaling of refurbished smartphones (see also chapter 5.2).

Figure 22 again summarizes this VCA in a schematic way. It shows the consortium of Telefonica/AfB as an ally partnership that currently mainly operates a system to close the recycling loop for older mobile devices.

41 According to CSR-Report of Telefonica Germany (Telefónica Deutschland 2015, 43)

42 Total volume in 2015 was 267,000 devices http://www.afb-group.de/de/unternehmen/wir-ueber-uns (accessed on 02.11.2016).

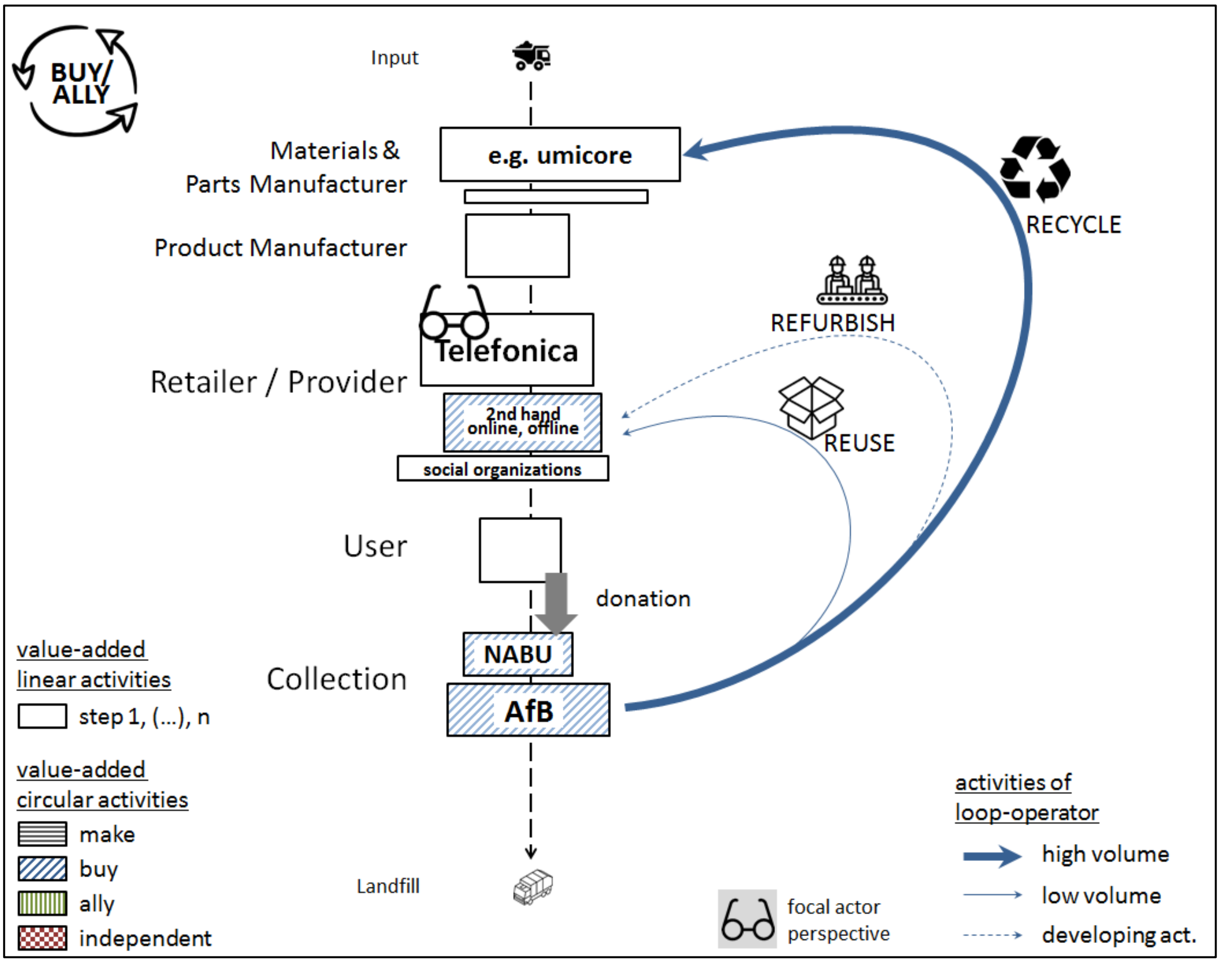

Figure 22: Schematic representation of VCA 3 which is based on an “ally/buy” relationship between the focal actor and their loop operators.

5.3.4 Motivation and value creation

Telefonica is only legally obliged to participate in the take-back model described in case 4. However, the set-up analyzed in this chapter is beneficial for two reasons.

- Credits towards Telefonica’s EAR[43] quota
- Publicly effective CSR activity

Since Telefonica collects additional quantities of WEEE through the set-up described in this VCA, Telefonica can count these towards its EAR quota (see also case 4). The EAR quota is calculated throughout all sold devices by Telefonica and represents also Telefonica’s collection quota. This could potentially decrease their costs, because AfB cross-finances the collection through the resale of still functioning devices. Additionally, Telefonica could develop a publicly effective CSR activity from the described VCA. Telefonica can advertise with the name of an environmental NGO and highlight its positive measures.

43 National Register for Waste Electric Equipment (EAR). See also VCA 4 in the next chapter.

AfB's motivation is to develop a profitable business model for take-back schemes for ICT products. The interview material suggests that they mainly engage in a market development at the end of the value chain, e.g. in second-hand ICT products as AfB's core value propositions are reverse logistics, valuation processes and certified data deletion processes.

The revenue model which is applied in this VCA can be described as a "freemium" model. The service offered by AfB is aimed to be free of charge for Telefonica as it can ideally be cross-financed through remarketing of functioning devices (although this fraction corresponds to 5% only). This is because margins from remarketing mobile devices in the second-hand market are considerably higher than pure material value gained through the recycling process with a partner company. It is unclear whether AfB already reached the breakeven point, as reliable data is not yet available. However, in the future collection rates for mobile devices with a reuse value are expected to increase.

5.3.5 Barriers and future development

Future development from the perspective of AfB as a loop operator is two-fold:

1) intensifying current loops,
2) developing additional loops.

A major barrier for AfB is the generally low collection rates for mobile devices (see also chapter 2.2). AfB needs to increase their processing volumes due to economies of scale decreasing processing costs per unit. Therefore, they want to increase collection rates and volumes together with Telefonica, but also with other partners. The interview material stresses that it is very difficult to motivate end-users to bring back their discarded mobile devices. This sentiment is also confirmed by an industry expert in VCA 4. One promising option is to collect unused devices directly through sales partners of Telefonica. Ideally, the end-user is motivated to give back their old mobile device at the point of sales.

> *"To reach end-consumers and raise awareness by saying give back your old device, it is a long and hard path". (AF, 24)*

Additionally, AfB wants to further develop higher order CE-loops to increase their profitability. Their business model would become significantly more efficient if reuse and refurbishing activities could be increased because higher margins can be achieved. There is sufficient market potential for used mobile devices in Europe alone. This is why AfB is trying to increase collection rates of valuable mobile phones (e.g. smartphones) that can be sold in the second-hand market.

> *"Of course we are very much motivated to put every device through its paces. And so that it can afterwards end up as remarketable device, not in recycling". (AF, 28)*

AfB sees their influence at the end of the value chain and wants to extend their business activities in this area. However, refurbishment activities are related to some challenges in particular. Two main barriers related to the refurbishing loop are mentioned in the interview material. Firstly, a main barrier is the limited availability of spare parts for some smartphone models. In many cases it is very difficult for AfB to obtain spare parts in a sufficient quality and at a reasonable pricing. As a work-around AfB is currently establishing an in-house loop of used spare parts.

> *"Spare parts do exist; they are just very expensive and are also rare. […] But: 'make one out of two'". (AF, 66)*

In summary this third case also represents a hybrid coordination between focal actor and loop operator with the aim to develop further loop activities.

5.4 Case IV: The Legal Case

This fourth VCA can be described as the legal case as it represents the German implementation of the Waste Electrical and Electronic Equipment directive from the European Commission (WEEE). Apart from legal (ElektroG 2015) and other official documents an industry expert who is part of the INaS network provided crucial insights in this VCA.

5.4.1 Involved actors

This take-back scheme is based on the German ElektroG law, which regulates the take-back of WEEE in Germany (see Chapter 2.3.4 for more details). A graphical representation of this scheme which includes an exemplary recycling company is given in Figure 23 the involved actors are summarized in Table 15 below.

Table 15: Overview of involved actors and their tasks for case IV

Actor	Details	Tasks and responsibilities
Focal actor	Distributing company (manufacturers, in some cases also retailers)	Commission and pay for assigned WEEE container
Loop operator	EAR, örE, reverse logistics specialist	Collection, calculation of take-back quota
Further partners	Recycling company	Process devices and separate different material fractions

Every distributing company (includes manufacturers, in some cases also retailers, etc.) is registered at the EAR (National Register for Waste Electric Equipment) and automatically reports its sales data (in line with: §31, Abs. 5 ElektroG 2015). The EAR is a privately organized institution that coordinates the take-back process in cooperation with public waste disposal authorities (örE) and the Federal Environmental Agency (UBA)[44]. It is funded through a membership fee which is paid by all distributing companies who are active in Germany (service fee).

> *"The allocation when a container is collected by whom, is managed by sales volume, according to market shares. There is no other way, because they never know where things are". (exp_1, 88)*

The end-user can bring discarded (mobile) devices to any örE free of charge. At the örE the devices are sorted by type and are temporary stored. The örE then reports a full container (e.g. of ICT devices) to the ear, who in turn assigns the container to a distributing company or producer (according to the previously calculated take-back quota). The distributing company then commissions a recycling company (e.g. Remondis) to pick up and process the devices. The recycling company conducts a contract with the producer which covers the collection and treatment costs.

All occurring costs regarding the collection and treatment of WEEE are distributed between all registered EAR partners according to previously reported sales data (recycling costs). To do this, an individual take-back quota is calculated for every distributing company. To fulfill this take-back quota, distributing companies can additionally offer privately organized take-back schemes (see VCA 3)[45].

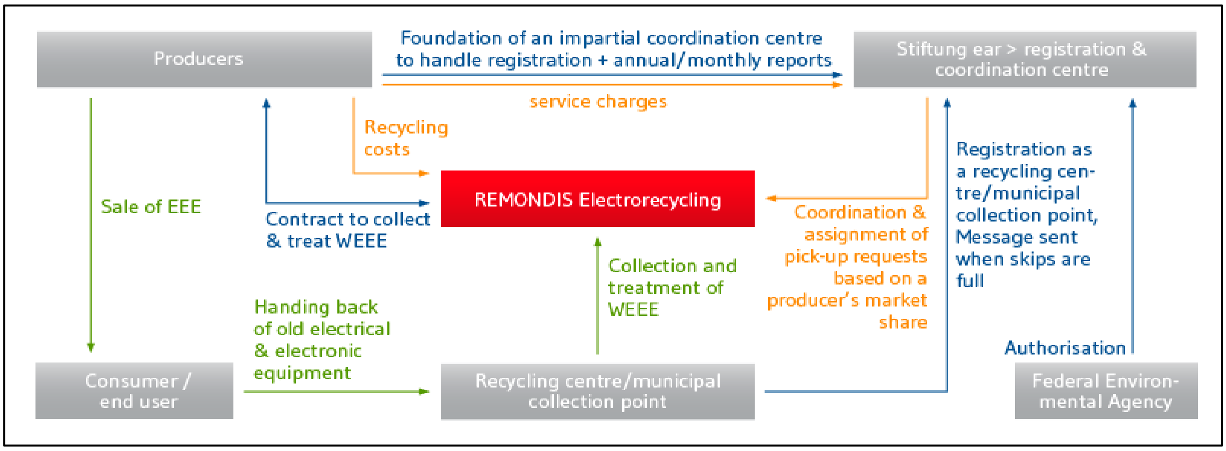

Figure 23: Schematic representation of the take-back system for WEEE coordinated through the EAR on basis of ElektroG in Germany[46]

44 EAR is the national register for waste electric equipment in Germany (Elektro-Altgeräte Register). Their landing page quotes: "The national register for waste electric equipment (stiftung ear) was founded by producers as their Clearing House (Gemeinsame Stelle) for the purposes of the Electrical and Electronic Equipment Act (ElektroG). Entrusted with sovereign rights by the Federal Environment Agency (UBA), stiftung EAR registers the producers of electrical and electronic equipment and coordinates the provision of containers and the pick-up of electrical and electronic waste equipment at the örE (public waste disposal authorities) in the whole of the Federal Republic of Germany (BRD)." https://www.stiftung-ear.de/en/ (accessed on 02.11.2016).

45 In this case "distributing companies" can either hand in collected devices at their local örE (public collection centers) or also commission a third party (e.g. loop operator) (§12 & §13, ElktroG). See also chapter 5.1.

46 Source: http://www.remondis-electrorecycling.de/uploads/tx_3sresponsiveslideshow/umsetzung_grafik_umsetzung_1_en.png (accessed on 05.11.2016)

5.4.2 Factors influencing the make-or-buy decision

The above described system is very efficient for collecting consumer devices in the B2C sector. It is a rather highly regulated collection scheme which is coordinated through a clearing house that is commissioned by the industry. It is therefore tailored to the requirements of the involved (focal) actors.

> *"This is a regulatory interference, not governmental. […] The [ear clearing house] is solely managed by manufacturers. […] And also payed for". (exp_1, 72)*

Due to the highly regulated collection scheme with clear responsibilities and duties for distributing companies, it involves little uncertainty for distributing companies. It is an industry wide system that was commonly developed and makes individual solutions obsolete. Additionally, it can be assumed that the required asset specificity to provide the above described offer is relatively low. This is because already existing infrastructure is used which includes for example public waste authorities (örE) and recycling companies (e.g. remondis, umicore).

Other factors such as strategic considerations are not relevant because of the legal binding nature of this model.

The standardization efforts reduce transaction costs considerably. Therefore, this "legal" take-back scheme is categorized as a strong "buy" coordination by focal actors (see Figure 24 below). This could also be observed in the field because distributing companies (e.g. producers) conclude contracts directly with the recycling company to collect and treat WEEE. These contracts come about on a short term basis (whenever a producer is required to take back a full container).

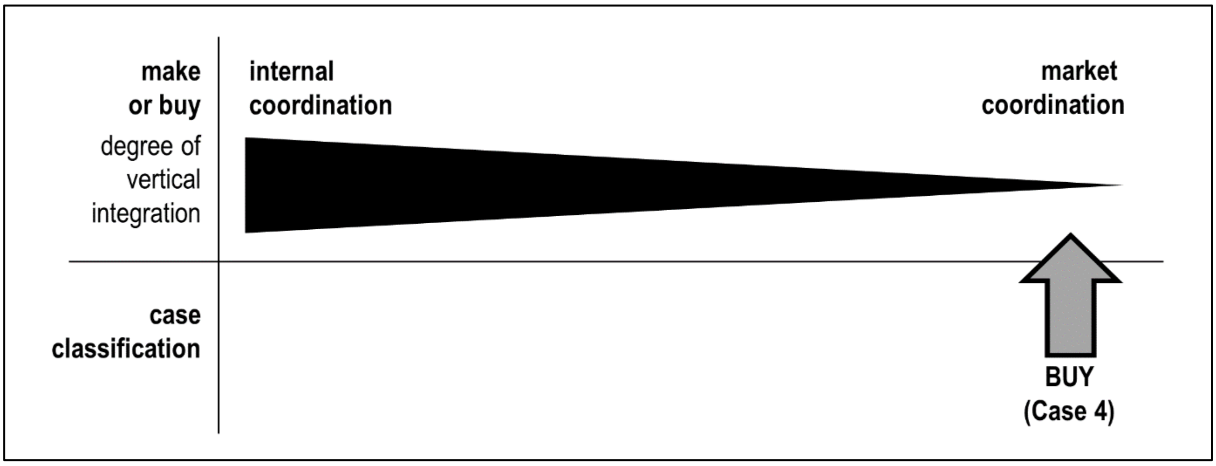

Figure 24: Classification of Case IV in Williamson's coordination types

5.4.3 Addressed CE-loops

Although this collection scheme is very efficient, it is not very effective concerning a circular economy perspective for two reasons. Firstly, overall collection rates for WEEE for this system are low. Secondly, it only addresses the recycling loop as no devices collected through this scheme are processed in a more valuable loop.

Table 16: Contribution of Case IV to closing the loops of a CE

CE-Loop	Contribution to CE-loops	Collection type
Recycle	Collected ICT devices are processed through specialized recycling companies on a material basis only	Bring-in collection through end-users

It is especially important to note, that no devices collected through this scheme are processed in the reuse loop. This is a constraint that is built into the system due to practical or strategical reasons of the industry or the legislator. This, however remains unknown to the author at this time.

> *"At this point, when it comes from public collection, then nothing is going into reuse or remarketing. Everything is going into recycling". (exp_1, 44)*

The resulting VCA is shown in Figure 26 below. It summarizes the legal case as a coordination model that is characterized through a "buy" relationship between focal actors and loop operators. The clearing house (EAR) acts as a loop operator together with the recycling companies (e.g. remondis). They are commissioned to feed collected mobile devices into the recycling loop on behalf of the focal actor, who may be a producer or retailer.

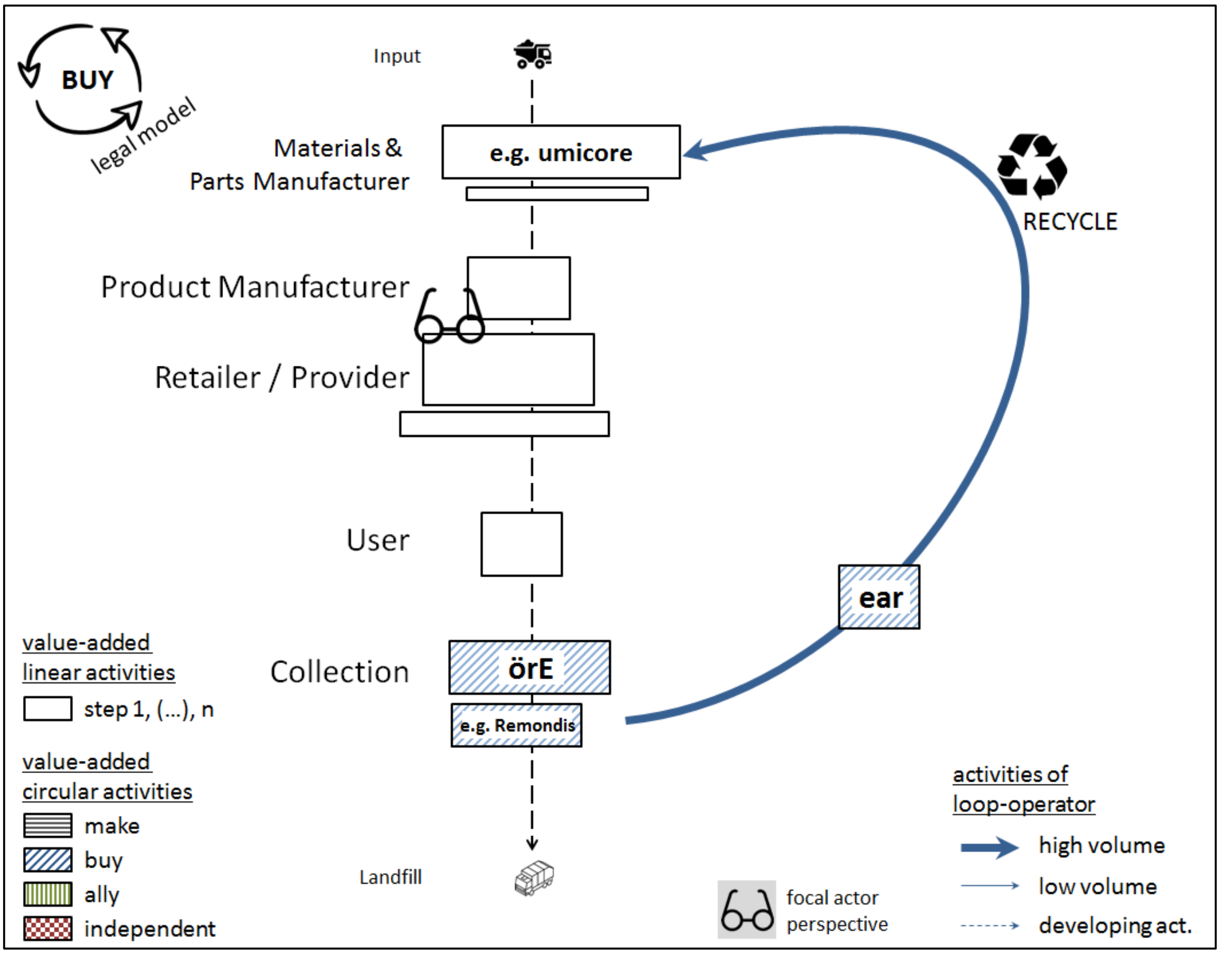

Figure 25: Schematic representation of VCA 4 which is based on an strong "buy" relationship between the focal actor and their loop operators

5.4.4 Motivation and value creation

The case is characterized through a compliance situation. It is legally required for distributing companies to take back discarded ICT devices, which includes smartphones. Therefore, the motivation is a clear legal one. It is legally required to be part of the system described above as soon as electronic devices are brought to the market in Germany.

Because this system is limited to the recycling loop possible value creation from discarded mobile devices is very limited. The recycling company can extract the pure material value from the collected WEEE. This material value, however, is too little to cover the expenses for return logistics. Therefore, distributing companies have to pay for the service as a service charge.

5.4.5 Barriers and future development

The main problem for the collection and recycling of mobile phones is to acquire sufficient quantities. According to industry experts, processing and recycling technology do exist for smartphones, however, they are not yet profitable, among other things, because inflow of material is not constant enough. The current take-back system is designed for efficient process structures on behalf of the industry, but transfers all responsibilities to the end-users who have to bring their devices to the collection points.

However, end-users tend to store their old electrical devices at home for a number of reasons. These may include unawareness of return-schemes, emotional value and monetary value of electronic devices.

> *“And the real barrier is actually the user, the user’s behavior, to withhold phones or smartphones”. (exp_1, 6)*

The future development should go into the development of sound business models which include an automated take-back process for discarded electronic devices. According to the industry expert a connection between manufacturers and the end-of-life phase of their products is missing.

> *“Ok but the challenge is to say: How can I establish a connection between manufacturers and the end-of-life phase of its product”. (exp_1, 84)*

Another possibility to increase collection rates through this system would be to introduce a deposit charge or a recycling fee for electronic devices.

5.5 Case V: Emergence of Independent Actors

In this last case a VCA is being described that is based on two independent firms who mainly offer repair services for smartphones and other electronic devices. Both, iPassions and akkutauschen.de act independently from large OEMs and do not maintain contact to focal actors along the value chain. Nevertheless, they effectively close CE-loops in the B2C sector through their offered services of standard repairs and battery exchange.

5.5.1 Involved actors and partnerships

The first case company was originally specialized in battery exchange for electrical products (e.g. electric toothbrush). However, over the years they broadened their offers to nearly all electrical and electronic products that include a rechargeable battery (e.g. smartphones). Akkutauschen.de is, according to own specifications, one of the biggest service providers for battery exchange for electrical and electronic consumer devices in Germany as they reached a volume of 1.8t waste batteries in 2015. They offer their service locally in a shop in Hamburg and in whole Europe via their online store and other platforms (e.g. amazon, ebay).

The second case company is a local repair shop in the city center of Lüneburg who is specialized in repairs for ICT products, especially smartphones and tablets. They offer both, spare parts and repair services to their local customers and to a limited extend via the internet. Additionally, they produce their own line of accessories for ICT products.

Table 17: Overview of involved actors and their tasks for case V

Actor	Details	Tasks and responsibilities
loop operator	independent repair shops for smartphones and other ICT	repair and refurbishing (battery exchange)
focal actor	OEM manufacturers, smartphone producers	no direct relationship, no contact
further partners	spare parts distributors and manufacturers	access to spare parts
	other firms in the sector	exchange and cooperation

According to the interview material they both act to a wide extend independently from other actors along the smartphone value chain. In particular, no contact to focal actors along the value chain (e.g. OEM manufacturers) exists. Although this contact is pursued and actively promoted by both companies, it is not yet achieved. They both describe their relationship to focal actors along the value chain as ambivalent. On the one hand they feel "unwanted" and "ignored" because through their services they decrease consumption levels for new products. On the other hand, both are convinced that their services increase customer satisfaction and thus customer retention for the focal company.

"They couldn't do without us. If we wouldn't be there and point out to their bugs". (indi_2, 102)

„Officially we are unwanted, unofficially we are the basis of their success". (indi_2, 100)

Important other partners are other independent repair shops with which there exists an intensive exchange regarding repair manuals and spare parts sourcing. Further key partners are so called intermediaries or traders for spare parts. They are located outside the original value chain and sell spare parts directly to these repair shops. These intermediaries are very important, because original spare parts are not offered from most smartphone manufacturers.

"But we also have folks in the industry who deal with similar things. […] We just know each other". (indi1_50)

"There we do not have contact directly to manufacturers but to intermediaries. This means in Germany and Europe there specialized wholesale traders, for such parts. […] Display, batteries, connectors, all the things that can brake". (indi1_56

Managing these crucial traders for spare parts is a time consuming activity, because it involves intensive personal contacts (see also next subchapter).

"I need to manage 10 different suppliers, every time. Generally speaking, this means I spent 10 days in a month, on the move, just to get the new goods that my suppliers received". (indi_2, 68)

5.5.2 Factors influencing the make-or-buy decision

According to both interviews with independent loop operators the most important factor influencing the focal actor's make-or-buy decision are suggested to be of strategical nature. Manufacturers do not necessarily have an interest in offering prolonged life times, because margins for selling new devices are considerably higher. A typical smartphone manufacturer or telecommunication provider has optimized business processes regarding the sales of new smartphones. Additional circular practices are not yet in bigger consideration.

> *"Yes, yes it is related to company policy, it is just a question of faith. It was like this, in case of doubt it has always been like this". (indi_1, 105)*

> *"They are actually not interested in these repair-processes". (indi_1, 97)*

Another reason for focal companies to neglect repair services are their complexity and thus high asset specificity. As it was shown in the previous chapters it is not easy to set up a repair service and also take-back processes are connected with a high asset specificity and uncertainty. Also, manufacturing companies and other focal actors already have the legal obligation to take back defect devices within the warranty period. Reverse logistics procedures for these processes exist. Additionally, focal actors are also legally obliged to participate in the legal take-back model for WEEE described in case 4. All additional circular practices are therefore of pure voluntary nature. From a focal actor perspective, the decision therefore actually is not between make-or-buy but rather between engaging in further circular practices or leaving it as an uncoordinated measure to the market.

One interview partner stressed that other strategic or product related issues, that give advantage to a non-observance of further circular practices, are security and liability risks. Fewer uncertainties are involved by simply exchanging an entire device, rather than opening it and repairing single modules or parts. Akkutauschen.de has spoken to manufacturers about the possibility of receiving official support, but received a negative answer due to liability risks.

> *"The argument is always the same: Customers need safety. Yes, but which safety? The functionality. I then say that we could guarantee that. Yes, but… […]. It is generally not wanted; selling a new device is clearly more efficient". (indi_1, 129)*

Smartphone manufacturers are aware of the fact that some of their customers want to keep their devices for a longer time period and therefore need to repair certain parts from time to time. One of the independent repair shops therefore expressed the suspicion that smartphone manufacturers purposely allow for a small flow of spare parts (see also section 5.5.5 for barriers associated with limited spare parts availability).

> *"I see it like this: manufacturers are absolutely aware of their position. They could say rigorously: together with the original parts manufacturer, whether it is about a battery*

or a display or a microphone or anything else, they could say restrictively that these spare parts ONLY go through us [manufacturers] and then directly build into the devices. But that they do not appear on the open market. But they [manufacturers] obviously let this happen". (indi_1, 95)

Generally, it is very difficult to assess the factors that influence the make-or-buy decision from focal actors and their motivations regarding circular practices from the outside. Nevertheless, this section attempted to collect some of these possible influencing factors. On the basis of the available information this VCA is characterized as an uncoordinated engagement of various independent actors which are distinct from a formal market coordination. Therefore, Figure 26 shows this coordination form outside the typically used continuum.

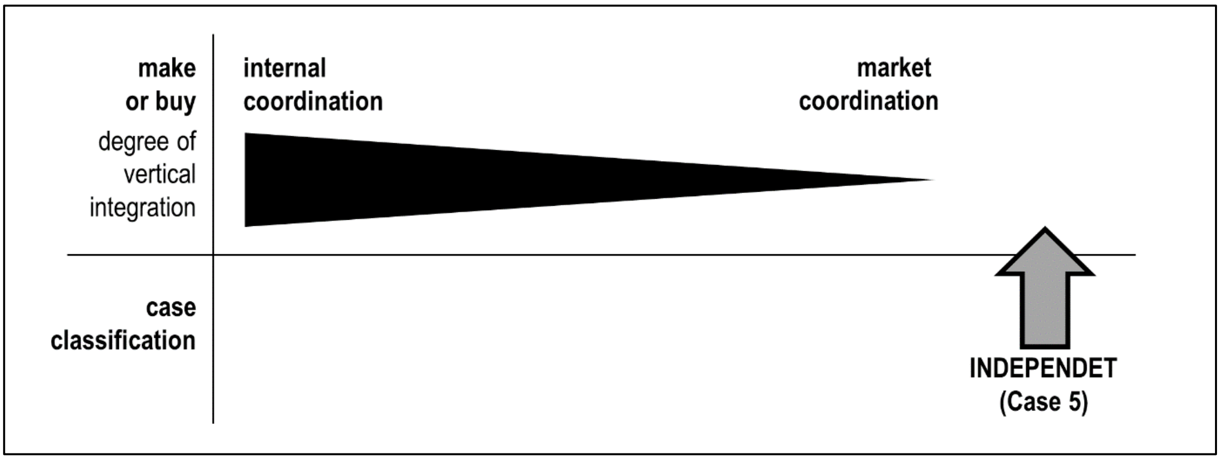

Figure 26: Classification of Case V outside Williamson's continuum

5.5.3 Addressed CE-loops

This VCA mainly addresses the maintenance loop and in part other CE-loops (see Table 17). The loop operator's value offer aims at smartphone users whose smartphones are not covered by the legal warranty. This is either because the warranty period has come to an end (generally two years after purchase), or because the defect is not covered through the legal warranty (third-party responsibility). Additionally, for most smartphone models, no official repair option is offered, or it is only available for a limited time period after the first publication date[47].

"The most common one are display, battery, charging socket. These are the three most common. All the things users interact with". (indi_2, 14)

Damaged displays can include cracks, fractures or damages caused by water. Batteries are wearing parts that need replacement after a certain time period. Charging sockets also underlie a heavy wearing and may fail after certain use times. Both loop operators see themselves as

47 e.g. Apple only offers repair services for their three latest models. See also: https://support.apple.com/de-de/iphone/repair (accessed on 20.12.2016)

repair specialists, because of their long term experience and although no official repair manuals exist, both akkutauschen.de and iPassions can fix most of their customers' issues.

> *"We are better in most of the things. I can solve problems that apple employees […] wouldn't even understand". (indi_2, 54)*

They both do not engage in classical refurbishing activities of mobile devices in order to resell them in the public market. Rather they cannibalize old devices for their internal storage system of spare parts. This material loop, which they call "the small loop", refers to their collection and reuse of used spare parts for future repairs.

> *"Everything that is still working or functioning is taken apart and removed. It is stored in boxes for if there is ever any need, that someone says I need this or that". (indi_1, 38)*

Table 18: Contribution of Case V to closing and slowing resource loops of a CE

CE-Loop	Type	Details
Maintain	Direct	Offering a wide range of repairs for smartphones for all customers and all smartphone brands
Refurbish/ Internal	Cannibalization/ internal reuse	Used phone parts are reused in-store for future repairs
Recycle	Indirect	Professional recycling of faulty parts and batteries

Other CE-loops such as reuse and recycling are only of partial relevance for both loop operators. Both loop operators do not engage in the reuse loop. This means that trading of used mobile devices is not part of their value offer. The recycling loop is relevant only for the professional disposal of faulty parts and batteries.

Figure 27 displays this VCA including the internal loop for reused spare parts.

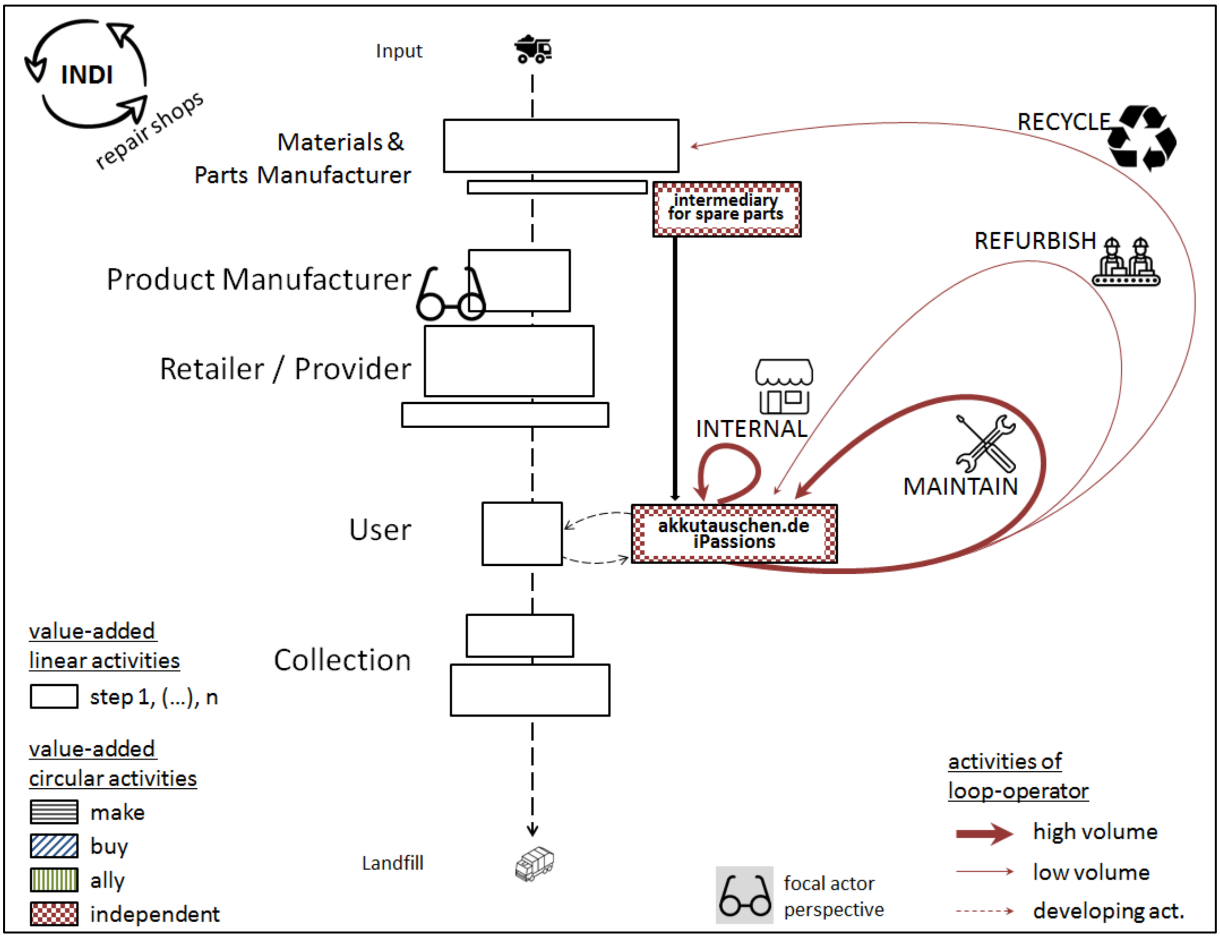

Figure 27: Schematic representation of VCA 5 which is dominated by “independent” repair shops

5.5.4 Motivation and value creation

Through their maintenance and repair activities, both loop operators contribute to prolonged use times of electronic and electrical devices. Since official repairing facilities for smartphones are rare and manual repair is complex, they both offer a valuable service for all smartphone users.

The CEO of akkutauschen.de emphasizes that he developed a fully functional economic entity that generates reasonable profits. One of his aims is to prove the possibility of commercially prolonging life times for electrical and electronic devices through his profitable business. Part of his motivation is also intrinsically driven, which is also reflected in his successful candidature to a major German sustainability award[48].

> *“We are not a project. This is a functioning economic system that we build up or in that we participate. And thereby we are also economically functioning. I think this is the greatest positive point and the greatest of our achievements”. (indi_1,48)*

48 In 2015 akkutauschen.de won the German sustainability award “Werkstatt N”. See also: http://www.akkutauschen.de/index.php?section=presse for more information. (accessed on 20.12.2016)

The main motivation for iPassions besides operating a profitable business is the CEOs technical affinity and interest in technology.

> *“Fun. Fun in experiencing technology. Being the first one to take apart everything. Being the first one to solve any problem”. (indi_2, 8)*

From a focal actor position, it remains unclear, in the scope of this study, why manufacturers do not offer easy access to repair and refurbishing services. Both independent loop operators who were interviewed expressed the assumption, that smartphone manufacturers focus purposely on the sales of new smartphone models because of high margins (see also section 5.5.2).

5.5.5 Barriers and future development

Two major barriers are mentioned in the interview material. These are on the one hand a missing support from smartphone manufacturers in form of official repair manuals and on the other hand, a very limited access to necessary spare parts.

Most of their knowledge about repair processes is based on learning-by-doing processes but consequently part of their unique selling proposition. This is also a time consuming process, similar to the one described for the supplier management in section 5.5.1.

> *I need to use my experience constantly to further extend my knowledge. So that I can say, wait a second, we had such [a problem] before, and now this failure appears again. (indi_1, 99)*

However, in general, repairability is not the most limiting factor for the offerings of the independent loop operators. Due to their experience, and support of developing online communities, both interview partners stated that they can repair nearly all defects in a smartphone. The most relevant barrier is the missing access to original spare parts and this is why they developed their own cannibalization techniques to reuse used spare parts, as some customers prefer used spare parts that definitely comply with the original quality.

> *“Here we are of course fully self-sufficient, this means offside from manufacturers. […] For example, we do not have any access to spare parts. This means we are dependent to solve these things in the small loop”. (indi_1, 48)*

Interestingly, it was stated that it is always possible to get hands on original spare parts; it is just a question of the right contacts to a dealership network. According to one interview partner only a handful of such dealers exist in Germany and all repair shops buy their spare parts with these partners. The presumption was expressed that smartphone manufacturers purposely allow for a limited flow of original spare parts, in order to limit customer dissatisfaction.

> *„they [focal actors] could be absolute rigorous […] original spare parts ONLY through us“. (indi_1, 95)*

Both loop operators from this VCA mention the automotive industry as an example for both functioning maintenance mechanisms and spare parts availability. Although they are also aware of the differences between a car and a smartphone.

> *“I think a good example is the automobile industry. […] These small garages all have a full license. […] Warranty services I can get from any automobile technician. […] Every garage can put a stamp in my service booklet”. (indi_1, 99)*

Currently they see themselves rather as a parallel industry that developed around the smartphone industry, similar to an automobile tuning community.

> *“This is like in the car industry. There are manufacturers and a tuning community. And that we do for example for iPhones”. (indi_2, 98)*

In the future, both loop operators would like to act as authorized repair shops for IT equipment. They would like to be recognized by focal actors along the value chain. This would lead to new synergy effects that could transform the market and help create more sustainable consumption levels. Together both manufacturers and (independent) loop operators could find new business models and increase overall profits.

> *“Well, I am not certified, but this could be regulated by manufacturers. Then one could say that I have the knowledge. Let’s find out on a technical level where there are problems and sensitivities and which things are important. Let’s make these things clear and then we can fully take over”. (indi_1, 131)*

This last case can be seen as an extreme case which represents a VCA that is not coordinated by a focal actor, however still enables functioning businesses for the high order maintain loop.

6 COMPARATIVE ANALYSIS

This chapter first summarizes the results presented in Chapter 5 (see also Table 19). In a second step, the results are compared with respect to their circular economy practices as well as from a perspective that takes Williamson's coordination types into account. The section concludes with the proposition of a continuum of integration strategies for closing material loops in a circular economy which is inspired by the cases analyzed in this work.

6.1 Case Summaries

The first case is dominated by a vertically integrated smartphone manufacturer and thus represents a clear *make coordination*. The Shift GmbH is a small family owned company which on the one hand, includes closed CE-loops as part of their qualitative approach, as it is a service which is taken for granted. On the other hand, Shift does not have the resources that are required to offer a perfectly professional service regarding these CE-loops. Therefore, they decided for strategic reasons to offer repair, take-back and refurbishing services themselves. However, extending their support to these three circular economy loops, results in considerable additional efforts and to date, a self-supported business model for these CE-loops has not yet been developed. In the future they want to professionalize and may choose to outsource their maintenance activities to a loop operator, in order to decrease costs.

The second case is characterized by collaboration between a focal actor (e.g. telecommunication provider) and a service company (loop operator). It can therefore be considered a *hybrid or ally coordination* form. Together with Teqcycle Solutions GmbH, Telekom Deutschland GmbH developed a buy-back system for smartphones that builds on experience gathered through a public collection scheme, which focused on the first level recycling loop. This buy-back mechanism, in turn, allows for the realization of higher-order CE-loops (e.g. refurbish and reuse). Their collaboration is based on a long term partnership through a special ownership structure, which allows for intensive investments in CE infrastructure. A solid business model with sufficient margins was developed around this buy-back program and further developments target at intensifying refurbishment activities.

The third case, described in Chapter 5, has likewise emerged from collaboration between a telecommunication provider as a focal actor and a service company for reverse logistics as a loop operator. However, their relationship does not include ties as close and commitment as long term like observed in case two. Hence, it can be best described as a coordination

Table 19: Cross-case summary

Case	Case details	Relationship to focal actors	Williamson's Coordination	CE-loops	Motivation	Barriers
Case I	Small scale smartphone manufacturer CE- loops offered as a matter of course No direct monetary value creation CE-services available upon request only Recycling loop realized through partners	Case's example company is a focal company which engages in CE-loops	Make	1. Maintain 2. Reuse 3. Remanufacture 4. (Recycle)<	Intrinsically motivated & Quality driven	Requires consider able work force
Case II	Experienced loop operator w/ Telekom Buy-back programs for used smartphones developed out of public collection scheme Profitable business model Batch sale to B2B customers	Long term contractual arrangements, Focal company is shareholder (no influence)	Ally	1. Reuse 2. (Refurbish) 3. Recycle	Compliance Increase market shares	Customer awareness, Limitations regarding refurbishing
Case III	Experienced loop operator w/ Telefonica Public collection of mobile devices Mobile phones are "donated" Cooperation with an environmental NGO Compliance as main goal	Contractual arrangements, Close collaboration with focal actor, Exclusivity agreements	Buy/ally	1. Recycle 2. Reuse 3. (Refurbish)	Compliance for Telefonica, CSR driven	Low collection rates Quality of devices
Case IV	Legal arrangement to fulfill ElektroG law Highly regulated collection type User brings-in device to örE Logistics and coordination through ear	Short term contractual arrangements between focal actor and loop operator Redeem from liability	Strong buy	1. Recycle	Legally required	Generally low collection rates
Case V	Independent repair shops (online, offline) Fill an unobserved niche for smartphone repairs Knowledgeable actors w/ high problem solving capabilities Profitable businesses	Ambivalent relationship between focal actor and loop operator No formal connection Some mutual benefits	Independent	1. Maintain 2. Refurbish 3. (Recycle)	Focal actor: inobservance Loop operator: fill market niche and intrinsic motivated	Spare parts availability Focal actor as missing partner

Form situated between *buy/ally*. The value proposition offered by the consortium of Telefonica, AfB and NABU is based on public collection of mobile devices and feeds mainly into the low-level recycling loop. It is based on a compliance issue that arises out of the German EletroG law and from the perspective of Telefonica it is a publicly effective CSR activity that includes the support of an environmental NGO. Future development is aiming at higher order CE-loops (e.g. refurbishing).

The fourth case represents the legal situation in Germany for the take-back of WEEE, which includes the complimentary take-back of smartphones. The electrical and electronics producing industry must coordinate their take-back processes through a clearing house (EAR). Occurring costs are taken over by the distributing companies. Through this highly regulated system transaction costs can be reduced considerably and short term contracts between focal actors (distributing companies) and recycling companies (loop operators) become possible. This allows for a simple *buy coordination* between focal actor and loop operator. The resulting system, however, only addresses the recycling of mobile devices and does not consider any other higher-order CE-loops. Future efforts are going into increasing collection and recycling rates through this system.

The last case presents two independent market actors that fill the niche of smartphone repairs which are not covered by warranty. Akkutauschen.de and iPassions both act as independent loop operators mainly for the maintenance loop. Their relationship to focal actors along the value chain can be described as ambivalent, as they receive no official support but are tolerated. The filled niche results from a non-observance of CE-loops through focal actors along the value chain and probably has strategic objectives. Although both independent loop operators have to deal with considerable obstacles regarding spare parts availability and device repairability, they both operate a profitable business. Further development efforts aim at a formal recognition from important focal actors (in particular OEMs) and promising collaboration possibilities. One such positive collaboration example, identified by both parties, is the automotive industry.

6.2 Integration Strategies for Circular Economy Practices

None of the investigated actors is fully engaged in all four technical CE-loops, rather all loop operators are highly specialized in one or two loops. Generally, high vertical integration levels allow for an engagement in multiple CE-loops. For large focal actors, engagement in CE-loops is closely connected with the legal situation and thus focuses on the recycling loop while their core business remains sales-driven. A major challenge that was be observed throughout all cases is the missing involvement of end-customers and partially unknown strategic objectives of large focal actors.

In Figure 28 the findings from all five cases are summarized in four distinct integration strategies for CE practices on a more abstract level. From a focal actor's perspective, it shows the relation between chosen coordination forms and resulting circular economy practices clearly, however, it does not claim general validity. The four strategies derived from above conducted case studies are integrating CE practices through:

1) vertically integrated loops,
2) cooperative loop-networks,
3) outsourcing to loop operators,
4) independent loop operators.

The first strategy is integrating CE practices through *vertically integrated CE-loops*. This indicates a considerable strategic relevance of circular economy practices for the focal firm. In the case of Shift, this is in line with their general approach as an "alternative smartphone" manufacturer. A vertical integration of CE practices enables the engagement in multiple CE-loops and thus also includes higher order CE-loops such as maintenance or reuse. Nevertheless, vertically integrated firms deal with a high asset specificity of their CE offers, because offering these services requires considerable skilled labor and costly support structures. Since relationships with other loop operators are only partly relevant for this strategy, it allows for a fast adaptation to changing market situations. In the vertically integrated VCA in this study, a more intrinsic motivation was observed which was combined with a quality-driven approach. Although a vertical integration of CE practices allows for business model integration, for example through an 'extended service' approach, it seems difficult to offer CE practices in a cost-covering way, as observed in VCA 1.

The second integration strategy is characterized through *cooperative loop networks* to unfold CE practices. Focal actors, who recognize circular activities as being potentially relevant in the future, follow this strategy. Such hybrid coordination forms allow for (close) collaboration and long-term relationships with loop operators, for instance through equity investments, as observed in VCA 2. Cooperative loop networks facilitate a reduction of the CE related offer specificity through professionalization and close process integration. In the case studies conducted above, the observation was made that initial engagement of large focal actors in CE practices usually is related to low-level CE-loops. However, following a cooperative loop-network strategy can advance these commitments to higher order CE-loops such as remarketing strategies. Focal firms who follow this strategy are observed to also integrate their circular practices in a profitable way. It can thus be suggested that a potential business case 'for circularity' has been recognized, as for example shown in VCA 2 through automated buy-back processes of used smartphones.

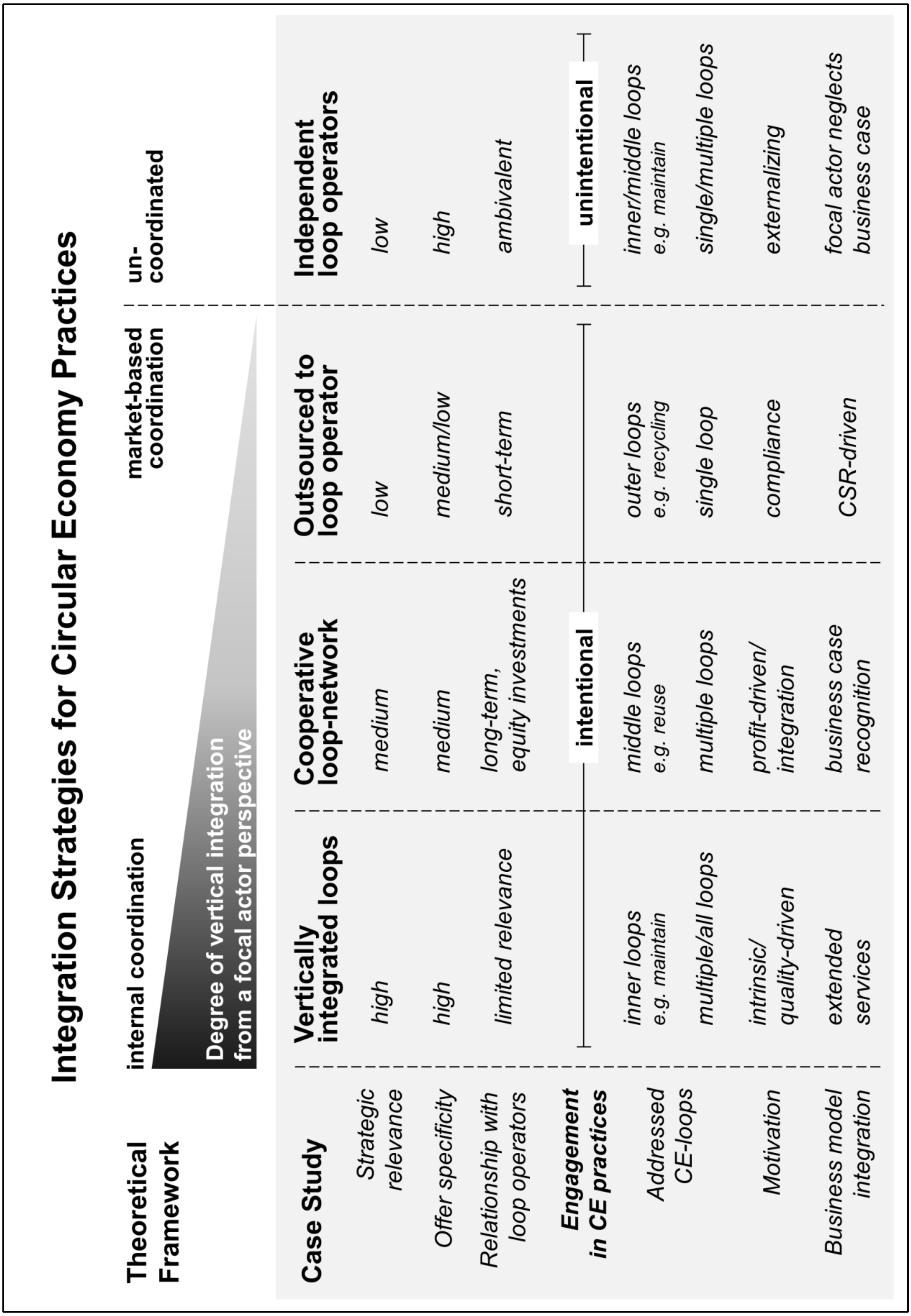

Figure 28: Different integration strategies for circular economy practices that contribute to closed resource loops presented along a continuum representing their vertical integration from focal companies perspective along the value chain

The third integration strategy for intentionally engaging in CE practices is based on *outsourced loop operations*. Focal actors who follow this strategy buy their CE practices mainly through loop operators such as recycling firms or reverse logistics specialists. Thus, from a focal actor's perspective, a low strategic relevance is assumed, because the main focus is still driven by sales of new smartphones. These short-term relationships between large focal actors and loop operators, however only favor engagement in single CE-loops and in such of lower order as, for instance, the recycling loop. Consequently, the asset specificity of the offer is considerably lower, especially if a highly regulated situation is provided by policy makers (as demonstrated in VCA 3 and 4). The motivation of focal actors for such a low level engagement in CE practices is thus driven by compliance issues that arise from the legal situation. Hence, no integration to the focal companies' business model is given and the activities are CSR-driven.

In contrast, the fourth integration strategy is related to unintentional arrangements of circular practices from a large focal actor's perspective. A non-observance of CE practices due to strategic considerations leads to the emergence of niches that are filled by *independent loop operators* who offer circular services to focal firm's customers (e.g. maintenance of smartphones). Because independent loop operators receive no support from focal firms they have to deal with high asset specificity due to their limited access to necessary information and knowledge. They are thus limited in their service offerings to few CE-loops such as maintenance or remarketing. Nevertheless, analyzed independent loop operators in this study operate successful businesses. Although no formal contact with focal actors exists, their relationship can still be described as being ambivalent because both parties neither support each other, nor do they detain each other completely. The motivation of large focal actors remains unknown within the scope of this thesis, however a potential business case is neglected and circular practices are somewhat "externalized" to other actors in the market.

Finally, it must be noted that the four strategies presented above, represent a continuum between internal coordination and 'uncoordinated' coordination with a market coordination in-between. Yet, further hybrid forms of coordination are conceivable. Generally, it can be summarized that the first three integration strategies refer to an intentional engagement of focal actors in CE practices. An intensive cooperation between focal actors and specialized loop operators is beneficial to further develop CE practices and engage in higher-order CE-loops. Leaving CE practices uncoordinated to the market leads to the emergence of independent loop operators who are limited in their services but nevertheless operate profitable businesses.

7 DISCUSSION

The case studies conducted in Chapter 5 in the context of the smartphone industry produced valuable insights into functioning value creation architectures for closing so called technical resource loops of a circular economy. Additionally to the development of integration strategies, the results allow for the formulation of hypotheses regarding the successful implementation of circular economy practices. In this chapter, these hypotheses are related to existing literature and in a second step, recommendations for further research are formulated, which could include a testing of these hypotheses on a larger scale (see also section 7.2).

7.1 Discussion of Results

1) **Commitment to higher order circular economy loops (e.g. maintenance or reuse) result in increased asset specificity and thus require considerable coordination efforts.**

Existing literature suggests that implementing a circular economy requires increased collaboration efforts and joint infrastructures (e.g. EMF (2016, 13); Roy & Whelan (1992)). In addition to literature, this study puts forward that asset specificity increases particularly for higher order CE-loops (e.g. maintenance or reuse). Necessary coordination levels between individual industry actors increase in particular because additional and significant investments are necessary in order to close higher order CE-loops. These investments include 'production' and logistic assets, human capital assets and procedural assets (e.g. VCA 1 and 2). In line with TCT this is due to the high specificity of processes that are necessary to close higher order CE-loops (e.g. Williamson (1979); Picot (1991)).

As Ghisellini et al. (2016) show in their literature review, a large body of academic literature still deals with the recycling loop only; rather than making higher order inner loops a subject of discussion. Also in practice, the recycling loop is subject of debates for a longer period of time. The above analyzed case studies demonstrate that volumes and quality of returned products suitable for the refurbish or reuse loop are considerably lower than for the recycling loop. Volume and quality, however, are essential drivers for the development of effective CE-loops (Guide & van Wassenhove 2009), as higher collection volumes are necessary to reach significant economy of scale benefits. This would in turn reduce coordination efforts. Schneider et al. (1994, 77) call this the life-cycle effect which would further come into effect with more experience and best-practice examples from other industries.

Further, higher order CE-loops are more difficult to implement, because they require timely processes. This is because the use-value of smartphones is linked to the course of time due to technological developments (Guide & van Wassenhove 2009, 15). Take-back processes are further challenged through a common ownership transfer for smartphones at the point of sale. In this way it is very difficult for sales oriented manufacturers and telecommunication providers to raise customer awareness for a second use-period of mobile devices.

2) **Hybrid forms of coordination agreements are a promising approach to decrease transaction costs regarding circular practices and at the same time accelerate development of innovative services and products.**

This study could show that specialized service providers, or so called loop operators, are valuable partners for focal companies in the value chain when implementing a functioning circular economy. According to TCT, long-term cooperation and other hybrid forms of coordination are promising approaches to deal with the emerging complexity (Williamson 1991). Long-term relationships are thereby beneficial because they allow for a close integration of processes. For example, VCA 2 illustrates close process integration between Telekom and Teqcycle, i.a. for automated buy-back processes at the end of the contract period. Other valuable processes that are developed by loop operators concern valuation schemes of mobile devices that are the basis for deciding whether a smartphone's use-value is high enough for remarketing. Therefore, communication and partnerships between focal actors and loop operators are crucial for closing CE-loops as it is also proposed by EMF & McKinsey (2012).

Scholars further argue, that firms commonly utilize their network of service providers as a source of innovation (Perrons et al. 2005, 671). This is also in line with innovation research literature which suggests that new solutions are promoted through network based collaboration efforts (e.g. Gemünden et al. (1996) and Pittaway et al. (2004)). Such an innovation behavior could be recognized in VCA 2 which is based on a hybrid form of coordination. Additionally, an evolutionary development of offered services towards higher order CE-loops could be observed in this case.

3) **Engagement in multiple and/or higher order CE-loops requires a strong motivation, either through integration in the focal firm's quality commitment or through business model recognition.**

Initial engagement of focal actors with circular practices mostly relates to recycling schemes, but can serve as a starting point for further engagement in higher order CE-loops. Similar to the different ethical motivations that were summarized by Schaltegger & Burritt (2015) regarding business case recognition, in this study different motivational backgrounds regarding an engagement in circular practices could be observed. Initial circular activities promoted by focal actors in the value chain mostly relate to visible CSR activities and address outer loops (e.g. recycling). Rather than putting the circular activity in focus, these CSR activities "offer an opportunity to enhance corporate reputation” (Schaltegger & Burritt 2015, 14). In contrast, the vertically integrated VCA in this study included a case company that had a strong intrinsic motivation to close CE-loops. It thus sees its activities as “an opportunity to enhance societal and environmental well-being” (Schaltegger & Burritt 2015, 14). Simultaneously the case company from VCA 1 engages primarily in higher order CE-loops such as maintenance and reuse.

Further, it should be noted, that small firms such as Shift have more flexibility in changing directions because of their relatively flat organizational structure. Generally, the company’s size and experience seem to play a role in make-or-buy decisions, which is also suggested by Bigelow & Argyres (2008). However, Bigelow & Argyres (2008) analyzed make-or-buy decisions in the automobile industry and found a positive correlation between industry experience and internalization. In this study the vertically integrated case company has little experience in the industry, but still fully integrates circular activities. The motivational factor or other strategically motivations may outweigh their make-or-buy decision.

4) **Circular economy activities do not necessarily have to come from focal actors in the value chain. They can also be pushed forward by specialized loop operators or even independent loop operators.**

A non-observance of circular opportunities by focal companies leads to the formation of niches that are filled by independent loop operators. Contrary to common research on innovation networks (e.g. Gemünden et al. (1996), Pittaway et al. (2004)) a non-observance of value-added circular activities through focal actors can nonetheless lead to innovative results. Both independent loop operators analyzed in this study developed innovative solutions, despite their limited available resources. One example are internal reuse loops for used spare parts that are not available on the free market. Additionally, these independent repair-shops developed a successful business model even without official contact to large focal actors. This is surprising as literature suggests that loop operators need to be coordinated through focal actors in order to utilized their potential regarding closed-loop supply chains (e.g. Guide & van Wassenhove (2009)).

Yet, this constellation is far away from a welfare optimum. As this study also suggests that a close cooperation between focal actors and independent loop operators would be even more beneficial. However, current relationships between independent loop operators and focal actors are ambivalent. They somewhat benefit from each other’s activity, but rather than cooperating they live a parallel existence. On the one hand, independent loop operators developed valuable knowledge regarding circular practices; on the other hand focal companies could benefit from this experience and utilize the loop operator’s effective customer contact after the point of sales. Both independent loop operators in this study named the automotive industry as a positive example for a successful cooperation between manufacturers and loop operators.

5) Circular design of products and services could decrease necessary coordination efforts and thus decrease overall costs of CE practices.

A holistic approach to design, which would include circular design practices such as design for disassembly and design for repairability (see also chapter 2.3), could decrease necessary coordination efforts. This was shown by nearly all of the above discussed case studies. Even the example of a vertically integrated VCA showed this in a vivid way, as ‘modularity and repairability’ are seen as a solution to decrease coordination efforts with customers. According to literature this would be beneficial because of standardization effects and reduced uncertainties (Schneider et al. 1994, 69; Williamson 1991, 291). Circular and modular design, however, must begin on a supplier level and thus become an industry wide standard. As of today only a few examples for circular designed smartphones exist and all use custom-made parts (e.g. Fairphone 2 (Schischke et al. 2016)). An ideal circular device was designed on a conceptual level by Poppelaars (2014) in a master’s thesis, however, it also uses custom-made parts. The EMF estimates that costs related to remanufacturing processes of mobile phones could be reduced by 50% through the use of circular design techniques (EMF & McKinsey 2012, 8).

A reliable availability of original spare parts would similarly decrease coordination efforts for services offered by CE loop operators. In all but the first of the above analyzed VCAs, limited spare parts availability was a major issue. For a reliable commitment of smartphone manufacturers to CE practices a reliable availability of spare parts would be a necessary precondition. For this purpose, accessibility limited to authorized service providers or repair shops would be sufficient. Case companies in this study named the automobile industry as a positive example for such a system. Both, in academics and in practice a comprehensive engagement with automobile repairs and remanufacturing of parts can be observed (e.g. Guide 2000, 475).

Further, circular design of services in form of new business models is vital to reduce necessary coordination efforts, e.g. to ensure efficient take-back processes for used smartphones. A simple but effective solution to increase return rates may be Shift’s solution to introduce a 22 Euro ‘deposit’ on their smartphones. Bocken et al. (2016, 313) relate this strategy of “extending product value” to their business model innovation strategies for slowing resource loops. Also, a centralized collection scheme, similar to the one described in case 4 would decrease coordination efforts considerably. The development of such centralized collection schemes is for example suggested by the EMF (2016) in their recent report on reverse logistics. Further circular business models that are intensively discussed in the academic literature are access and performance based business models (e.g. Stahel & Reday-Mulvey 1976; McDonough & Braungart 2002; Hansen et al. 2009; Bocken et al. 2016).

7.2 Limitations and Future Research

This study aimed to learn and understand how circular economy practices are implemented in the smartphone industry, in particular which coordination forms result from these practices. All of the above presented VCAs contribute to a circular economy, some of them being more advanced, others solely focusing on recycling. However, it was not the aim of this study to rank these different coordination types regarding their sustainability performances. Nevertheless, this study is limited, as it only represents a small section of possible cases which were selected through so called 'information oriented' selection (Flyvbjerg 2006, 230). Therefore, this research does not claim general validity or transferability to other industry sectors. To achieve a more general validity the above developed hypothesis would need further validation on a larger scale.

The concept of a circular economy lies at the interface of many different research streams, including ecological economics, industrial ecology and conventional economic sciences. The present study gives a first overview on existing value creation architectures using transaction cost theory as a theoretical lens. It is thus limited with regard to other disciplines. A promising neighboring research field for further analysis of above presented VCAs would be 'reverse logistics' and 'closed-loop supply chains', which deals with take-back processes in greater detail (e.g. Ferguson & Souza 2010 and Guide & van Wassenhove 2009).

Further limitations of this study are rooted in the nature of this master's thesis. Most of the work related to the presented research is conducted by one researcher only. This decreases reliability and validity measures. For example Mayring (2010) proposes certain quality criteria for a structured content analysis that increase reliability and validity of the research. As a reasonable method he suggests an analysis of the collected material by a second researcher, using the same coding-scheme. Mayring calls this procedure "intercoder-reliability" (Mayring 2010, 117). This process was not carried out and thus objectivity is limited. Nevertheless, results of this master's thesis did receive some form of verification through "communicative validation" (Mayring 2010, 120; Flick 1990, 253). This was achieved firstly through a presentation and discussion of results with industry-experts within workshops of the INaS network. Secondly, results were discussed with other researchers from the field on a continuously basis, i.a. at the research colloquium on Innovation & Value Creation (I+VC) 2016.

Although transaction cost theory as a theoretical framework turned out to be a valuable structure to analyze different coordination types regarding the implementation of circular practices, the collected information was mostly limited to a service provider's perspective, which produced some problems with regard to the taken perspective. Future research regarding this topic should include the focal actor's perspective in order to fully capture their strategic motivations and other influencing factors regarding the analyzed make-or-buy decisions. Further research would also be necessary to confirm the adaptions made regarding Williamson's coordination types (Williamson 1979), i.a. as no 'independent' coordination type is included in classical transaction cost theory. This extension of theory was necessary in order to capture emerging activities that are based on the non-observance of customer demands regarding repair services from focal actors. The general application of make-or-buy analysis on concepts that try to reduce unaccounted externalities, such as the concept of a circular economy, would thus require further research.

Nevertheless, this work can serve as a basis for future research regarding the development of possible business models aiming at closed material loops. Business cases for sustainability in general and for circularity in particular are at the core of transformation processes towards a sustainable economy (Schaltegger et al. 2016; Bocken et al. 2016; Tukker 2015). Future research in this area could build on this work regarding the analysis of cooperative business models. Economically sound business models are necessary in particular regarding take-back schemes and possible incentives to increase collection rates of unused mobile devices (e.g. leasing or deposit systems).

Concerning the practical relevance of this work, participants of the innovation network on sustainable smartphones (INaS) generally confirmed the presented results, however asked for further research concerning a monetary analysis of the presented actor relationships. Such an analysis should include existing and possible monetary flows and financial benefits or related financial incentives. In particular, it would be interesting to analyze which actor earns how much by offering circular economy related products and services. This could be operationalized in a detailed analysis of their business models.

In order to facilitate transformation processes towards a circular economy it would also be necessary to analyze decision processes within the above presented value creation architectures. Focal companies seem to play an important role in the transition to a CE. However, as it was suggested in this thesis also highly specialized loop operators can contribute successfully to such transformation processes.

8 CONCLUSION

The objective of this thesis was to investigate how different value creation architectures contribute to closing technical loops of a circular economy in the smartphone industry. In particular, it derived four different strategies for focal companies in the value chain (e.g. manufacturers or telecommunication providers) to deal with the emergence of a CE. Transaction cost theory was used to assess existing VCAs regarding their interactions between focal companies with loop operators and their contribution to a CE. Combining CE approaches with classical transaction cost theory led to a unique research framework, which was utilized for a qualitative case study approach on relevant case companies participating in the INaS-Project at Leuphana University of Lüneburg. A total of five different cases were analyzed in detail regarding their partnerships, circular practices, motivation, factors that influence the make-or-buy decision and perceived barriers.

The analysis suggests that all of the above investigated VCAs contribute to a circular economy, either by offering services that contribute to prolonged life-times of smartphones such as repairs and remarketing, or through basic take-back processes that aim at functional recycling of valuable materials. The findings further provide evidence that circular practices do not necessarily have to be pushed forward by focal actors in the value chain but can also be fostered by specialized loop operators or even independent actors.

This thesis indicates that an interrelation between coordination forms and advancements of circular practices exists. On the basis of the presented case studies, a continuum of four integration strategies for circular economy practices was developed (see also Figure 29). These integration strategies include 1) vertically integrated loops, 2) cooperative loop-networks, 3) outsourcing to loop operators and 4) independent loop operators.

It is suggested that initial engagement in CE activities usually starts on the basis of short-term buy coordination and aims at the recycling loop. This approach is fostered by current take-back legislation for used electronics which focuses on recycling. These low-level CE activities are suggested to be CSR-driven. It is further suggested that engagement beyond recycling activities requires either integration in current business models or strong embeddedness into the focal companies' overall motivation. This is because increased asset specificity of higher order CE-loops (e.g. maintenance or reuse) could be observed which in turn lead to additional coordination requirements. One possible solution to reduce transaction costs that were observed in the case studies is an ally-relationship on the basis of long-term cooperation or equity investments between focal actors and loop operators. Another possibility is the vertical integration of circular practices, which could be observed in a smartphone manufacturing company that integrated CE-loops in their quality commitment.

In addition to make, buy or ally coordination forms which are in line with coordination forms suggested in TCT literature, this research observed a fourth option. Focal companies in the value chain can also continue with business as usual and leave circular practices uncoordinated to the market. This non-observance of circular opportunities leads to the creation of niches which are filled by independent loop operators, i.a. repair shops for smartphones. They developed profitable and innovative services, which makes them valuable cooperation partners. Nevertheless, their relationship with focal actors is suggested to be ambivalent, because they benefit from each other but do not support each other.

Generally, results from the analysis indicate that increased coordination requirements for CE implementation can be reduced through circular design of products and services. This is because common limiting factors throughout all analyzed VCAs for further engagement in CE-loops are missing modularity of devices, complex repairs, limited spare parts availability and required support levels.

This thesis can be seen as a small-scale exploratory work regarding conceivable VCAs in a circular economy. However, the study's validity may be limited regarding two factors. Firstly, it is limited concerning its methodological approach, as a qualitative content analysis ideally asks for more advanced validity and reliability measures, which could not be realized within the scope of this thesis. Secondly, the selected case companies only represent a small fraction of the whole population of potential case companies. In particular, the focal actor's strategic considerations and influencing factors regarding their make-or-buy decision could only be analyzed from an outside-in approach.

Although the validity and reliability of this research may be limited, its findings can provide a strong basis for further analysis. In particular, an analysis of large scale smartphone manufacturers and telecommunication providers is expected to produce missing insights regarding their motivation. Further, the scope of future analyses should be extended to financial components of closed CE-loops and include reverse logistics research.

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10 APPENDIX

1. Enclosed to this document:

a. German translation of quotes used in Chapter 5
b. Interview guideline (in German)
c. Category system used for the content analysis

2. Available as supplementary material (upon request):

a. Audio files recorded during interviews
b. Transcripts
c. MAXQDA file
d. Codings from the content analysis

Appendix 1a

Source	Original German Quote
SP_47	Wir sind schon am gucken an Werkstätten, die Reparaturen für uns machen können und machen wollen.
SP_15	Die Leute melden sich bei uns und sagen es ist kaputt. Und dann haben wir eine persönliche Beratung für jeden. Dann hören wir uns das an, und dann beraten wir ihn und sagen mach es vielleicht lieber so oder so und schaue dir mal das Video an. Und dann spricht man mal weiter und dann kommt man darauf welches Teil braucht er.
SP_47	Ach vielleicht auch, weil wir die Partner jetzt noch nicht kennen. Also wir sind da offen, auch mit anderen zusammen zu arbeiten. […] Reparatur, wäre sogar auch sinnvoll, weil wir kommen auch irgendwann an unsere Grenzen. […] Das wird schon mehr je mehr Stückzahlen wir haben. Irgendwann können wir das dann hier auch nicht mehr stemmen.
SP_95	Nur das Hauptproblem ist, dass wir die Dienstleister, die bereit wären, für so einen kleinen Lohn wie wir arbeiten im Moment nicht findet. […] Und wenn du dann wieder Partner hast, die haben dann wieder einen riesen over-head und dies und alles muss dann so und so sein, und teure Versicherung. Keine Ahnung was es da noch alles gibt, was man unbedingt haben muss.
Shift-Report 2016, 11	All diese Bereiche decken wir mit SHIFT selbst ab und bearbeiten sie mit unserem kleinen Team inhouse. So betreiben wir eine kleine Reparatur-Werkstatt, einen Gebrauchtmarkt und versuchen möglichst viele unserer Teile selbst wieder verwerten zu können.
SP_23	Guck, im Prinzip, du kannst jedes Kabel, jeden Sticker. Alles gibt's als Ersatzteil im Prinzip bei uns.
SP_15	Wir haben das nicht im Shop, weil meistens es dann so komplex ist, dass die Leute gar nicht genau wüssten, welches Teil wäre das jetzt.
SP_33	Reuse ist so, Leute können entweder upgraden bei uns und schicken uns ihr altes Gerät zurück oder sie sagen, ach ich brauch jetzt doch ein anders Gerät und ich möchte das wieder zurückgeben.
Shift-Report 2016, 11	Wir wünschen uns, dass ein SHIFTPHONE niemals einfach weggeschmissen wird, denn es beinhaltet wertvolle Rohstoffe und Teile, die wir wiederverwenden möchten. Daher haben wir in diesem Jahr 22 EUR Gerätepfand eingeführt. Shift-Report 2016, 11
SP_35	Wir haben genug Anfragen von Leuten, die ein altes wollen. Und sagen es muss nicht das neues Android haben, Hauptsache ich kann ein bisschen WhatsApp schreiben.
SP_11	Aber unsere Phones wollen wir auf jeden Fall... Das brauchen wir selber. Also das können wir am besten selber, re-usen und recyceln. Weil wir kennen ja unser Phone, wir wissen ja ganz genau wo was herkommt.

SP_11	Da würden wir jetzt mit jemandem zusammenarbeiten. Also für unsere Sachen, da recyceln wir selbst. Aber wir nehmen ja auch andere Phones an jetzt.
SP_63	Dann gucken wir wie können wir das am besten machen, wie sparen wir am besten Ressourcen, wie gehen wir am besten mit der Umwelt um, wie gehen wir am besten mit den Menschen um.
SP-13	Die Kreisläufe haben wir alle intuitiv einfach so gemacht. Ohne uns das vorher zu überlegen, hat sich das einfach so entwickelt. Weil wir gemerkt haben: Um das gut zu machen müssen wir das irgendwie machen.
SP_55	Das [Support] machen wir umsonst. Da muss man auch nicht für bezahlen. Das ist eher ein Service, den wir bieten. D.h. das müssten wir beim Geräteverkauf mit einberechnen.
SP_89	Und das ist eigentlich der Grund warum man modulare Phones braucht. Die quasi so gebaut sind, dass man eigentlich nichts kaputt machen kann. Auch wenn man es aufmacht. Und da sind wir noch nicht. Das wäre zu teuer gewesen von der Entwicklung, das hätten wir gar nicht geschafft.
SP_91	Wir glauben, dass es für uns erst dann zu stemmen ist, wenn wir wirklich modular sind, so dass wirklich jedes Kind das Ding selbst reparieren kann.
TQ_3	Wir sind sozusagen derjenige, der Prozesse, logistische Leistungen liefert, und dafür sorgt, dass die Sicherheitskriterien eingehalten werden.
TQ_71	Wir arbeiten im Wesentlichen mit einem Partner zusammen der in der Nähe von Göttingen sitzt und der die Geräte nach DIN-Norm recycelt. das Heißt die Ressourcen, die Einzelbestandteile, die man heute wirtschaftlich erfassen kann, werden gewonnen und der Datenschutz ist sichergestellt.
TQ_63	Wir sind halt das was eine Firma nicht hinkriegt: Eine große Firma ist ein riesen Tanker. Die haben ihren Geschäftsauftrag und der Tanker fährt gerade aus und ist wahrscheinlich sehr erfolgreich. Sie können dem Tanker aber nicht sagen, morgen musst du mal das Gegenteil machen und in die Richtung fahren.
TQ_49	Wir helfen der Telekom in dem wir Prozesse zur Verfügung stellen, die sie selbst zwar machen könnte, aber die für sie viel aufwendiger, kostenintensiver wären, wenn sie sie selbst machen.
TQ_51	Da hat die Telekom im letzten Jahr, gegenüber alten, eigenen Prozessen, 3,5 Millionen Euro in einem Jahr gespart. Also das ist tatsächlich ein wirtschaftlich sinnvoller Schritt, solche Dinge auszulagern.
TQ_25	Die Telekom ist als Investor an unserem Unternehmen beteiligt mit 20%.
TQ_3	Im Rahmen dieser Arbeit [public collection] ist dann die Idee weiterentwickelt worden, Handys auch anzukaufen. Auch da hat man zunächst mit der Telekom sehr stark zusammengearbeitet.
TQ_51	Und das ist so ein Randthema, das hat nie die Bedeutung in der Telekom, dass man das wirklich wirtschaftlich sinnvoll betreiben kann.

TQ_53	Das ist nicht ihr Kerngeschäft. Kerngeschäft ist: Uns beiden Anschlüsse zu verkaufen
TQ_83	Das ist eine sehr individuelle detaillierte Betrachtung. Das heißt wir haben da entsprechende Systeme.
TQ_83	Aber der Prozess ist so, dass das Gerät einmal angeschlossen wird [ans System], geprüft wird, dann werden die Funktionen überprüft. Dann werden die Bestandteile überprüft, dann wird das Gerät Datengelöscht und zum Schluss wird es in einem ersten Schritt refurbished. Das besteht aber nur daraus, dass es poliert wird und nochmal ein Stückweit aufgewertet wird.
TQ_83	Wenn in diesem Prozess ein Gerät auftaucht, wo die Sales-Kollegen die Erfahrung gemacht haben, dass es besser zu verkaufen ist, wenn zb ein Blitzlichtgerät funktioniert. Und das Blitzlichtgerät bei dem ist kaputt. Dann wird der Prozess an der Stelle so angehalten, dass es an der Stelle rausgenommen wird und eben in diesen Prozess reingeht wo jetzt eben das Blitzlichtgerät repariert werden kann.
TQ_33	Refurbish heißt, ein Gerät so wieder aufzubereiten, dass man es als A-Ware, also als Neuware, wiederverkaufen kann.
TQ_35	D.h. wir machen dann auch immer mal Besuche vor Ort. Wir machen Stichproben, um dann zu sehen ob sich alle an die Regeln halten. Jeder der bei uns ankauft, muss das auf jeden Fall unterschreiben, dass er es nicht tut.
TQ_35	Das kann auch ein Händler sein, der in China die Geräte refurbisht, weil da der Refurbish-Prozess deutlich billiger ist, als in Deutschland, und sie dann wieder verkauft.
TQ_17	Das hat schon ein Stückweit was mit Image zu tun. So ein riesen Unternehmen, die haben irgendwie 40 Millionen Kunden, da muss man so ein Thema auch bedienen.
TQ_43	Bei der Telekom machen, wir nun beides: Gesetzliche Rahmenbedingungen erfüllen und Geschäft ankurbeln.
TQ_79	In den Gesamtpaketen [mit Rückkaufprozessen] ist es so, in der Regel bekommt der Kunde von uns ein finanzielles Angebot.
TQ_55	Aber es wird nie ihr Kerngeschäft sein. Also da müsste sich am Markt richtig was ändern.
TQ_81	Der bietet sein Telekompaket an und sagt dann zum Partner: ach und übrigens, ich kann euch auch noch etwas Geld besorgen für die alten Geräte.
TQ_115	Es ist schwieriger die Sachen ranzukriegen. Das verkaufen ist überhaupt kein Problem.
TQ_105	Da muss man Geduld haben. Wir brauchen die Geduld, bis die Menschen merken, dass da eben Ressourcen verbrannt werden.
TQ_85	Bei manchen [Gerätetypen] lohnt es sich zb nicht, und bei manchen geht es einfach nicht.

AF_16	Unser Kunde, mein Auftraggeber ist Telefonica Deutschland, der sagt mir oder hat uns als einzige Organisation in Deutschland dazu beauftragt und auch dazu befähigt Mobiltelefone in Deutschland zu sammeln und das ist mein Kunde.
AF_28	Aber es ist, also im Hintergrund kann ich Ihnen wirklich sagen, die gehen all-the-hands-in. Man muss wirklich sagen, die haben eine Person abgestellt die sich hauptamtlich jetzt und diese Thema kümmert, Löhne und Gehälter.[…] Telefonica unterstützt auch in vielen anderen Stellen.
AF_50	Wir wären sonst auch gar nicht in den Markt reingegangen, also die Handysammlung wär gar nicht unser Markt gewesen. Wir sind spezialisiert auf Konzern-IT.
AF_26	Da sind natürlich die Prozesskosten, die haben wir halbiert weil auf Grundlage der Menge einfach mussten wird diesen Prozess vereinfachen. Und so können wir dann auch das weiterhin kostenlos machen für Endkonsumenten und für Telefonica im Endeffekt.
AF_22	Heißt wir machen momentan, sammeln wir die Schubladengeräte ein, die verspendet werden. […] Wir versuchen natürlich uns weiter zu entwickeln, weil wir im B2B erfahren sind, auch genau darein zu gehen.
AF_24	Aber der Zugang zu den Endkonsumenten und das Bewusstsein zu schaffen: ey gib doch mal dein Handy ab, ist ein langer harter Weg.
AF_28	Sind wir natürlich sehr motiviert das jedes Gerät auf Herz und Nieren getestet wird. Und nachher rausgeht als Wiedervermarktungsgerät und nicht als Recycling-Gerät.
AF_66	Es gibt ja Ersatzteile, die sind nur teuer und die sind noch rar. […] Aber aus zwei mach eins.
CE_88	die Zuteilung: Wann wer welchen Container abholt. Die erfolgt nach Verkaufsmenge. Nach Marktanteilen. Anders können Sie es nicht machen: Weil sie nie wissen wo was ist.
CE_72	Das ist eine geregelte Einflussnahme, staatlich ist das nicht […] Die ist lediglich, die wird von den Herstellern getragen [..] Und auch bezahlt.
CE_44	An der Stelle, wenn es über die öffentliche Sammlung geht, dann geht nichts mehr in die Wiederverwertung, oder -verwertung. Es geht alles ins Recycling.
CE_6	Und die echte Barriere ist tatsächlich der Nutzer, das Nutzerverhalten, Telefone, Smartphones zurückzuhalten.
CE_84	So aber die Herausforderung ist zu sagen: Wie kann ich eine Verbindung zwischen Hersteller und dem End-of-Life seines Produktes herstellen.
indi_2, 102	Die können gar nicht auf uns verzichten. Wenn wir nicht da sind, wenn keiner denen die Fehler aufzeigen.
indi_2, 100	Wir sind offiziell unerwünscht. Inoffiziell, sind wir die Basis deren Erfolgs.

indi_1, 50	Aber wir haben auch Leute in der Branche, die mit ähnlichen Dingen zu tun haben […] Man kennt sich halt, […].
indi_1,56	Da nicht direkt beim Hersteller sondern das geht über den Zwischenhandel, das heißt es gibt in Deutschland und Europa Spezialisten im Großhandelsbereich, die sich auf diese Teile eingeschossen haben. [...] Displays, Akkus, Kontakte, Stecker, alles was irgendwie kaputt gehen kann.
indi_2, 68	Ich muss 10 Lieferanten immer wieder abklappern und muss, das heißt auf gut Deutsch gesagt, 10 Tage im Monat bin ich auch Achse, um die neue Ware was meine Lieferanten geholt haben.
indi_1, 105	Ja, ja es ist eine firmenpolitische Sache, es ist eine Glaubensfrage einfach. Das war so, im Zweifelsfall auch das war schon immer so.
indi_1, 97	Die sind eigentlich an diesem Reparaturprozess nicht interessiert
indi_1, 129	Argument ist dann immer: der Kunde braucht eine Sicherheit. Ja welche Sicherheit denn? Ja die Funktionalität. Ich sag das könnten wir ja leisten. Ja aber ... […] Ist aber nicht gewollt ein Neugerät ist deutlich effizienter.
indi_1, 95	Ich sehe das aber auch so, dass der Hersteller sich durchaus über seine Stellung bewusst ist. Er könnte ja rigoros sagen: mit dem Originalteile-Hersteller. Egal ob es sich jetzt um ein Akku handelt oder um ein Display oder Mikrofon oder sowas. Restriktiv, diese Dinge dürfen nur an UNS oder in unsere Geräte direkt eingebaut werden. Aber nicht auf den freien Markt kommen. Aber das lassen sie ja offensichtlich zu.
indi_2, 14	Die üblichen Displays, Akkus, Ladebuchsen. Das sind so die drei üblichsten. Alles wo der Mensch Hand dran hat.
indi_2, 54	Wir sind in vielen Dingen wesentlich besser. Ich kann Probleme lösen, die würden Apple Mitarbeiter […] nicht mal ansatzweise verstehen.
indi_1, 38	Alles was noch Arbeitsfähig oder funktional wird zerlegt wird ausgebaut, wird in Kisten eingelagert für den Fall der Fälle, dass mal einer kommt und sagt ich brauch mal.
indi_1, 48	Das ist ja hier kein Projekt. Das ist hier ein funktionierendes Wirtschaftssystem was wir hier machen, oder an dem wir hier teilnehmen und damit und wir sind ja auch wirtschaftlich funktional. Ich denke mal das ist der größte plus Punkt oder die größte Errungenschaft die wir hier auf die Beine gestellt haben.
indi_2, 8	Spaß! Spaß an der Technik. Der erste zu sein, alles auseinander zu nehmen, der erste zu sein der irgendwelche Probleme löst.
indi_1, 99	Ich muss mit meiner Erfahrung versuchen ständig mein Knowhow zu erweitern. Um zu sagen Moment mal wir hatten das schon mal irgendwann gehabt und jetzt taucht der Fehler wieder auf.
indi_1, 48	Da laufen wir natürlich auch ganz Autark, das heißt abseits von den Herstellern. […] Wir haben keinerlei Zugriff auf Ersatzteile zum Beispiel, das heißt wir sind drauf angewiesen diese Wege auf diesem kleinen Kreislauf zu lösen.

indi_1, 95	Er könnte ja rigoros sagen […] diese Dinge dürfen nur an UNS oder in unsere Geräte direkt eingebaut werden.
indi_1, 99	Ich denke mal ein gutes Vorbild ist da die Autoindustrie. [...] diese kleinen Werkstätten, die haben ja eine vollständige Lizenz […]. Garantieleistung bekomme ich bei jedem Kfz Meister. […] Jeder kann mir ein Stempel in mein Serviceheft reindrücken.
indi_2, 98	Das ist wie in der Auto-Branche. Da gibt es Automobilhersteller und die Tuner-Community. […] Und das machen wir mit den iPhones bspw.
indi_1, 131	Naja zertifiziert bin ich nicht, aber das kann man ja über den Hersteller regeln. Dann sagt man ich habe das Knowhow. Lass uns bitte einmal auf der technischen Ebene rausfinden wo noch was hängt, wo ihr noch Befindlichkeiten habt oder wo ihr wert drauf legt. Lass uns das gerne regeln und dann können wir das gerne übernehmen.

Appendix 1b

Interview Leitfaden (Stand: 04.10.2016)

	Frage	Vertiefung/Verortung
Person/ Unternehmen	1. Können Sie sich zunächst kurz vorstellen? In welcher Verbindung stehen Sie zu *Unternehmensname*? 2. Können Sie die Historie von *Unternehmensname* kurz erläutern?	Umstände des Interviews Einordnung Entwicklung des Unternehmens
Aufgaben	1. Welchen Service bietet Ihr Unternehmen bezogen auf Smartphones an? 2. Wer ist Ihr Kunde? 3. Wie sieht der Prozess im Detail aus? 4. Was ist der Unterschied zu Sammelaktionen vom BUND, oder anderen kommunalen Anbietern? 5. Wo kommen Sie an Ihre Grenzen? Was können Sie nicht? 6. Wo verorten Sie sich entlang der Wertschöpfungskette? (Kärtchen verwenden)	1.1 Können Sie das näher erläutern? 1.2 Was machen Sie genau? 1.3 Was führen Sie am häufigsten durch? 2.1 Für wen agieren Sie als Dienstleister? 2.2 Wie teilen sich die Kosten und Erlösstrukturen grob auf? 3.1 Woher kommen die Altgeräte? 3.2 Wie viel % an Re-use und wie viel an Recycling? 5.1 Was müsste sich ändern? 5.2 Welche Hindernisse ergeben sich bei der Ersatzteilbeschaffung? 5.2 Gibt es Originalteile?
Netzwerk	1. Wie schätzen Sie die Rolle von *Unternehmensname* in der Smartphone-Industrie ein? 2. Wie sieht Ihre Beziehung zu Herstellern oder Providern aus? 3. Gibt es Mitbewerber?	1.1 Mit welchen Unternehmen haben Sie Kontakt? 1.2 In welcher Beziehung (s. rechts) stehen Sie zu Herstellern oder Händlern oder anderen Akteuren? 2.1 Können Sie Beispiele nennen? 2.2 Inwieweit beeinflusst Ihre Tätigkeit die Hersteller?
Kreisläufe	1. Welche Aufgaben der Kreislaufwirtschaft übernehmen Sie? 2. Mit welchen Akteuren arbeiten Sie hierfür zusammen? 3. Was hat der Kunde davon? 4. Was unterscheidet Sie von anderen bestehenden Unternehmen?	1.1 Welche Aktivitäten genau? 1.2 Können Sie Beispiele nennen? 2.1 Clearing-Stelle (EAR) 2.2 Remondis, Aurubis? 2.3 Hersteller, Inverkehrbringer?

Einschränkungen/Entwicklung	1. Gründe für das Engagement 2. Wie sieht bei Ihnen die Zukunft aus? Wo soll's hingehen? Weitere Entwicklung 3. Welche neuen Entwicklungen erkennen Sie auf dem Smartphone-Markt? 4. Und wie sieht es aus mit den Entwicklungen zu Mietgeräten?	1.1 Wieso engagieren Sie sich genau in diesen CE-loops? 1.2 Was hält Sie davon ab, sich auch noch in anderen CE-loops zu engagieren? 2.1 Wie würden Sie sich gerne weiterentwickeln? 2.2 Welchen Hindernissen sehen Sie sich ausgesetzt? 2.3 Wenn Sie mit den großen Playern (Apple, Telekom) sprechen könnten, was würden Sie denen sagen? 3.1 Würden Sie das begrüßen? 3.2 Was würde sich dadurch für Sie verändern?
Sonstiges	1. Möchten Sie noch etwas hinzufügen?	

Appendix 1c

Codesystem

First level	Second level	Third level	Fourth level
other sustainability challanges and effects			
future development			
Demografic Information of Case Companies			
	expert_1		
	binee		
	shift		
	Teqcycle		
	AfB		
	iPassions		
	akkutauschen		
ICT and Smartphone Industry			
Circular Economy			
	CE activities		
	motivation		
	legal developments (in Germany and EU)		
	loops		
		internal loops	
		maintain	
		re-use	
		refurbish / remanufacture	
		recycle	
	loop operations		
		income	
		broader industry-influence	
		competitors	
		customers	
		cost structure	
		barriers	
		key competences	
		value offer	
	Building Blocks of a CE		
		skills in building cascades / loops	
			support

			certified partners
			treatment
			collection
		new business models	
			Product Service Systeme
			performance based
			additional services
		skills in circular product design and production	
			knowledge
			material selection
			spare parts availability
			reparability
			modularity
Transaction Cost Theory			
	relationship to focal actor		
		institutionalization	
		characterization	
			negative
			frequency
			strong
			none
			loose
		Value Creation Architecture	
			independent
			ally
			buy
			make
	network		
		partnerships with NGOs	
		manufacturer	
		additional partner	
		customer	
		supplier	
		key partner	
	classical influencing factors		
		asset specificity	

	uncertainty
	frequency of transaction
additional influencing factors	
	cost
	no partner known
	degree of innovation
	quality requirements
	technological developments
	legal developments
	strategic relevance