Master's Thesis Internship - Sustainable Business and Innovation

Transition Towards a Circular Economy for Mobile Telephones: A Qualitative Analysis on Misalignments in the Socio-Technical System

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Abstract

The circular economy receives growing recognition and is becoming a spear point in the EU's economic and environmental policies. Implementing the circular economy requires all actors in a system to adapt to this new standard altogether. The multi level perspective is a theory that can explain the process of large-scale innovation changing entire socio-technical systems. Perspectives of different social groups – regimes - need to become aligned to ensure implementation of the large-scale innovation. This thesis adopts this theory and analyses the current status of the regime alignment regarding the implementation of the circular economy for mobile phones in the EU. Nine experts covering different regimes in this socio-technical system are interviewed. This data is discussed and triangulated with desk- and literature research. 30 misaligned relations are found, covering 14 different topics. These 14 topics are categorized under 3 broad topics. First, the current policy regime is both promoting and hampering the circular economy with different legislations. Second, no circular business models are in place resulting in market transactions, design issues, and lack of incentives between manufacturers and end-of-life service providers. Finally, some residual misalignments are found and presented. Also, the case for transparency and traceability emerged and is emphasized as a facilitating and supporting role in creating trust and awareness and foster regime alignment.

Executive summary

This thesis is commissioned by 4SquareReturn and aims to generate insights in the advancement of implementing the circular economy in the mobile phone industry. The Multi-Level Perspective theory's view on the alignment of the perspectives of social groups –regimes- is adopted and creates a clear image of the views of these different stakeholder groups and how these misalign with each other. The main findings include policy implications due to the misperception of policy makers of the market, the lack of 'real' circular business models, and a lack of transparency and traceability of materials in the supply chain. These main findings consist of multiple smaller topics, while in addition a final residual group of misalignments is identified.

Recommendations are presented towards 4SquareReturn how the company can support the implementation of the CE in the mobile phone industry. The first recommendation covers leadership skills for organisational change, and does not follow directly from the results of this thesis. Within organisational change literature, however, leadership skills are emphasized as crucial for the success of implementing sustainability in organisations. The important challenges in leadership are stakeholder engagement, creating a culture, holistic thinking, organisational learning, and measurement and reporting. In addition, characteristics of successful change agents and optimized conditions to facilitate these agents are presented.

Second recommendation presents the value proposition, value creation and delivery, and value capture of the general archetype of circular business models. In short, the value proposition is eliminating waste. This value is created and delivered with new activities and partnerships throughout the supply chain and potentially even across economic sectors. Value is captured through the elimination of both economic and environmental costs. A handbook is proposed for establishing a new business model, which 4SR can use to propose and support new business models throughout their network. In addition, they can enhance this business models by deploying their own extensive network to cover the new partnerships and activities in this new business model. Two ideas for this new model are proposed. The first idea is leasing new mobile phones so the OEM maintains ownership of the physical unit. Second idea involves the recovery of units that are already out there stockpiled by consumers. This second part of the circular business model involves a cash incentive, easy to use infrastructure, and a marketing story to mobilize the consumer to initiate the reverse logistics. One final aspect facilitating the circular business model is to increase the user time of a mobile phone by a single consumer.

Third recommendation covers the need for transparency and traceability for a successful implementation and performance of the CE. Two versions are proposed corresponding, again, with new mobile phones and phones already out

there. First, mobile phones already sold are to be updated with an application that informs why and where the consumer can initiate the subsequent life cycle of the mobile phone. Second, new phones can be equipped with a GPS tracker so that when the mobile phone is offline the material can still be traced. The second version better serves the needs for NGOs and policy makers to track and trace WEEE to avoid dumping in developing countries.

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CAQDAS:	Computer Assisted Qualitative Data Analysis
CE:	Circular Economy
CRM:	Critical Raw Materials
DfC:	Design for Circularity
EEE:	Electrical and Electronic Equipment
EERA:	European Electronics Recycling Association
EPR:	Extended Producer Responsibility
EoL:	End-of-Life
EU:	European Union
GHG:	Greenhouse Gas
IPR:	Individual Producer Responsibility
MLP:	Multi Level Perspective
OEM:	Original Equipment Manufacturers
PC:	Personal Communication
PROs:	Producer Responsibility Organisations
REE:	Rare Earth Elements
ST-system:	Socio-Technical system
US:	United States of America
WEEE:	Waste of Electrical and Electronic Equipment
WEEED:	WEEE Directive

1. Introduction

1.1 Background

The increasing human material demand is outgrowing the carrying capacity of our planet (Postel, 1994; Wackernagel & Rees, 1998, p1). Consumption of natural resources skyrocketed in the past century. Not only total demand of materials increases, development of economies significantly changes the composition of this material demand. Krausman et al. (2009) note that where biomass dominates material demand in developing nations, developed economies increasingly demand for ores and industrial minerals. Extraction and consumption of these materials increased 27fold from 1900 to 2005, mainly driven by post-WWII period of economic development and a skyrocketing population growth worldwide. Even though increasing material efficiency is driven by economic incentives, there is no evidence that the rapid growth in material demand will slow down in the near future (Krausman et al., 2009).

Since the popular publication *Limits to Growth* in 1972, many researchers performed material scarcity analysis on different types of materials, geographical focuses and methodologies. In general, conclusions include the message that of most materials the demand should be reduced significantly to enable a sustainable supply for future generations. Henckens, Driessen, & Worrell (2014), for example, note that for at least 15 metals a major reduction in primary consumption is necessary to ensure a sustainable supply. According their analysis, the global extraction rate of antimony needs a reduction of 96% and tops the list, while a considerable 63% reduction for copper is the lowest necessary reduction in the group of 15 metals.

In addition, material demand reduction contributes to combatting climate change. In 2013, the industrial sector emitted approximately 37% of global CO2 emissions, of which an estimated 67% is related to material production (Worrell, Allwood, & Gutowksi, 2016). Combining material efficiency improvements with energy reduction and renewable energy policies can significantly contribute to the global combat against greenhouse gas (GHG) emissions (Worrell & Carreon, 2017).

Global policy leaders and businesses start to acknowledge the need for improved material management. The objective of the European Union's (EU) environmental policy is to preserve, protect and improve the quality of the environment. In the fifth environmental action programme, it is stated that: "the achievement of sustainable development calls for significant changes in current patterns of development, production, consumption and behaviour and advocates, inter alia, the reduction of wasteful consumption of natural resources and the prevention of pollution." (EU, 2012, p.38). To achieve advancements towards more resource efficiency and combatting pollution, the EU adopted the circular economy (CE) package in 2015. This package includes legislative proposals on waste, and an action plan supporting the CE throughout product lifecycles "from production to consumption, repair and manufacturing, waste management and secondary raw materials that are fed back into the economy." (European Commission, 2017, p. 2).

As noted before, advanced economies demand a more diverse mix of materials as products in these economies become more complex (Krausman et al., 2009). One of the most complex product categories is Electrical and Electronic Equipment (EEE), which entails all products with a power plug or a battery. This economic sector demands one of the most diverse mixes of materials for production (Huisman et al., 2012). However, within the EEE sector, material demand significantly differs between products. For instance a refrigerator is a far less complex material composition compared to a mobile phone. On the contrary, modern mobile phones demand advanced design skills and knowledge, and complex material configurations. This product group, and more generally all advanced electronic technologies, have gone through rapid innovations through the application of rare earth elements (REE), and represent the most rapidly changing industry to date (O'Connor, Zimmerman, Anastas, & Plata, 2016).

Electronics manufacturer Apple reports that computers in the 80's contained about twelve elements, primarily plastics, steel, aluminium, and copper (Rujanavech et al., 2016). Current computers contain over 60 different elements, often in small amount dispersed throughout the devices (ibid.) Mobile phones developed over the course of 40 years from relative simple devices, to small 'supercomputers'. Modern smartphones contain over 40 different materials, including metals like copper and tin, special metals including antimony and indium, and precious metals such as gold and palladium which are required for the device to function properly (Ongondo & Williams, 2011a).

The complexities typical for these products, and the materials they encompass, make waste management a difficult task. Innovation to harvest materials from these complex waste streams has been lacking and the more complex these products become the more difficult it becomes to engage with efficient recycling and remanufacturing programs (O'Connor et al, 2016; Reck & Graedel, 2012). Hence the necessity for the EU to launch a specific study focused on the improvement of resource efficiency, eco-design, and the CE of electronic products, and specifically focusing on smartphones (European Commission, 2017). Next to product complexity, waste of electrical and electronic equipment (WEEE) is one of the largest and fastest growing global waste streams (e.g. Tanskanen, 2013). For mobile phones, this is only partly caused by the fragility of the products. More important, consumers regard mobile phones rapidly as obsolete, mainly due to quick introduction of improved features and functions in new models (EU, 2012; Ongondo & Williams, 2011a). Most smartphone manufacturers, like Apple or Samsung, introduce new and improved versions every year and consumers from high-income countries typically replace their 'old' mobile phones once every 12-18 months (Bains et al., 2006). The reusability of old but working phones, albeit for less demanding consumers, and the material composition of broken devices make it the most valuable electronic 'waste' product currently found in large quantities (EU, 2012; Ongondo & Williams, 2011b).

1.2 Problem description

In this section issues regarding mobile phones are described. First, global issues resulting from the current economic sector of mobile phones are presented, followed by current regulations and policy programs and consumer behaviour regarding the easiness of retaining an old phone. Subsequently the scientific relevance and the problem for the internship organisation are presented.

Sustainable development entails the three pillars of social, environmental, and economic aspects over an intergenerational time span (Bruntland, 1987). The current performance of the mobile phone sector has consequences in all these aspects. Some examples of social consequences from mobile phones is the use of conflict minerals that finance bloody civil wars in Congo killing millions of people (Epstein & Yuthas, 2011; Kim & Davis, 2016), and inadequate WEEE management leading to lead poisoning of children (Lu et al., 2015). Environmental consequences are due to a significant carbon footprint of mobile phones of 200-400 kg/kg (O'Connor et al., 2016) while mining and processing of the raw materials result in severe pollution of soil, water and air (Krausmann et al., 2009). From a business perspective, inefficient management of WEEE is a literal waste of money as the density of gold in mobile phones is 60 to 70 times higher compared to gold ore (Hagelüken & Corti, 2010). While from a macro-economic perspective the global economy could use an alternative source for the Chinese near-monopoly position on the REE market, with a market share of 97% contributing to geo-political conflicts (Baldi, Peri, & Vandone, 2014; Gavin, 2013). Projected growth for most REE is around 8-11% per year, for those REE crucial for green technologies, such as windmills and electro-motors; projected growth is even higher (Gavin, 2013). Finally, the current consumption of REE affects the ability to meet the needs of future generations, as these raw materials are finite. The implementation of a CE ensures these materials are retained over multiple life cycles, decreasing the need for mining and its related social and environmental consequences, while ensuring more material security for future generations.

However, the current economic system has established as such that the extraction of raw materials from the earth is preferred above the reuse and recycling of materials (Reck & Graedel, 2012). Although densities of precious metals and other materials is higher than in ore, the complexity of mobile telephones is a trade of against the costs of recovery and economic value of these materials (Tanskanen, 2013). Regulations do exist to stimulate material efficiency, like the WEEE legislation in the EU. The focus of these policies is, however, more on recycling than the implementation of CE (Ghisellini, Cialana, & Ulgiata, 2016; Zoeteman, Krikke, & Venselaar, 2009). This focus on recycling poses a problem for a CE, as less energy intensive options such as repair, reuse, and remanufacturing tend to become neglected (Ellen MacArthur Foundation, 2013). On the other hand, the EU is promoting the CE economy through other programs, such as the previously mentioned CE package. It appears these different programs tend to conflict and result in ambiguity regarding CE and recycling (Alev, Agrawal & Atasu, 2016; Lifset, Atasu & Tojo, 2013; McCann & Wittman, 2015).

Due to their small size mobile phones are easily stored and forgotten by consumers once replaced, or deliberately stockpiled as back-up phone. Nokia estimated that in 2008 worldwide about 44% of replaced phones are still possessed by consumers (Darby & Obarra, 2005; Ongondo & Williams, 2011a). Although collection and treatment of WEEE improved since the introduction of the WEEE legislation in 2003, the system is far from being a CE. This lack of effectiveness is expected to be the result of misaligned perspectives among the many involved actors, such as between the CE package and the WEEE legislation.

In the scientific community, concepts such as circular economy, extended producer responsibility (EPR), and the distinction between different cycles of the circular economy are well-documented definitions. And although discussion always exists between researchers - for examples see Kirchherr and colleagues (2017) for the analysis among 114 different CE definitions - in general these kinds of concepts are fairly clear for researchers to work with. However, different social environments of different stakeholders result in so-called blurriness regarding sustainability concepts, hampering their implementation in reality (Ghisellini et al., 2016; Kirchherr et al., 2017). This disagreement between science and practice, and other actors like the government and consumers is present for the EPR in WEEE legislation and CE for EEE. Huisman (2013) quotes about the misalignment between researchers and policy makers around EPR in WEEE legislation: "We have been a little too academic about this" (p.173). Many researchers pledge for implementing design for recovery (e.g. Atasu & Subramanian, 2012; Huisman, 2013; Massaruto, 2014), but in practice manufacturers such as Apple disagree. Firstly because it diminishes product quality, and secondly most collected WEEE is shredded in the pre-processing stage, making design for disassembly useless (Rujanavech et al., 2016). Hence, these kinds of conflicting perspectives between theory and practice pose issues for implementing the CE.

The internship organisation, 4Square Return, is a company group targeting electronics manufacturers to consult and support them with WEEE legislation in the EU and beyond. The different businesses units in the company group offer consulting, demarketing, reverse logistics, and recycling services. Partnerships of the company are present with business and political actors, like Foxconn (mobile phone manufacturer), and Umicore Hoboken (state-of-the-art metal recycling company). 4Square Return's main issue is their believe that WEEE legislation in practice failed and is out-dated, and not as the scientific community intended it to be. This confirms the misalignments discussed in the previous paragraphs. The company is currently already engaged with partners for high-level extraction of metals from e-waste streams. However, partly due to the current regulation of WEEE resulting in the absence of sufficiently available volume, this sorting of specific materials from WEEE cannot grow. Their vision is the establishment of a circular economy for WEEE, and this research will form the starting point for the creation of strategies to be a player in this vision. They aim to become a front-runner in the move towards CE for WEEE and ideally becoming one of the driving forces behind the creation of this CE in Europe and other geographies.

Many researchers, policy makers, and consumers believe that a circular economy is the solution for a sustainable economic system (e.g. Ellen MacArthur Foundation, 2013; European Commission, 2017; Ghisellini et al., 2016). Some research on more holistic levels is conducted, as discussed in the next section. However, a holistic view identifying misalignments, such as the previously two mentioned, involving all the different actors in society regarding the CE for mobile phones has not yet been published. Hence, a gap in this research field exists providing this analysis how the different perceptions following from social environments of the involved stakeholders lead to conflicting issues and perspectives on the CE for EEE, hampering its implementation. Business and policy stakeholders can use outcomes of this research to facilitate strategic decisions to overcome these misalignments and foster CE implementation. For the scientific community, this research aims to overcome the bridge between theory and practice, aiming for more implementable research directions regarding CE. In addition, it forms a theoretical contribution for the field of research regarding large-scale change of socio-technical systems, which is elaborated more in later chapters.

1.3 Previous work on the problem

Ghisellini et al. (2016) published a paper with an extensive literature review on the CE over the past two decades. One of the primary lessons learned is that the CE transition success depends on the "involvement of all actors of the society and their capacity to link and create suitable collaboration and exchange patterns." Other researchers who performed comprehensive studies on the CE found the same aspect, a general need for the involvement and collaboration of all actors to enable a successful transition (e.g. Lieder & Rashid, 2016; Winans, Kendall & Deng, 2016). These publications are all literature reviews, and focused on the CE in general. On the other hand, Sarath et al. (2015) performed an extensive literature review on views and trends in the mobile phone waste management and recycling. However, they did not report on the circular economy in this publication.

Reck & Graedel (2012) note on the challenges in recycling including social behaviour, product design, technologies, and thermodynamics and the social and behavioural aspects might be even more important than the technological aspects. Hence with a holistic focus, however no notion on the CE, while their focus is on metal recycling in general. Also, EPR as a policy principle is researched, encompassing the policy's effect on businesses, consumers, and the market. However again, this is EPR in general, with no notion on WEEE, mobile phones, or the CE (Massarutto, 2014).

Jurgilevich et al. (2016) performed a holistic analysis on the CE with the same theoretical framework as this thesis, which is presented in the next chapter. Their analysis is on the food system, and the use of the theory provided them with "insights on how certain experiments on the way to circular economy in the food system can be up scaled to established practices". Finally, non-scientific publications are present on e.g. circular business models for the mobile phone industry (Watson et al., 2017), a science and technology options assessment about waste management in general in the EU, moving towards the CE (Hollins et al., 2017), and a how-to about the CE in the mobile phone industry by the well-known Ellen MacArthur Foundation (2012).

Other current research focuses on specific parts of CE and WEEE related issues and does not take any system perspective. For example, O'Connor et al. (2016) report on strategies for green engineering to establish the CE electronics. Other research focuses specifically on the collection stage through reverse logistics (Ghoreishi, Jakiela, & Nekouzadeh, 2011), or on the producer as responsible for their waste, which is EPR as theoretical basis for legislation (Atasu & Subramanian, 2012; Lifset et al., 2013), EPR and its interference with the reuse cycle in CE (Alev, et al., 2016), or the relation between firm's behaviour and policies for reverse logistics (Subramanian et al., 2014). It is clear though, that there is a mismatch between implementing CE and the current WEEE economic system with its legislation (Ghisellini et al., 2016; Zoeteman et al., 2009).

Hence, a holistic analysis on the relations within and between actor groups on the implementation of a CE for mobile phones is currently lacking in scientific literature.

1.4 Aim

This research is conducted in combination with an internship at 4Square Returns, specialized in WEEE legislation and processing. Due to this participatory approach with the economic environment, the researcher gains a more practical experience with this environment. This contributes to the goal of providing the scientific community, and the organisation, with a clear picture of reality, while avoiding being too academic, as has been identified as problematic (Huisman, 2013). Aim is to identify misalignments between the different stakeholders' perspectives, facilitating improved coordination to advance towards a CE. With the EU's focus to implement CE, and the hot topic of WEEE management, this research provides a clear contribution to science and society.
It aims to answer the following research question:

> *How are the perspectives within and between stakeholder groups misaligned in the implementation of the circular economy in the socio-technical system of mobile phone in the European Union?*

So, as a start, the aim of this research is to provide a snapshot of the current economic sector involved in the handling of WEEE, and more specifically for mobile phones.

> *How do the WEEE environment and the social groups in the socio-technical system of mobile telephones look?*

Following this depiction of the stakeholders involved in this economic sector and their activities, the viewpoints per group are identified in the second sub question. Goal is to highlight the discrepancy between the different actors in the transition to CE for mobile phones. Note that perspectives, business models, and/or policies are possibly different within certain stakeholder groups. So, there are both inter- and intragroup differences regarding actors' perspectives on the issue and the road towards circularity.

> *What are the different perspectives about the circular economy in the regimes in the mobile phone sector?*

To narrow the focus and create clear-cut barriers for this research, some focus points apply starting with a product-focus on mobile telephones. The interesting physical aspects such as the left-over value of the materials, its quick obsolescence due to rapid innovation, sources of the mined minerals, and their relations to geo-political instability are a few of the reasons to take this product as a focus point of WEEE. Also, the host-organisation of this research is collaborating with a major mobile phone manufacturer making this focus point interesting for the organisation.

As a geographical focus North-Western European Union applies, as this is the area 4Square Returns is mainly operating. However, as the WEEE economy is an intercontinental economic sector these boundaries are not set exclusively. Importantly, due to applying the mobile phone as the product-focus, the outcomes of this research cannot blindly be generalized for all WEEE products, as no one-size-fits-all approach is appropriate for WEEE policies (Darby & Obara, 2005; McCann & Wittman, 2015).

2. Theory

In this section, the theoretical framework guiding this research is presented. It starts shortly with the origins in scientific literature. Subsequently the theory in general, and the important aspects applied in this research are elaborated. Finally, a definition and some implications of the CE are presented.

An essential improvement in innovation system theories is the recognition of the co-evolution between an innovation and the socio-technical system (ST-system) around it (Geels, 2004; 2005; Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007). When an innovation leads to a new technology or concept, this doesn't automatically mean this new concept becomes successful; rather the ST-system has to be ready to embrace this novelty. Actors are part of regimes in this system, which include scientists, users, policy makers and societal groups besides engineers and firms. These social groups interact and form networks with mutual dependencies, resulting in the alignment of activities. This inter-group coordination is represented with the concept of socio-technical regimes (Geels, 2004; 2005; Geels & Kemp, 2007; Geels et al., 2016; Geels & Schot, 2007; Späth & Rohracher, 2012).

As identified previously, there is a lack of alignment between the different social groups regarding the circular economy and the sociotechnical transitions theory can help to understand this. Hence, this string of innovation theory forms the theoretical framework applied in this research. The developed Multi-Level Perspective (MLP) is an analytical tool for large innovation and implementation processes that fulfil societal functions, for example the introduction of the automobile (Geels, 2005), the implementation of the sewage system in the Netherlands (Geels, 2006), or the implementation of the CE in the food system (Jurgilevich et al., 2016).

In short, the framework consists of three analytic levels, from low to high, niche-level, regime-level, and the landscape-level. These levels correspond with the analytic levels micro, meso, and macro, respectively (Geels, 2004; 2005; Späth & Rohracher, 2012). The niche-level is where technological niches with radical innovations develop and are protected in the early 'life' years. The creation of the concept of niches has resulted in a whole string of research: Strategic Niche Management (e.g. Schot & Geels, 2008). When a dominant design emerges, an innovation from one specific niche becomes more widespread and eventually breaks through to the regime-level, meaning the corresponding social groups start adopting the new innovation (Geels, 2005). This process is time consuming, and supported by important internal and external drivers. The internal drivers foster the innovation, e.g. improvement of price-performance ratio, and the support of powerful actors with financial, organizational, and/or political capital (Geels, 2004; 2005). The external drivers occur at landscape-level and create so-called windows of opportunity, allowing an environment for the regimes to change and adopt the new innovation. These drivers are tensions between elements in the regimes, i.e. when activities within and between social groups become misaligned (Geels, 2005). The regimes represent the set of rules that guide the activities of the corresponding social group; this is further elaborated later in this chapter. The different regimes' internal dynamics can lead to fluctuations and variations from their initial set of rules. Mostly these fluctuations tend to be damped due to the interconnectedness with the other regimes through co-ordination. Sometimes however, these fluctuations result in the activities of the different regimes going into different directions leading to misalignment in the ST-system. When the regimes are misaligned changes are possible in the ST- system. Regime actors do not change their activities immediately; this rather involves conflict, contestations, power struggles, and dedicated translations (Geels & Schot, 2007; Späth & Rohracher, 2012).

Subsequently, after an additional time consuming period of change, different regimes embodying the innovation have to become aligned allowing the innovation to break through the landscape level (Geels, 2004; 2005). The 'new' landscape replaces the landscape around the old technology (Geels, 2004). So the landscape plays a dual role, first it allows windows of opportunity for the regimes to co-develop with the new innovation. And later in the adoption process, the new regimes cause the landscape to embody the new technology. Landscape is the hardest level to change, and embodies the material and spatial arrangements of cities and infrastructure (Geels, 2005).

Regarding the MLP theory, the transition from a linear to a circular economy for mobile phones, and WEEE in general, is on the brink of changing the landscape level. Regimes are advancing towards CE over the past years. Some examples are larger scale projects implemented by business from the technological regimes like Desso circular carpet or MUD with their circular jeans. In the policy regime research and decisions are made on different levels, such as the EU's circular economy package (European Commission, 2017) or a report on the vision and possibility of CE in Amsterdam (Amsterdam Circulair, 2015). It is when all the regimes align large scale implementation of a new system is possible, which in this case is moving away from a linear into the circular economy as the standard, the new landscape (Geels, 2004; 2005). Other researchers confirm this need for alignment among all the actors (Lieder & Rashid, 2016; Ghisellini et al., 2016; Reck & Graedel, 2012; Späth & Rohracher, 2012; Winans, et al., 2016). The status of alignment of these regimes in the ST-system of WEEE is thus what is analysed in this thesis.

Geels (2004) divides these regimes in technological, user and market, socio-cultural, policy, and science regimes. Similar categorizations are made in the field of material efficiency where this research is rooted in, noting technological, business, socio-cultural, policy, and the research community as key actors in the system (Worrell et al., 2016; Reck & Graedel, 2012). Alignment of the regimes is analysed according cognitive, normative, and regulative rules that coordinate the actors in the regimes (Geels, 2004). Examples of rules within the different regimes are presented in table 1, adopted from Geels (2004). It is these rules following from the corresponding social bubble, making actors characteristically for a specific regime. So, these rules guide and orient activities of social groups, and the regimes are understood as the semi-coherent sets of these rules (Geels & Kemp, 2007; Späth & Rohracher, 2012). Alignment of these inter- and intragroup interactions leads to stability in ST-systems establishing the status quo, for example designer's search heuristics from the technological regime are aligned with user's preferences in the user market regime (Geels, 2004). This is what the current WEEE system needs; all the regimes need to become aligned in order to realize the CE.

The definition of CE adopted in this thesis resulted from the analysis of 114 definitions:

> *"We defined CE within our iteratively developed coding framework as an economic system that replaces the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes. It operates at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, thus simultaneously creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations. It is enabled by novel business models and responsible consumers."* (Kirchherr et al., 2017, p.229).

Some important aspects of this definition are noted. First, the waste hierarchy is the importance of preferring reuse above remanufacturing, remanufacturing above recycling etc. Worryingly, only one third of the 114 definitions explicated this hierarchy. Second, it incorporates a systems perspective encompassing many different stakeholders. This relates back to the applicability of the MLP framework on large innovations fulfilling societal functions. Finally, novel business models and consumer awareness are important enablers in this systemic shift.

Concluding, this theory is applied to map the current misalignment of the regimes that guide behaviour of the social groups. According this theory, if alignment of the regimes is achieved, large-scale implementation of CE at the landscape level is facilitated.

	Formal/Regulative	Normative	Cognitive
Technological	Technical standards, product specifications (e.g. emission or weight), functional requirements (articulated by customers), accounting rules to establish profitability, ROI, R&D subsidies	Companies own sense of itself (what company are we? What business are we in?), authority structures in technical communities or firms, testing procedures.	Search heuristics, routines, exemplars, guiding principles, expectations, technological guideposts, technical problem agenda, presumptive anomalies, problem solving strategies, technical recipes, 'user representations', interpretative flexibility and technological frame, classifications
Science	Formal research programs (in research groups, governments), professional boundaries, rules for government subsidies.	Review procedures for publication, norms for citation, academic values and norms	Paradigms, exemplars, criteria and methods of knowledge production.
Policy	Administrative regulations and procedures that structure the legislative process, formal regulations of technology (e.g. safety standards, emission norms), subsidy programs, procurement programs.	Policy goals, interaction patterns between industry and government (e.g. corporatism), institutional commitment to existing systems, role perceptions of government.	Ideas about the effectiveness of instruments, guiding principles (e.g. liberalization), problem-agendas.
Socio-cultural	Rules that structure the spread of information production of cultural symbols (e.g. media laws).	Cultural values in society or sectors, ways in which users interact with firms.	Symbolic meanings of technologies, ideas about impacts, cultural categories.
User-market	Construction of markets through laws and rules, property rights, product quality laws, liability rules, market subsidies, tax credits to users, competition rules, safety requirements	Interlocking role relationships between users and firms, mutual perceptions and expectations	User practices, user preferences, user competencies, interpretation of functionalities of technologies, beliefs about the efficiency of (free) markets, perceptions of what 'the market' wants (i.e. selection criteria, user preferences).

Table 1 Examples of the rules in the different regimes, adopted from Geels (2004)

3. Methodology

In this research a deductive research strategy is applied within a case study design with a qualitative methodology, further explained in this section. First, the deductive approach is shortly elaborated. Second, the different steps in answering the research question are presented. Third, an elaboration of the different activities performed in these steps and the assurance of research quality are presented. Finally a short summary is presented to conclude on this methodology.

The deductive approach, most characteristically related to quantitative research, represents the commonest view of social research (Bryman, 2012, p.24). In this approach an established theory drives the research process by enabling the researchers to observe reality and explaining its observations through the accompanying theory. Subsequently this leads to results and a potential revision of the theory in the conclusion and discussion (Bryman, 2012, p.24). This approach is most often, but not always, accompanied by quantitative data. In this research qualitative data is collected, as this better suits the exploration of rules and behaviour of people (Bryman, 2012, p.35-36).

First, for the first sub-question a literature review is performed defining the social groups in the ST-system of mobile phone life cycles and their process towards CE. Short explanation of the groups and their role create a depiction of the WEEE ST-system. The second sub-question focuses on the shared perspectives on WEEE and the existing regulations, knowledge, and intentions. Based on desk and literature research the different social groups are merged into six larger groups sharing similar perspectives. These shared perspectives among the social groups are the regimes, as explained in the theoretical section. Subsequently the desk and literature research explore the formal, normative, and cognitive rules that structure the regimes as accurate as possible. This forms the basis for answering the main question. These two sub-questions form the background for the main research question, and are presented in chapter 4.

The main research question is answered by analysing the perspectives explored in chapter 4, of the different regimes, identifying misalignments delaying the CE implementation process. For this analysis, data gathering consists of three different methods. Qualitative data is gathered by interviewing experts both with WEEE knowledge in general and/or specifically from the mobile phone ST-system. In addition, literature research and desk research are performed to supplement the interview data. These three methods together allow triangulation and discussion of the findings of different regimes and actors.

Desk research incorporates gathering information from industry specific journals or magazines, both online and offline. In addition, documents are retrieved from organisational archives. These play a supportive role in organisational case studies using interviewing methods (Bryman, 2012, p. 551).

For the document research Scott's four criteria are taken into account ensuring authenticity, credibility, representativeness, and meaning of these secondary sources (Bryman, 2012, p.551).

Interviews are carried out using semi-structured interviews with an interview guide to ensure covering all regimes and rules, while avoiding closing off potential new insights not previously covered by the literature review (Bryman, 2012, p.472). The interview guide is created based on the literature review of the relations between and within the regimes, and following Bryman's semi-structured interview guideline 'Preparing an interview guide' (p.472). The interview guide is presented in appendix A. Interviews lasted between fifty minutes and one hour and 15 minutes, averaging about one hour. After the interviews are conducted and transcribed, interviewees were asked to check the transcripts to ensure correct data.

A case study design is employed in this research, with the case environment based in the internship organisation, 4SquareReturns. Although, it is necessary to encompass the system related to the implementation of the CE of WEEE. So, the case involves the related network of this environment with 4SquareReturns in Germany in the centre. Most interviewees are approached and interviewed through this network, and some additional interviewees are approached via other channels. A total of 9 interviews are conducted, all with experts with different backgrounds but all involved in WEEE, mobile phones, and/or CE. The interviewees, minor job description, and the regime they felt affiliated with or had enough knowledge about are presented in table 2. Note that interviewing occurred on an anonymous basis, while this thesis is under NDA; hence some information is absent.

Interviewee 3 preferred no audio recording during the interview; time between questions was made available to ensure sufficient notes. Interviews 7, 8, and 9 are all in Dutch due to a higher level of convenience during these interviews. These interviews are not translated. Besides these two 'issues', no other issues or problems have occurred during data collection. A few approached potential interviewees have not responded, so unfortunately no EU-level policy maker is interviewed. Desk research of policy documents such as letters, amendments, proposals, and directives are found on EU websites and complemented interview data. Hence, with the current interviews and complementing data theoretical saturation is achieved.

Data from interviews, documents, and desk research were analysed by coding using computer assisted qualitative data analysis (CAQDAS) with the NVivo software. This software is discussed in Bryman (2012, p.592), and makes coding and retrieving faster and more efficient. Concerns described in this discussion, such as the quantification of findings and de-contextualisation of statements, are taken into account in the analysis process.

PC	Job description	Regime(s)
PC1	Research and consultancy on WEEE take back issues	Research and consultant for technological OEM, technological EoL, and user-market. Familiar with socio-cultural and science
PC2	Business development specialist of recycling solutions provider, collaborating with OEMs on tailored recycling processes, take-back solutions and other CE issues	Working in technological EoL. Guiding and supporting policy and technological OEM.
PC3	Vice president sales of recycling solutions, selling tailored equipment to recyclers	Technological EoL
PC4	Legal counsel for WEED consultants and OEMs, former lawyer on environmental law. Expert on EU circular economy package.	Knowledge on policy, supports OEMs on user-market issues
PC5	Owner of law firm, counsel on legal aspects on WEEED. Guest professor on WEEE take-back and recycling. Former government affairs director for OEM at EU level, worked for state government of EU member state.	Science, technological OEM, User-market, good relationship with and knowledge of policy, and supports technological EoL
PC6	Business development manager on building blocks for CE; reverse logistics all the way to secondary raw material	Technological OEM
PC7	International Business Manager for a branch organisation of electronics recyclers	Collaborating with science, representing recyclers (technological EoL), lobbying on policy
PC8	CEO & Founder repair and refurbishment company	Technological EoL and user-market
PC9	Director Operations for refurbishment company	Technological EoL

Table 2 Information of the 9 personal communications (PC) in the form of interviews. In text references to interviews are marked with PC#.

With the analysis of the expert interviews, triangulated and complemented with literature- and desk research, relevant misalignments between regimes are identified. Between the different regimes, 15 possible relations occur (1-15) and 6 possible misalignments within a regime (16-21), as presented in figure 1. These 21 relations formed the initial 21 nodes for the coding process creating some structure in the vast data set. Some data is coded under more than one relation if related to multiple relations. Subsequently, coding is performed via open coding, which is 'the process of breaking down, examining, comparing, conceptualizing and categorizing data' (Bryman, 2012, p.569). This allowed for exploring concepts without previously defining them. In this second round of coding 30 misalignments are uncovered over the 21 relations. Subsequently, the concepts were grouped and formed categories (Bryman, 2012, p.569). Through categorizing the data of the 30 misalignments, 14 different topics were identified. Hence, most topics involve two or more misalignments. Every topic is elaborated per section in chapter 5, analysing and explaining the related misalignment. The different formal, normative, and cognitive rules structure and support the analysis (see table 1). Finally, through further categorization, the 14 different topics are merged in three broader topics. Each broader topic is presented and discussed in its own sub chapter, with the

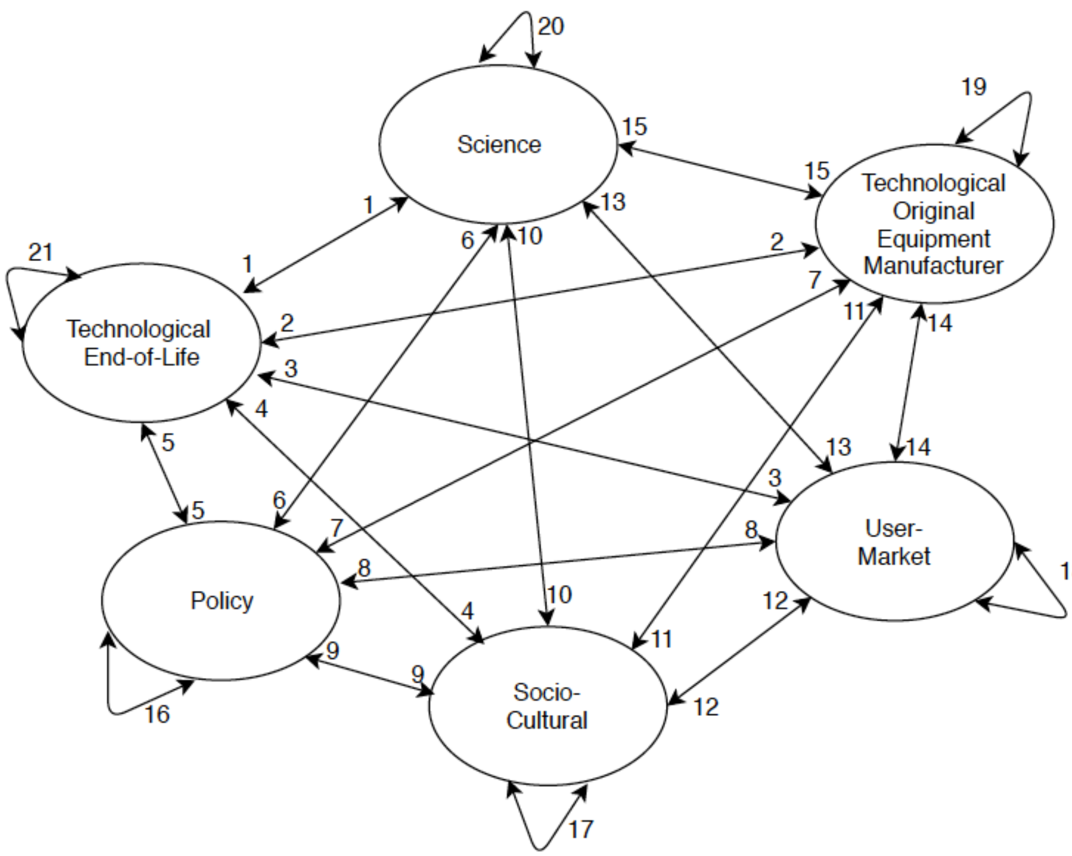

Figure 2 All inter- and intragroup relations within the ST-system

topics of misalignments as section herein.

So, for example, in the first round of coding, data from interviews regarding the relation between technological EoL and technological OEM regimes are coded: “2. Technological EoL and Technological OEM”, as can be adopted from figure 1. During the second round of coding this node was divided regarding topic, resulting in the codes: “Refurbishment and other business models”, “Market transactions”, and “Product design”. In the third round, these three nodes are arranged into a larger category of nodes across multiple relations representing “Lack of Circularity”. Hence, the topics are presented in sections under sub chapter 5.3. The complete NVivo codebook is supplemented in appendix B.

The quality of this research is assured according the reliability and validity concepts adapted from the deductive approach (Bryman, 2012, p.390). First, external reliability is the degree to which this study can be replicated. This is assured with the publication of the interview guide. In addition, researchers replicating this research are advised to adopt a similar participatory role. Second, internal reliability is the degree of consistency. This is ensured by reporting on the choice of interviewees, choice of coding, and other decisions so the supervisor and other readers can act as auditors on the process. Third, internal validity is the match between theory and observations. This is ensured with data triangulation of desk research, interviews, and literature research. Finally, external validity is the degree to which the results can be generalized across different settings. The misalignment of regimes can be generalized over all socio-technical innovation processes. However, it is important to note that more specific outcomes are not to be generalized over other products than mobile telephones. As noted previously no one-size-fits-all approach can be adopted even within WEEE streams.

To conclude, literature study, desk research, and experts interviews are combined analysing misalignments between the perspectives of groups of actors involved with mobile phone production, consumption, and End-of-Life treatment. Accordingly, the advancement towards the CE is analysed for this ST-system.

4. The MLP perspective on mobile phones

In this chapter the MLP theory is applied on the case study of this thesis answering the two research sub questions. In the first sub chapter the social groups in the mobile phone industry are explored to understand the involved actors in the different regimes. Policy regarding this industry encompasses the EEE sector in general. Hence, the first sub question involves exploring WEEE environment for these more generalized social groups affecting the mobile phone industry. The second sub question, answered in the second sub chapter connects the social groups with the regimes. The rules that structure the behaviour within these regimes are explored. By creating this depiction of the social groups and the regimes according which they behave supports the understanding of misaligned perspectives hampering the CE implementation for mobile phones presented in chapter 5.

4.1 Social groups in the socio-technical system of the mobile phone industry

Figure 2 presents the author's interpretation of this system based on Geels' (2004) view on the social groups that carry and reproduce ST-systems, complemented with own insights from involvement with the industry through the internship organisation and literature. The filled lines represent material and product flows, while the dashed lines represent other non-physical relations. The different social groups are presented, following the visualisation as presented in figure 2.

The production chain is the part of this system wherein the physical product is produced from scratch. This production chain starts with *design firms and technical institutes*, on the left side in the middle of figure 2. These are in-house activities by mobile phone brands like Apple and Samsung. The design is, after all, the core business of the brand representing what it delivers. Apple notoriously inscribes in every iPhone: Designed by Apple in California, Assembled in China, making design one of Apple's core activities (Apple Inc., 2016).

Then, *suppliers of materials, components, and tools* ensure physical input for production. Raw materials are scarce and regularly involved in economic or political conflict on global scale. Both Samsung and Apple discuss risks for their businesses with conflict minerals and rare earth materials in their annual reports (Apple Inc., 2016; Samsung, 2018a). Additionally, production of components is mostly outsourced to specialized companies. Samsung, for example, currently has approximately 2500 suppliers for raw materials and components across the globe (Samsung, 2018a). The enormous numbers of suppliers and the involved risks in their production chain demand brands like

Apple and Samsung to be excellent supply chain managers, which is another part of their core activities.

The next step is where *firms, engineers and designers* are involved; all components are assembled into the final product. Apple outsources its assembly process to third-party manufacturers, as can be derived from the previously mentioned inscription in every iPhone. So, for Apple this social group involves actors from multiple companies, like Foxconn (Apple Inc., 2016). The other biggest mobile phone brand, Samsung, owns its assembly factories hence engineers and designers in this stage are working within the same company (Jin-young, 2015). In-house or outsource manufacturing is typically a strategic decision based on a company's competencies and resources.

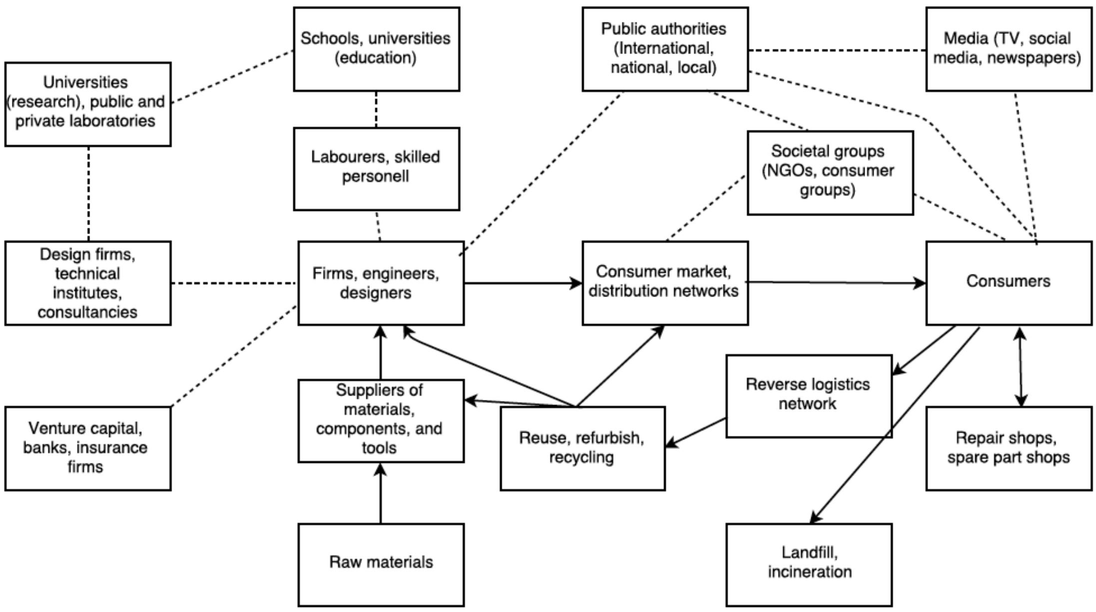

Figure 3 The social groups in the mobile phone industry (adapted from Geels, 2004)

Subsequently the products are distributed to customers through *distribution networks* and *consumer markets*. Apple reports that their distribution and sales channels in 2016 consisted of 25% through their direct channels of retail and online Apple stores, while 75% is distributed through cellular network carriers, wholesalers, retailers, and value-added resellers (Apple Inc., 2016). Subsequently, *consumers* use the mobile phone in the user-phase. This user-phase of one consumers averages 18 months in developed countries (Bains et al., 2006). In general, the consumer market can be divided between private and business use of phones. Business phones are most often leased in large batches to an organisation, while private phones are more likely to be bought.

After-sales service is an important industry involved in the user-phase and is facilitated by *repair and spare parts shops*. Samsung and Apple repair service is both in-house in service centres or stores, and outsourced via third parties such as insurance companies, brick-and-mortar repair shops, or network carriers.

Public authorities set rules and laws for all the other actors in the ST-system. This social group plays a crucial role in the implementation process, as they ensure institutionalisation of the innovation (Geels, 2005). This social group, especially in the EU, is influenced by public opinion represented through, and formed by *societal groups*, *media*, and the *consumers* (Ghisellini, et al., 2016). Regarding CE in general, the EU implemented the Circular Economy Package in 2015. This includes legislative proposals, financial research support, and an action plan contributing to "mainstreaming the concept of circular economy" (European Commission, 2017). Affecting the mobile phone ST-system specifically, the EU implemented Directive 2002/96/EC on WEEE in 2003, which was updated with Directive 2012/19/EU in 2012. This directive aims to contribute to sustainable consumption and production, promoting reduce, re-use, recycling, and promoting environmental performance of WEEE. Another important legislation is the Basel Convention, which is posing strict regulations on the trans boundary shipments of used EEE. Under this regulation, WEEE is bound under strict rules during cross border shipping (Secretariat of the Basel Convention, 2017).

After-use phase of the products is the potential input for the different cycles possible in the circular economy, i.e. reuse, remanufacture, and recycle. The performance of the CE in the current system is not close to real circularity. Last data published specifically regarding mobile phones in the EU is from 2010, when 85% of all mobile phones either ended up in the landfill or is 'unaccounted' (Ellen MacArthur, 2012).

The WEEE directive (WEEED) puts the responsibility of waste treatment at the OEMs through EPR. However, the core business of OEMs is the production of mobile phones rather than organising waste treatment processes, resulting in the establishment of producer responsibility organisations (PROs). PROs subcontract collection, and waste treatment companies to carry out the day-to-day activities. The costs are recovered from the OEMs proportioned according their market shares, while the PROs report the results to the national government. Operations of PROs differ between the EU states, depending on the transposition of WEEED into national law. In general PROs are based national, upon industry sector, or multinational, or there are multiple competing schemes within a country (Mayers & Butler, 2013).

PROs usually organise *reverse logistics* of disposed phones through municipal and retailer collection points (Mayers & Butler, 2013). Although subject to high differences between EU states, only about 37% of all WEEE generated is collected in the EU (Baldé et al., 2017). Some OEMs and all refurbishers, contrarily, set-up own reverse logistics to collect used phones. Typically these phones are mostly still working. These collection schemes differ from PROs in the sense that they are controlled as the company knows what the consumer is handing in through information systems. Based on this information the company gives some financial reward to the consumer, hence these mobile phones are likely to be resold, repaired, or refurbished and therefore of higher quality. As a result, these reverse logistics systems involve more investment for deploying this infrastructure, and generate lower volumes compared to municipal collection sites.

Some of the products are ready for direct *reuse* and resold by third party companies or by consumers themselves via Internet marketplaces. This stream is more likely to be collected by other parties than the PROs. Remanufacturing in the electronics industry is termed *refurbishing*, and refers to "replacing faulty components with functioning components cannibalized from other stock or bought new" (Parker et al., 2015). According some estimates the current refurbishment market for all ICT and electronics (including mobile phones, laptops, tablets etc.) in the EU is €1.8 billion, about 1% of the first hand market value (Parker et al., 2015). The majority of collected phones in the refurbishment sector come back due to finished lease deals of business phones with organisations. Hence, these streams are large batches of similar phones, without the need for complex collections infrastructure. Also, regardless of legislation opposing export of used EEE, informal repair, refurbishment and resell shops are big business in developing countries like Nigeria (Odeyingbo, Nnorom, Deubzer, 2017), or Ghana (McCann & Wittman, 2015). Again, these streams are more likely to be arranged by other parties than PROs. In line with the waste hierarchy, refurbishment is preferred above recycling in CE (Ellen MacArthur Foundation, 2012). Finally, *recycling* involves processing the used products back to raw materials, meaning no parts or components of the original device are assembled. This stream is mostly handled by PROs via the previously mentioned municipal and retail collection sites. Also, at least in reported data required under the WEEED this is the majority of the WEEE.

Subsequently, the dashed lines in figure 1 present non-physical relations between other social groups part of the ST-system. *Societal groups*, like NGOs or consumer groups, have the leverage power to influence consumer behaviour, and vice versa are fuelled by consumer interests. Greenpeace, for example, published 'The Guide to Greener Electronics 2017' to create awareness among consumers how the 17 leading consumer electronics companies perform environmentally. When these groups receive enough support they can lobby at public authorities to implement or adapt regulations, especially in the EU where social pressure is important for EU policymaking (Ghisellini, et al., 2016).

Media play a similar agenda-setting role to both create consumer awareness and pressurize public authorities. One of media's tactics, and of NGOs and international organisations, is 'naming and shaming' (Hafner-Burton, 2008).

This happened to consumer electronics producers due to the relation of conflict minerals financing warlords and resulting in the death of millions of people in Congo (Hobson, 2016). Following this media attention and public outrage the US implemented the Conflict Minerals Act (Vogel & Raeymakers, 2016).

Schools and universities are responsible for the creation of human capital, educating *labourers and skilled personnel*. In addition *universities and public and private laboratories* are responsible for research and development. These social groups generate and facilitate innovations in the corresponding economic system. This in turn fuels the *design firms, technical institutes, and consultancies* that play part in the design and manufacturing phase of the mobile phones. Finally, *venture capital, banks, and insurance firms* play an important role in financial support for innovation processes. However, in the case of large mobile phone producers like Samsung and Apple the financial resources are abundant with immense financial performance and stock listing.

4.2 The regimes in the ST-system

The rules that form the regimes are presented in table 1 in chapter 2. The social groups presented in the previous section (figure 2) behave according these rules. As a result, these groups are part of regimes, presented in figure 1. In this section these regimes in the ST-system of mobile phones are elaborated. Hence, the different perspectives about the circular economy within the mobile phone sector are identified according this framework. This answers the second sub question of this thesis.

4.2.1 Technological regime(s)

The technological regime consists of companies delivering a product or a service. More specifically the formal and regulative rules guides engineers and designers with technical standards, product specifications and functional requirements. While more generally for the company accounting rules, ROI and R&D subsidies are mentioned by Geels (2004). These rules are partially set by other regimes, i.e. technical standards and product specifications in part by policy regime, while functional requirements are linked with consumer preferences of the user-market regime. The normative rules encompass aspects such as the company's sense of itself, authority structures and testing procedures (Geels, 2004). Cognitive rules in this regime are comprised of activities such as search heuristics and routines, and concepts such as the technical problem agenda and problem solving strategies (Geels, 2004).

Two technological regimes are introduced for the analysis of the transition to CE in WEEE. Although both of the technological regimes are part of the environment, they clearly represent two very different social groups and need to be separated for a clear analysis. The first introduced technological regime is involved with the end-of-life (EoL) treatment of WEEE, enabling the reverse logistics, recycling, refurbishing, and/or reuse of mobile phones, and other EEE. The second technological regime in this ST-system guides the social groups involved in the design and manufacturing of the EEE, hence the OEM and their designers, engineers, management etc. Dividing the technological regime in these two different regimes represents the two different economic sectors involved in the complete life cycle of mobile phones, as visualized in figure 1.

4.2.2. Technological EoL Regime

EoL can be argued to be the wrong term regarding the CE, as the goal in this system is that there is no waste, so there will never be the end-of-life of a material. In this analysis, however, EoL is referred to as the end of a lifecycle for a product, so whenever it leaves its current owner either as donated to family or friends, for remanufacturing, or for recycling.

The social groups of this regime are represented in figure 1 with the reverse logistics network, and the reuse, refurbish, and recycling treatment flows. As companies delivering these services are all in the loop that is closing the material circle, these are categorized under this one regime. Their activities and environment are so different compared to technological OEM, hence these two technological regimes are separated for this analysis. As discussed in the previous chapter, the OEMs are responsible for the waste of their products under the WEEED. They organize these activities through PROs in the WEEE so they can focus on their core business of manufacturing. PROs subcontract collection, and waste treatment companies to carry out the day-to-day activities. The costs are recovered from the OEMs proportioned according their market shares, while the PROs report their results back to the national government (Mayers & Butler, 2013). Subsequently, the national government report the results to the EU, and this data can be found on the Eurostat website. In addition, however, more valuable streams are collected by e.g. refurbishment companies. They created their own reverse logistics channels collecting mobile phone from consumers and rewarding with cash incentive. The actors within this regime, therefore, still behave on slightly different rules and are presented individually.

PROs

PROs are the result of the regulative rules of the WEEE directive, and are non-profit organisations. They are responsible “to collect a sufficient quantity of waste from local authority and retailer waste collection points to cover their aggregated producer members’ obligations at a cost low enough to sustain competitive pricing compared to other PROs.” (Mayers & Butler, 2013). So, local authorities are customers of the PROs and exert commercial and political pressure to address needs and concerns. An ongoing commercial relation needs to be managed not only with the local authorities, also with every individual collection point (Massarutto, 2014; Mayers & Butler, 2013). The organization and management of PROs differs between EU nations, but in general PROs costs are covered by the OEMs who pay according their market share, while downstream sub-contractor partier, such as recyclers, pay for PROs for the streams. A big general issue in this process is scavenging; valuable parts or devices disappear from the collection points before ending up at recyclers. It is these parts where recyclers make the most money, and wherefore they pay the PROs for the streams to process (EUWID, 2018; Mayers & Butler, 2013).

Normative set of rules is similar as with other organizations. With the search of subcontractors price and quality of service are important, hence a market mechanism is in place, e.g. this is the case in the UK. Competition with other PROs potentially causes problems through under- and over collection. In countries such as the UK, this balancing goes through negotiation, PROs can deliberately over collect and charge high prices to balance their collection with the under-collected PRO (Mayers & Butler, 2013). In Germany or the Netherlands, the authorities are more involved with PROs. However, here it appears that recyclers pay to high prices, while subsidies go to other activities such as awareness creation. Also, other potential downstream partners, like refurbishers, face a general lack of interest from PROs to collaborate. These issues are more elaborated upon in chapter 5.

Cognitive rules are based around the organization of all the activities subcontracting recycling, collection, and waste treatment while reporting to the authorities and competing with other PROs. Planning of these organizations are likely to start a few years prior commencing. Examples of these activities are submission of licensing applications, auditing of subcontractors, and the establishment of evidence based reporting to authorities, while being cost effective (Mayers & Butler, 2013).

Reverse Logistics Network

Important challenges for the CE for mobile phones are in the *reverse logistics network* (Parker et al., 2015; Sarath et al., 2015). Consumers tend to retain their phone after acquiring a new model; hence an active approach to enable the collection of their old model is important. Nokia did a global survey on what consumers have done with their previous mobile phones, finding that 40% kept its phone as a spare. 18% gave it to friends or family, while 9% either sold it or traded it for a new phone. 12% ensured the phone was recycled and 7% lost it, broke it, or it was stolen, leaving an additional 14% corresponding with non-mentioned activities (Tanskanen, 2012).

As previously mentioned, a general distinction can be applied between two types of reverse logistics networks. On the one hand, the majority of collection occurs through the organisation by PROs via municipal and retail collection sites. Formal rules are how the PROs organise these activities, dependant on the available infrastructure in countries. Their costs are covered via the OEMs, and in some countries the recycling partners pay the PROs for the waste streams. The 'technical standards' in these collection processes are rather characterized by bunk collection of all types of WEEE in big container or collection boxes. Hence, if a device was still working and could be repaired or refurbished, this standard decreases the value. However, these collection processes by PROs are bound for recycling immediately anyways, as no sorting activities are applied in this process.

On the other hand, reverse logistics is organised by OEMs, resellers, or refurbishers. These one-by-one collection are mostly initiated online, where as a phone owner you can fill in information, you receive an envelope and a financial reward, and your phone is repaired, refurbished, or resold by a third party. One example of an OEM is the Apple GiveBack program. Third parties involved in this activity are numerous and can easily be found online. In these reverse logistics processes technical standards are set in such a way that the value of the collected phones is retained. Profitability is largely dependant on the collection process ability to retain this value, and the volume it can and will generate. Hence, in these market driven processes, the company controls the quality and quantity of the stream with the right incentives towards the consumer (Guide & van Wassenhove, 2009).

Normative rules differ between these two types of collection processes as well. PROs are established under WEEED as non-profits handling WEEE commissioned by OEMs. Their authority structures are not pro-active, lacking interest in additional activities, as will be discussed later in chapter 5. Normative rules of the market-driven collection schemes are discussed in the refurbish section on the next page.

Cognitive rules are formed by the problem agenda regarding collection process of mobile phones. As mentioned previously, mobile phones tend to be stockpiled by their owner requiring the need for innovative strategies to create the right incentives. Ease of use, strong messaging, and the right incentives are crucial factors for these strategies (Tanskanen & Butler, 2007). Ghoreishi et al. (2011) modelled a take back process for mobile phones, and found that a discount incentive is more successful compared to a cash incentive, and that the frequency and quality of advertisement has a higher effect on return compared to the height of the financial incentive. In addition, costs of collection are an important factor in the recycling and refurbishing of mobile phones, especially in more rural areas where these costs can become significant expenses (Parker et al., 2015).

Reuse

The reuse stream is the least energy consuming, and therefore the most preferred option in the CE. Consumers who are selling or donating their phone are likely to pass them on to friends and family, or sell it through Internet market places (Parker et al., 2015). These activities are not necessarily driven by environmental concerns, but rather economic incentives or the belief the product has value for other people (Clausen et al., 2010).

For companies involved in the reuse cycle, the economic incentive mentioned in the previous section is the most important part of their business model. With the right incentives for collection they are able to collect large enough volumes. The normative rules for these companies are two-fold, as some companies emphasize the environmental benefits for reuse; other companies are purely in this business for economic gains. Data on re-use activities is lacking in general, the only case study is performed in Flanders where turnover quadrupled from 2001-2012. Flemish government actively promotes reuse activities with a strong network including job provision for vulnerable target groups. Its reuse activities are structurally embedded in Flemish waste policies (Hollins et al., 2017).

Refurbish

Formally, the refurbishment industry is characterised by trans boundary shipments, leading to the fact this falls under the Basel Convention opposing illegal WEEE transport to third world countries. In practice, however, buying used products one-by-one is not seen as large-scale shipment; hence on these single-phone streams no reporting is observed. Another formal rule regarding this social group is the need for reporting on their refurbishing activities under the WEEE legislation (EU, 2012). However researchers note reporting is a large part of a refurbisher's costs (Hollins et al., 2017; Parker et al., 2015), in practice this reporting by the refurbishers is not observed either. In addition, Parker et al. (2015) note on the cost structure of refurbishers and their ability to create jobs for highly skilled personnel for refurbishment. Refurbishers labour costs are relatively high to cover inspection, disassembly, remediation, reassembly, testing, etc. Product standard for the refurbishment industry is 'as new' conditions, and selling these products is mostly in original packaging (Parker et al., 2015). However, there is no international benchmark of these product standards, hence these 'standards' differ per refurbishment company. Another boundary imposed by legal and formal issues is a lack of technical information of third party products. Although included as a requirement for OEMs in the WEEED, knowledge necessary to facilitate refurbishment of mobile phones is not readily available for non-OEM refurbishment companies (Parker et al., 2015).

An important normative rule for the refurbishment companies is that of the testing procedure related to the previously mentioned product standard. As the product standard presented to consumers is 'as new', although a general standard between companies is absent. Hence, as examined by the Consumers Association in the Netherlands, 6 out of 18 tested 'as new' refurbished iPhones are labelled as 'A good deal'. The other devices suffered bad batteries, and significant scratches and damage. Hence, the differences in quality between the refurbishment companies are remarkable (Consumentenbond, 2018).

The main cognitive rule coming forward from literature is regarding the problem agenda for refurbishers. Parker et al. (2015) summarized these in three challenges for *remanufacturers across all industries.* First, product design plays an important role in determining the ease of refurbishment. This issue appears to be one of the greatest issues in remanufacturing and recycling of mobile phones and is mentioned by policy makers, OEMs, scientists and actors from recycling and refurbishing industries (e.g. EU, 2012; Rujanavech et al., 2016; Huisman, 2013). Second, remanufacturing process technologies need to be further developed to create efficiency. One of the main issues is the costs related to manual disassembly, which is high in western, high income countries (e.g. Reck & Graedel, 2012). Third, business models for refurbishing companies have to be viable, especially regarding collection of old devices and selling 'as new' (e.g. Consumentenbond, 2018; Tanskanen, 2013).

Recycle

According to the previously mentioned study of Nokia, it appeared from consumer survey that 12% ensured their phone was *recycled* (Tanskanen, 2012). Recent estimates of the amount of mobile phones that are actually recycled are difficult to find, one study estimated that in 2010 in the Netherlands recyclers processed 43% of IT products put-on-the market 3 years prior (Huisman et al., 2012). Globally, an estimated 20% of all the WEEE categories combined was documented and recycled. It is important to note that recycling and collection rate across the EU, and globally, significantly differ between states (Baldé et al., 2017; Hollins et al., 2017; Huisman, 2010).

Recycling companies in this analysis are categorized according three characteristics, as presented in table 3. These categorizations, however, are not mutually exclusive nor comprehensive and only presented to add some clarity to the text. Pre-processing recyclers buy waste streams from PROs, and from other sources. They pre-process it according two different pre-processing technologies; shredding or disassembly. Shredding is on a larger scale, however disassembly is a better separation technique and improves the quality of the output. Then, in a later position in the market companies ensure secondary raw material is prepared for reuse (e.g. through smelting) and subsequently fed back into the market. Finally, a separation is possible on the basis of formality. Formal recyclers are registered and report their performance for national recycling reporting. Informal recyclers do not report, and are companies or people who pick up old scrap from the streets (i.e. 'oudijzerboeren' in the Netherlands). Also, the repair, refurbishment, and recycling in developing countries fall under this category.

Category		
Position in market	Pre-processing	Feedback to market
Pre-processing technology	Shredding	Disassembly
Formality	Formal	Informal

Table 3 Categorizations of recycling companies

Formal and legislative rules for recyclers are under the same legislatives and formalities as the other social groups in this technological EoL regime. Regarding recycling there is less legal ambiguity, as it is clearly waste processing. The administrative costs for reporting under WEEE are significant, typically around 20% of operating expenses for recyclers (EUWID, 2018). The informal waste sector currently treats most WEEE globally and operates both in countries lacking formal and regulative rules, and in regulated countries (Tanskanen, 2013; Zoeteman et al., 2009). This constitutes work that takes place in unincorporated enterprises that are unregistered or small, but not necessarily illegal (McCann & Wittman, 2015). In regulated countries, this allows them the 20% cost savings avoiding reporting (EUWID, 2018). Illegal exports of WEEE resulted in the informal sector in developing countries. Due to many environmental and social issues, this is controlled with WEEE regulations (Annex 6 of WEEED) and the Basel Convention (McCann & Wittman, 2015). Currently, however, there is an increasing demand from this informal sector in developing countries to import used devices for their second hand, and repair markets (e.g. Odeyingbo et al., 2017).

In the formal sector, recyclers' normative rule 'sense of themselves' is both environmental and economic, based on supplying the EU with a secure and consistent flow of raw materials (Hollins et al., 2017). Between the different recyclers additional normative rules are slightly different, due to the different positions in the industry. This position can be divided in pre-treatment and feedback to the market (Tanskanen, 2013). First, pre-treatment involves sorting and separation of materials and components. This activity is executed either by shredding of devices, or disassembling in components (Rujanavech, 2016; Tanskanen, 2013). Manual disassembly for recycling, contrarily to remanufacturing, is not economically feasible in western countries (Reck & Graedel, 2012). Apple, for example, developed a disassembly robot for this pre-treatment process; dissembling devices in 8 separate components in 11 seconds increasing economic viability. As a result, disassembled components are send to specialized third party recyclers increasing economic and environmental performance of the whole process and a higher quality of secondary raw materials (O'Connor et al., 2016; Rujanavech, 2016; Tanskanen, 2013).

Alternatively, shredding devices is the pre-treatment process involving shredding of mostly non-sorted WEEE streams into tiny pieces. This is currently the most applied pre-treatment process in the WEEE recycling industry. (Rujanavech, 2016; Tanskanen, 2013).

The formal product standard defines the quality of the output secondary raw materials, i.e. the recycled materials needs to be as pure as possible to retain high quality in subsequent production processes. This presses the need for recyclers to gain information about the ingredients, which is largely dependant on OEMs willingness (O'Connor et al., 2016). Concluding, the authority structure, as a normative rule in this system of recyclers, affects the stream of information and is an important criterion for the quality of the output of the process.

Normative rules for the informal sector are purely economic, and their activities are mainly defined as 'cherry picking'. Cherry picking is the collection and recycling of only the valuable parts, leaving the remaining waste for others to process (McCann & Wittman, 2015). This scavenging is costing the EU WEEE recycling industry an estimated €170m per year (EUWID, 2018). In developing countries the informal waste sector consists of poor labourers 'mining' waste streams to earn a living, under poor labour conditions (McCann & Wittman, 2015; Zoeteman, 2009).

The cognitive problem agenda for the formal recycling sector is set by product design, output quality, and business models to improve collection rates (Hollins et al., 2017; Golev et al., 2014). In addition, Golev and colleagues note the need and ability for industrial processes to accept the recycled materials, hence the creation of the 'reintroduction market'. This aspect is dependent on the quality of the output material, while the price has to be competitive to that of 'traditional raw materials'. Currently however, recycled materials are not yet price competitive with raw materials. Raw material extraction is generally at large scale supported with cheap energy, while recycling is more on local scale and more labour intensive (Reck & Graedel, 2012). According to researchers, from a technological point of view basically all waste streams, including WEEE, could be used as resources for subsequent production. The actual recovery rates, however, are disappointingly low (Hollins et al., 2017).

The problem agenda for the informal waste sector is purely set by maximizing income, in developing countries representing poor labourers earning their living, while in industrialized nations with the avoidance of legislation to decrease costs (EUWID, 2018; McCann & Wittman, 2015).

4.2.3 OEM Technological regime

Formal rules as articulated in table 1, for OEMs are driven by competition with other OEMs and maximizing shareholder value. Consumer wants set functional requirements of products, forming the main guideline for OEMs in product design (Rujanavech, 2016). Technological development in the mobile phone industry is at a rate unprecedented (O'Connor et al., 2016; Ongondo &

Williams, 2011a; 2011b), and companies can go from market leader to a small player within years if it fails to keep up with innovation, i.e. Nokia. Rules for profitability are based on maximizing shareholder value; meaning short-term profit maximization jeopardizes investments in sustainability (e.g. Shankleman, 2014). Finally, by imposing EPR via the WEEED, OEMs are intended to implement DfC in their product design (EU, 2012).

Normative rules stating the companies' sense of itself is mostly regarding innovation and becoming a strong brand, as can be adapted from mission and vision statements (e.g. Huawei, 2018; Samsung, 2018b; Rowland, 2017). In addition, OEMs suffer difficulties exerting authority in their immense supply chains. As stated previously, mobile phone supply chains are immense containing hundreds of suppliers. This leads to corresponding issues in implementing sustainability and eco-design innovation, as this demands close collaboration throughout the entire supply chain (Franco, 2017; Kim & Davis, 2016).

Hence, cognitive rules for OEMs are setting the fast innovation agenda. For some OEMs, however, social and environmental issues set a part of the problem agenda. Parker and colleagues (2015) tested the reactions of EEE companies over the critical materials issue. Besides Apple and Fairphone, most companies go for long-term agreements with suppliers, stockpiling, or alternative materials while sustainable strategies are almost completely absent. Hence, this majority of OEMs, correspondingly, do not engage with any strategies or initiating projects related to the CE (Cook & Jardim, 2017). This problem agenda resulted in Apple developing automated disassembly robots contributing to more effective pre-treatment in recycling (Tanskanen, 2013). For collection Apple initiated the previously mentioned Apple GiveBack program. With these pre-treatment robots; Liam, and its successor Daisy, Apple sees the opportunity to 'close the loop of material use in their own product stream' (Apple Inc, 2018; Rujanavech, 2016). Fairphone implemented eco-design and created a modular phone to enable repair and refurbishment by consumers, hence contributing to the CE (Fairphone, 2018).

4.2.4 Science regime

The main formal driver for the science regime is the Horizon 2020 research program. This research-funding program of the EU seeks to ensure global competitiveness in the future (European Commission, 2018b). One of the directions this program is EASME, where research for the implementation of CE is sponsored to ensure resource security and sustainability for the EU (European Commission, 2018a). In 2016-2017 €650 million is on research demonstrating the economic and environmental feasibility of the CE. One of the research directions under this program is specifically focused on mobile phones in the Eco

Design Working plan on potential product requirements supporting the CE (European Commission, 2017).

Academic values and norms under normative rules allow different viewpoint in science, as long as the research is according 'the scientific method'. There is a gap between scientists and other social groups due to theoretical manner of scientific thinking and the interpretation of definitions. These slightly differing definitions between scientists, and the engagement of other social groups with more practical views, causes so-called blurriness (Ghisellini et al., 2016; Kirchherr et al., 2017). To overcome some of this blurriness regarding CE, Kirchherr and colleagues analysed 114 CE definitions in publications. This analysis found that one-third of the scientific definitions of CE do not incorporate a waste hierarchy wherein reuse is preferred above refurbish, refurbish above recycle etc. (Kirchherr et al., 2017).

The cognitive rules of science regarding WEEE management have evolved around the EPR paradigm adopted from the polluter pays principle (Gui et al., 2013; Massarutto, 2014). The dual goal of EPR is shifting EoL management responsibilities to the OEMs, hence creating incentives to induce design for circularity (DfC) (e.g. EU, 2012; Massarutto, 2014; Mayers & Butler, 2013; Zoeteman et al., 2009). Although science does acknowledge difficulties in environmental policies (Gui et al., 2013; Söderholm, 2011), EPR was expected to ensure the DfC considerations for OEMs but this never occurred (Huisman, 2013). As a response, EPR theory is extended into IPR, individual producer responsibility. The logic behind IPR is that when the OEMs are responsible for the EoL treatment of their own products, instead of collective, design for CE is implemented. The benefits of DfC are then fully received by the OEM itself (Atasu & Subramanian, 2012; Huisman, 2013). IPR is, however, never implemented in practice due to a higher degree of complexity compared to collective management of WEEE under EPR (Huisman, 2013).

Another paradigm under some scientists is regarding costs and prices of recycled materials. Zoeteman (2009) stated that at the end of the first decade of the 21st century recycled materials compete in price with raw materials, although this did not occur. In a recent publication, however, copper and gold are found as the first materials to be more cost-effective from urban mining compared to virgin mining (Zeng, Mathews, & Li 2018).

Other issues regarding cognitive rules in the science regime are a lack of research on recycling of mobile phones compared to other waste streams (Sarath et al., 2015), and a decrease of technological innovation, according the amount of patents, in waste management processes since 1997 (Hollins et al., 2017), a focus on recycling compared to preferable treatment such as refurbishment (Hollins et al., 2017), and a lack of research focus on PROs (Massarutto, 2014).

Finally, authors suggest scavengers and decomposers are additional social groups that need additional research. Although deemed destructive in the EU recycling market (EUWID, 2018), some authors suggest a further investigation in the role of scavengers and decomposers in closing the WEEE loop (Ghisellini, 2015), and training for scavengers in developing countries to limit environmental and health damage (Sarath et al., 2015). This is important, as e.g. in Ghana, a well-organized informal recycling network collects 85% of WEEE and generates income for more than 30.000 people (McCann & Wittman, 2015).

4.2.5. Policy regime

The EU regulative rules constitute that on the EU level legislation is formulated and developed, and subsequently trans-positioned in national law. The national implementation however, is dependent on a nation's institutional contexts. As these contexts differ significantly from state to state one cannot speak of a single regulatory style in the EU. As a consequence, national implementation of the WEEE directive, and the Basel Convention resulted in different legislations among member states (Barteková & Kemp, 2016; Mayers & Butler, 2013; van Barneveld et al., 2016). Developing and implementing environmental policies is a difficult process for policymakers, not only due to the complexities of climate- and ecosystems (Gui et al., 2013; Söderholm, 2011). Moreover, developed policies mostly work for one industry (sub) sector, supply chain, product, or material. Generalizing policies may backfire, and no one-size-fits-all policy does exist. (Alev et al., 2016; Lifset et al., 2013). Hence, EU policy procedures and difficulties with environmental policies in general toughen CE policies.

The EU runs research funds regarding the CE subsidizing science regime. Also, start-ups and SMEs are subsidized under EU funding programs, and green public procurement programs are initiated for public authorities on a voluntary basis (European Commission, 2017).

Normative rules in the EU start with the fact that, as mentioned previously, the interaction patterns within the institutional context differ between the EU nations. In general however, the political importance of a CE implementation increased in the last years, e.g. with the deployment of the EU Circular Economy Package (Ghisellini, 2016). This development is driven by both economic concern regarding scarcity of resources, and environmental degradation (European Commission, 2017). The EU aims to encourage material recovery of critical raw materials (CRMs), notably present in smartphones; encourage member state action on this topic, and consider product requirements in the Ecodesign directive to improve the recyclability of electronic devices (European Commission, 2015). Regarding the Ecodesign directive, for so far it solely focuses on improving energy efficiency of electronic products in the user-phase, no improved recyclability is induced until this date. In addition, in this directive mobile phones are not mentioned at all (EU, 2009).

EU legislators committed to EPR mechanism for WEEE legislation. This mechanism is an overarching policy principle possible to be implemented with different combinations of policy tools and instruments, but focuses on the polluter pays principle (Massarutto, 2014). Goal of the WEEED is to instigate improved DfC among OEMs through creating financial responsibility for their products at EoL (EU, 2012).

Regarding the implementation of CE in the EU, one of the policy goals is the proposal of incremental resource efficiency steps as a first step towards CE and ultimately achieving a regenerative CE (Hobson, 2016). Also, the WEEE directive and the proposals for implementing CE focus more on recycling compared to other cycles in the CE waste hierarchy (Ghisellini et al., 2016; Lifset et al., 2013).

Idea about effectiveness of instruments is one of the cognitive rules for the policy regime. Although WEEE directive has been in place for some years now, and has been updated in 2012, there is still a lot of room for improvement in the legislation (Alvarés & Rosa, 2017; Reck & Graedel, 2012). Although policy makers have achieved increased collection and treatment of WEEE, the impact of WEEE on product design is disappointing (e.g. Massarutto, 2014; Mayers & Butler, 2013). It has mainly created an organisation network and infrastructure for postconsumer recycling (Lifset et al., 2013; Massarutto, 2014).

Additional cognitive rules in the policy regime are determined by guiding principles. One of the main principles is shifting the responsibility towards the OEMs as implemented under the WEEE directive (EU, 2012; Huisman, 2013). Another important aspect within EU regulation is the fact that it is guided by the knowledge and awareness of the EU inhabitants. Hence, awareness of consumers plays an important role in EU policies (Ghisellini, et al., 2016). Also, there appears to be a general lack of willingness for radical new policies. As noted, both the WEEED and proposals under the CE package tend to focus on recycling. While in the Ecodesign directive no improved design considerations are implemented. This appears to relate to policy makers retaining the status quo while implementing CE, emphasizing economic growth and neo-liberal governmental market-based interventions (Hobson, 2016).

The cognitive rules regarding the problem agenda are mainly formed by the EU desire to implement a CE in 2050, where legislators see Eco design playing an increasing important role (European Commission, 2016). Some of the ambiguity that relates to defining used products as waste has been partially dealt with. The Basel Convention, opposing illegal trans boundary movement of WEEE, adopted a guideline clarifying the distinction between WEEE and used EEE (Parker et al., 2015). Practical issues, ambiguity and other unforeseen causalities with legislations such as these, should remain high on the problem agenda for policy makers to encounter issues for this ST-system.

4.2.6. Socio-cultural

Formal rules regarding information sharing in our current age of technology rapidly changed. Spreading information in the digital age has become fast and easy. Some authors suggest exploiting this; to create circular streams of materials all stakeholders must support the process, e.g. industrial managers, government officials, researchers, and consumers etc. Public involvement is to be commenced through mass media channels like television campaigns and newsletters, and through educational institutes (Aznal, 2014; Geng & Doberstein, 2017; Sarath et al., 2015). In addition, social media is currently an easy-to-access and mass target media channel. Trends and information sharing, both by individual consumers, governments, or companies, can easily be started and supported on a large scale.

On the other, downside of this quick and easy sharing of information is that wrong or misinterpreted information circulates easily. Nowadays, deliberately spreading false information to alter public opinion are current practices (e.g. 'Fake news or climate change denial). Also, journalists reporting on misinterpreted scientific publications, or NGOs exaggerating certain aspects of problems to increase attention are issues. This is further elaborated upon in chapter 5.

In general, normative rules of consumers remain around take-make-dispose as the main economic models. Therefore, recycling of mobile phones is still not a general cultural value (Franco, 2017; Tanskanen, 2012). Also the framing of everyday sustainability practices, such as recycling or buying green products, among individual consumers has been critiqued. Hobson (2016) refers to many authors who state that although on individual level, consumers state they do behave in a sustainable way, from a collective viewpoint this is not evidenced. What consumers say does not reflect the actual decisions and behaviour they execute. Franco (2017) confirms this misperception: "Although there is a widespread perception that demand for sustainable products in general is on the rise, the efforts of some proactive firms have not scaled up as much as expected." (p. 840).

This lack of consensus regarding awareness and behaviour among consumers is represented in other literature as well. Research found that consumers believe recycled and refurbished products have negative consequences on functionality and quality (Hamzaoui Essoussi & Linton, 2010; Söderholm & Tilton, 2012; Subramanian et al., 2014). Contrarily, other research found that increasingly EU citizens are involved with some alternative form of consumerism, like leasing or buying remanufactured products (Hollins, 2017).

Cognitive rules state the symbolic meanings of technologies, and when buying a new phone having the newest model is the most important symbolic meaning for consumers. In this, functionality and fashion status are the primary factors (Ongondo & Williams, 2011a; 2011b). There is a general lack of idea of impact about recycling and the CE in general, and for mobile phones specifically, among the general public (Parker et al., 2015; Tanskanen & Butler, 2007). Awarenes and education, as mentioned should play a role here, hence media coverage and NGO awareness campaigns could increase this aspect.

4.2.7. User/market regime

Research analysing drivers for companies to engage with CE activities found that market pressure, government regulation, and leadership style are the most important factors (Liu & Bai, 2015; Subramanian et al., 2014). Formal rules for the user/market regime in the EU aimed to create the market pressure for OEMs to implement DfC, hence through government regulation. In general, the policies in place important for the user-market regime (and therefore affecting the technological regimes) are the WEEED, Basel Convention, Eco-design directive, while subsidies from the CE package facilitate businesses. Under these regulations the mobile phone market is incentivized to incrementally improve towards more material efficiency, retaining capitalist vision, corporatism, and a resulting focus on recycling (Ghisellini et al., 2015; Hobson, 2016; Lifset et al., 2013). This refrains the ST-system of radical innovation as needed for CE (Kirchherr et al., 2017), and protects established recycling companies against alternative strategies such as scavengers and decomposer companies (EUWID, 2018).

Normative rules are different between the markets within this ST-system, correspondingly with the separation of the technological regimes in OEMs and EoL. For the OEMs the interlocking rules between users and firms is mainly due to the perceived quality and functionality of their products, and the user experience. This relation is the main driver for company activities, guided by the socio-cultural rules defining consumers' wants. In addition the position of a company in the supply chain, and the power they exert over their buyers and suppliers plays an important role their ability to innovate (Franco, 2017).

The EoL market is typically arranging the reverse logistics and the treatment of collected used devices. OEMs, in this market the users of service provided by EoL, are interlocked due to WEEE policy compliance. PROs organize the EoL market collectively for OEMs, hence engaging with multiple manufacturers. In addition, municipalities, retailers, and material producers are both influential and independent users in this market. As a result, conflicting demands occur within the same waste collection and recovery services (Mayers & Butler, 2013). Within current legislation, however, there is no market support for the output of the EoL market. Hence, OEMs are not obliged to reintroduce secondary parts of materials back into their supply chain.

Cognitive rules are differing according the same market difference. As mentioned, interlocking role between consumers and firms drive company behaviour. As stated previously, user preferences and interpretation of functionality among consumers is lower regarding products that implemented DfC or are recycled or refurbished. In addition, these products are perceived to be more costly compared to conventional products (Franco, 2017). Hence, OEMs are not adopting DfC due to the normative rule of interlocking with the users and meeting their preferences.

Regarding the belief of the free market, OEMs operate on a global level. Hence, they assume that operating the EoL on global scale supresses costs and increases efficiency due to economies of scale (Zoeteman et al., 2009). Material markets are global as well, however EoL treatment are bound by strict trans boundary shipment legislation and can therefore operate mostly on a national level (Mayers & Butler, 2013).

User preferences in the EoL market for the collection process is a factor in the amount of mobile phones collected, identifying how in this case users are willing to hand-in their old phone. Research in this area shows that the ease of use of the collection process, convenience, and economic incentives (Ghoreishi et al. 2011; Ongondo & Williams, 2011a; Tanskanen & Butler, 2007).

5. Results and Discussion

5.1 Introduction

The previous chapter elaborated on the social groups involved in the ST-system for mobile phones, and the regimes according to which these social groups behave are depicted. In this chapter the misalignments between these regimes is analysed according to the interviews, discussed and triangulated with desk and literature research.

This chapter section is divided in three sub-chapters, each sub-chapter corresponding to one of the three generalized topics the misalignments relate to. The first sub-chapter presents misalignments regarding current policies and policy-making opposing the implementation of the 'real' CE. The second sub-chapter presents misalignments related to the separation between the two technological regimes: OEMs and EoL. Finally, the third sub-chapter presents the remaining results. Although not specifically sharing topics, most of these nodes (4 out of 6) are related to the science regime. A summary of the results is presented in table 4.

	Technological EoL	Policy	Socio-cultural	User-market	Technological OEM	Science
Technological EoL	- Cultural barriers - Infrastructure - Waste stream competition - Recycling Scale vs Efficiency	- *Formal Policy Goals Opposing CE* - *Policy Knowledge and Role* - Engineering Limitations	- Infrastructure - Cultural Barriers	- Market Transactions	- Refurbishment and other Business Models - Market transactions - Product Design	- Engineering limitations
Policy		- *Lack of enforcement*	-	- *Policy knowledge and Role*	- *Misinterpreting EPR* - *Lack of enforcement* - *Policy Knowledge and Role*	-
Socio-cultural			-	- *Public awareness*	- Cultural barriers - Refurbishment and other Business Models	- *Public awareness*
User-market				-	- Product design - Refurbishment and other business models - Market Transactions	-
Technological OEM					- Cultural barriers	- *Misinterpreting EPR* - Cultural Barriers
Science						- Lack of Shared Definition

Table 4 Summary of the results. Italics are the categorized subjects of policy vs the CE, presented in sub chapter "5.2 Policy vs the Circular Economy". Underlined topics are categorized and presented in sub chapter "5.3 Lack of Circularity", and the remaining topics are presented in the final sub chapter. Among some of the relations no misalignments are present.

5.2 Policy vs the Circular Economy

With the WEEED the EU is one of the first political organs implementing policies for WEEE and setting an example for other countries and regions (PC2[1]; Sthiannopkao & Wong, 2013). The policy regime is exerting influence, and receives influence from multiple other regimes. And although the WEEED was state-of-the-art legislation setting an example for the world, the next section presents that it currently opposes the CE for mobile phones. The EU learned this as well, resulting in amending the WEEED in the Circular Economy Package. However, unfortunately this amendment is 'not a milestone' (PC4) and solely amends the frequency and process of reporting from national governments to the EU (Bourguignon, 2017). Misalignments resulting in policies opposing implementing the CE are analysed in this sub-chapter. Figure 3 presents the misalignments that are identified under this categorization.

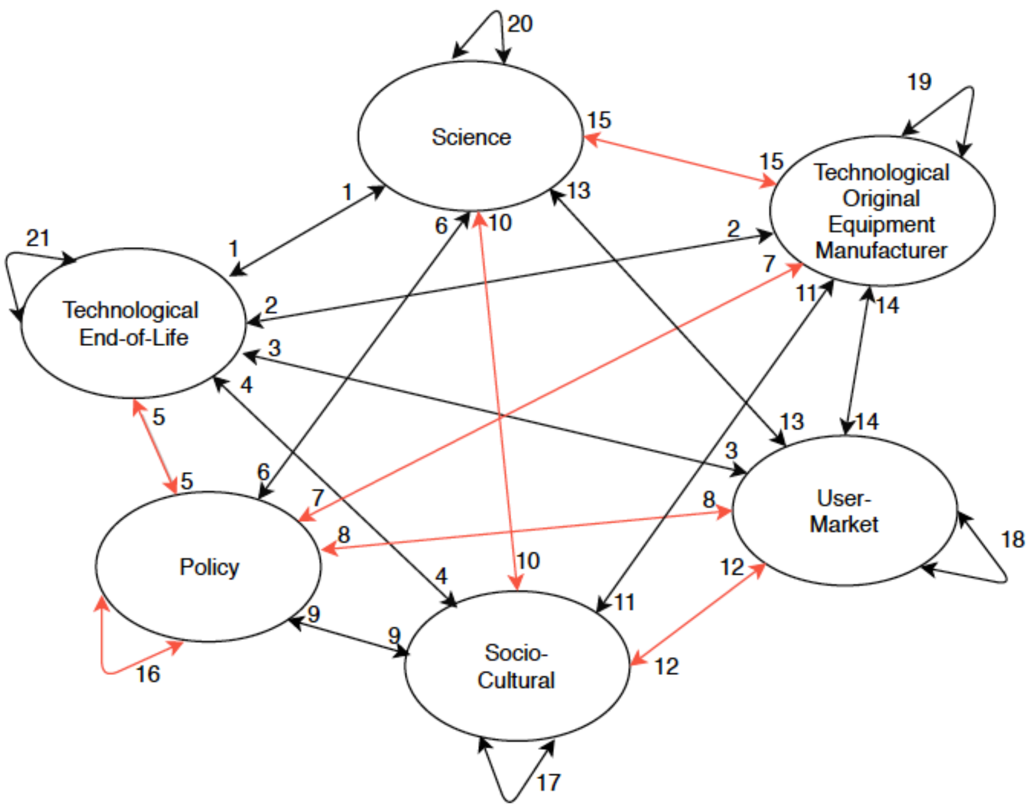

Figure 1 Misaligned relations presented in chapter 5.2

5.2.1 Formal policy goals opposing the 'real' CE

From the policy regime some formal rules oppose the CE. First, the waste hierarchy is included in the WEEED, where it does state that preparation for reuse is preferred above recycling (EU, 2012). In practice, however, all interviewees state there is some ambiguity in the WEEED resulting in the promotion of recycling and opposing better treatment such as refurbishment

[1]PC is the abbreviation for personal communication with the corresponding number of the interviewee presented in table 2

and reuse. Many researchers confirm this (e.g. Alev et al., 2016; Lifset et al., 2013; McCann & Wittman, 2015; Zoeteman et al., 2009).

The first aspect is the notion that in the legislation the statement of promoting reuse and refurbishment above recycling is too vague (PC1; PC5; PC8; PC9), and secondly, there is no division in the monitoring data between reuse, refurbish, recycling etc. (PC1; PC4; Eurostat, 2018). This results in a lack of promoting reuse and refurbishment infrastructure in the municipal collection systems. As noted by one interviewee, almost all municipal WEEE collection systems involve 'ruff handling' of the products, so even if a product was feasible for reuse or refurbishment the collection process is not retaining any possible value as the containers on the collection site are bound to go to recyclers immediately (PC5). In addition, the after-use private sector is not monitored and therefore does not contribute to recycling quota that must be achieved by countries under the WEEED (PC1). This private sector, however, is more preferring reuse and refurbishment, which corresponds with the CE waste hierarchy and therefore should be promoted above municipal collection infrastructure (PC2, PC8).

A second aspect that facilitates the CE is trans-boundary shipment of EEE and WEEE from one country to another country where repair, refurbish, or recycling facilities are more advanced, or where there is demand for second hand phones. Administrative costs (PC1, PC4, PC5, PC7), and the waiting time for a permit at the border – even within the EU - (PC5, PC7) form high barriers to get to the best after-use treatment. Interviewees mentioned two legislation issues that form these barriers. First, annex 6 of WEEED states the procedure for trans boundary shipment, which involves that equipment that is not fully functional must cross the border between EU nations as WEEE, instead of EEE. As a result an administrative burden is imposed, as WEEE is considered hazardous waste. Second, the Basel Convention requires an expensive and time-consuming assessment for used EEE shipments across the globe (e.g. Parker et al., 2015). Due to these legislations the CE is opposed on multiple points. Firstly, it opposes the ability to serve the huge African second hand market where used phones from western countries are preferred over new phones from cheap Indian and Chinese OEMs (PC1). Secondly, it opposes the transportation of broken phones to specialist centralized repair centres in Eastern Europe (PC5) or in African countries (PC1). An opinion article on Resource Recycling, Inc confirms this story even stating, "Nigeria's tech worker are the best at fixing them –used electronics- " (Ingenthron, 2018).

For the private EoL sector this legislation is less present, at least regarding collection for reuse and refurbishment (PC8, PC9). As long as the collection of phones occurs per consumer, e.g. by trading, discount on new phones, or even cash-back programs, the used phone is traded as a good instead of WEEE. Of course, for these companies collection occurs on individual base, compared to collective collection on municipal sites (PC8, PC9).

A third aspect of the CE is the existence of a demand for secondary parts and materials. Demand is closely related to price, where generally a lower price results in a higher demand. When consumers buy a new phone, taxes are paid over the phone and the materials. Currently, however, over a recycled or refurbished phone VAT has to be paid again. It can be argued whether 'new value is added' as it remains the same material and phone (PC5, PC7, PC8). These kinds of 'double taxes' are the final point of misalignment between formal policy rules and technological EoL opposing the CE. If these taxes are eliminated, secondary materials or products become cheaper, hence demand increases.

These three issues are a result of a misalignment of the normative rules of policy with the formal rules of the EoL regime setting standards, specifications, and accounting rules for profitability (table 1).

5.2.2. Misinterpreting Extended Producer Responsibility

The basic idea of implementing EPR was to induce product design that is easier to repair, refurbish, or recycle; however this failed (PC1; PC2; PC3, PC4, PC5, PC6, PC7, PC8). The main reason for this failure is the fact that producers do not get back their own products; rather they organized take-back collectively financing the collection infrastructure in a country through PROs. (PC5, PC6). Hence, in practice this lacks the incentives for OEMs to induce DfC, as they are not involved in the EoL management (PC5, PC6, PC7). This misalignment comes forth between the formal policy rules and cognitive rules of the technological OEM, specifically their 'problem solving strategies'. These strategies are based on best economic practice, resulting in neglecting DfC. If a company chooses to implement DfC, it serves the collective downstream processes and that is no incentive for an OEM.

> *The producer responsibility was thought to be the principle that brings OEMs to include DfR into their R&D specifications. This didn't take place, for a very simple reason. This only happens once a producer gets back his own product. (PC5)*

This comes forth from another misalignment, the misinterpretation of the abovementioned problem solving strategies of OEMs and the cognitive rules forming paradigms in the science regime, where the idea of EPR is developed. As Huisman (2013) mentioned about EPR: "We might have been a little too academic on this". The primary achievement of EPR is financing, creating, and expanding the recycling infrastructure (Lifset et al., 2013). And although most scientists now have acknowledged that EPR is not the effective strategy for CE (Alvarés & Rosa, 2017; Hobson, 2016; Huisman, 2013), the EU announced under their Circular Economy Package to improve EPR schemes and make them mandatory (Bourguignon, 2017). Section 5.2.5. further scrutinizes this behavior of policy regime.

5.2.3. Lack of Enforcement

Another issue regarding policy is a lack of transposition and therefore the enforcement of European law in its member states. More specifically in this case, transposition of WEEED into national laws has resulted in many differences, and there is a general lack of an enforcement system (PC1, PC4, PC5, PC6, PC7, PC8). As a result, some interviewees mentioned cases of OEMs deliberately not complying with the WEEED, as that choice is economically more attractive (PC1, PC4, PC6). Hence, formal technological OEM rules for profitability are misaligned with the formal policy rules regulating WEEED.

A main finding for this lack of enforcement is intragroup misalignment within the policy regime between the different transposition procedures of EU states. This transposition of the EU law into national law lacks harmonization, resulting in vague and non-uniform legislation and a resulting lack of enforcement (PC5; PC6; PC7; Barteková & Kemp, 2016). Identified reasons for this lack of harmonization is a dependence on a country's waste infrastructure (PC5; Hollins, et al., 2017) and the level of a country's ambitions (PC5; PC7; Hollins, 2017).

5.2.4. Public Awareness

Knowledge and awareness among the public is essential to create market pressure and induce policy behaviour for implementing CE (Geng & Doberstein, 2017; Ghisellini et al, 2016; Liu & Bai, 2014). WEEED can be complimented as it did achieve to establish a recycling industry in the EU and create some awareness among consumers and producers (PC1; PC4; PC5; PC7). The directive contributed to establish some change in the way consumers interact with firms, however this normative rule of the socio-cultural regime is not yet aligned with CE thinking. Information sources for consumers experience information asymmetry, ignorance and a lack of interest regarding the CE for mobile phones (PC1, PC2, PC7). Interviewees also mention the misperception of markets (PC2, PC7) and un-sexiness of CE and WEEE (PC7) as issues in spreading awareness and information. This misalignment is identified between formal (rules that structure information spreading) and normative (cultural value) of socio-cultural, and the cognitive rules of user-market regime, how the CE market works.

In addition, these same formal and normative socio-cultural rules misalign with science, Ingenthron (2018) notes that "researchers and organizations need some sizzle to draw more support from funders and others". While vice versa, media tends to exaggerate scientific reports. For example, one scientific report examined the case of Nigerian used electronics import for their second-hand and repair market. According to Ingenthron (2018), however, when reading the scientific publication, it appears that the majority are working devices for Africa's second hand market, while 25% of the devices are in need of repair and "Nigerians are the best at fixing them". The title of the article therefore misrepresents the actual message of the scientific research. In addition, yet another article in this journal is published, stating that the article by Ingenthron is "..perpetuating dangerous misinformation" (Puckett, 2018). This latter article states that, indeed true, under the Basel Convention shipments of electronics are allowed. However it does not emphasize the strict administrative burden necessary for these rules that impose the restrictions and oppose the CE. One additional example is a publication on the discovery of a large amount of four REE (Takaya et al., 2018). Media presented enlarged, i.e. CNN reported that it will 'change the world economy'. The discovery of the supply is seen as "tremendous potential" (Takaya et al., 2018), however the four REE are only a fraction of all REMs currently in use, and there is a lot more in the world economy than only REMs. Hence, the interpretation of scientific research can differ between journalists and the impact of correct news framing is important in this sense as it can jeopardize public awareness.

The rules in the socio-cultural regime play an important role in the creation of awareness of the public. Subsequently, this public awareness is a driver for the policy regime. Hence, the misalignments between socio-cultural and science, and socio-cultural and user-market are important obstacles for implementing CE. Education and objectiveness of the spreaders of information therefore form a key point here, however these are difficult to achieve on their own. An important facilitating aspect in this regard is transparency and traceability of product life cycles, which is suggested in earlier research (Ellen MacArthur Foundation, 2016; Franco, 2017; Geng & Doberstein, 2017; Lieder and Rashid, 2016). I.e. by improving transparency and traceability it becomes obvious where products or materials originate from, and end up in the EoL process.

5.2.5. Policy knowledge and role

Under policy regimes' cognitive rules for 'interactions patterns', and aligned with Zoeteman et al. (2009), two interviewees suggested policymakers should follow businesses instead of guiding them (PC5, PC6). Reasoning is that policy regime should let the market develop solutions, utmost playing a "supportive role" (PC6) and "cut negative developments" (PC5). Other interviewees posed more general questions about the rules in the policy regime. Cognitive rules of policy regime are questioned on whether their guiding principles fit a transition such as towards a CE, set by standards of the technological EoL. Do policy makers have a realistic view of the ST-system (PC1, PC4, PC6, PC7), the economy and entrepreneurship (PC5, PC7, PC8, PC9), and if democracy is fit for long-term and radical change processes (PC4, PC7).

> *"And the problem is in 2019, the commission will be changed. And so, many things will happen till the end of 2018 and then nothing will happen because the new commission needs to define where they will focus on." (PC4)*

Also, the previously mentioned aspect of 'double taxes' misaligning policy and technological EoL exposes an additional misalignment between the user-market regime and policy regime. A market for selling secondary material or products is vital for the CE. This so-called 'reintroduction market', however, is not promoted as normative policy rules are misaligned with formal rules of this user-market (PC5, PC7). I.e. policy makers have certain knowledge and perception of their role, which excludes supporting this reintroduction market. This is clearly stated by one of the interviewees about the response of a policy actor on actors from the recycling industry:

> *"The most important aspect that is missing is a reintroduction market for recycled materials, harvested parts etc. Because once there is no demand, what can you do with the old scrap? And the answer of the government agency was, 'Well this is not our turf. We don't take care of demand aspects,'"(PC5)*

In addition, the same cognitive rules of policy, 'interaction patterns', result in lobbying. Policy is affected by power, and simply because OEMs have more power than EoL, the technological OEM regime exert this power in the form of lobbying. In the end, most OEMs want to slow the legislation process to avoid large investments and protect their profits. Therefore lobbying occurs to weaken potential legislation (PC1, PC4, PC5, PC6, PC7).

> *"For me it seems rather economically driven, and not so much by the recycling associations. I mean there are these associations, but obviously OEMs have much more influence on policymaking, they were heavily influencing that process." (PC1)*

A possible explanation for policy to be sensitive for OEMs influence is found in literature. Hobson (2016) discusses the predominance of 'weak' ecological policy frameworks, as past policy approaches have been roundly critiqued for being ineffective due to an emphasis on economic growth and neoliberal government/market based interventions. These 'guiding principles' under the cognitive rules of the policy regime allow them to be vulnerable for creating an economic environment as demanded by 'unsustainable' OEMs and therefore be misaligned with other regimes regarding the CE implementation.

Hence, on the one hand OEMs exert power to weaken environmental legislation. But on the other hand, the OEMs should be allowed a more guiding role as their interpretation and understanding of the economic environment is more encompassing compared to the policy regime.

5.3. Lack of Circularity

Current WEEE policy in general fails to give the right incentives to OEMs to implement the CE. The main issue is argued to be a retained mismatch between the pre-use and after-use market, creating the need for market transactions between companies from the technological EoL and technological OEM regimes. As a consequence, currently companies from both regimes form parts of the circle. Although not (yet) being in place, strong circular business models will initiate far stronger CE compared to legislation integrating the companies into a smoother and comprehensive circle (PC1; PC2; PC5; PC6; Bocken et al., 2014; Franco, 2017).

> *"Totally independent from the law, because the law doesn't work btw. The business started to develop new business models having an impact on the objectives of waste legislation by far stronger compared to design for recycling, using less raw materials and so on. And that's the reason why this new development is so important."(PC5).*

In this sub-chapter, first two sections present cultural barriers regarding resistance to change, shared definitions, refurbishment and phone ownership. Subsequently, three sections present the market mismatch, exposed through product design, market transactions, and infrastructure. Finally, current trends regarding transparency and traceability are presented. Transparency and traceability are important aspects for a CE. All relations with misalignments presented in this chapter are presented in figure 4.

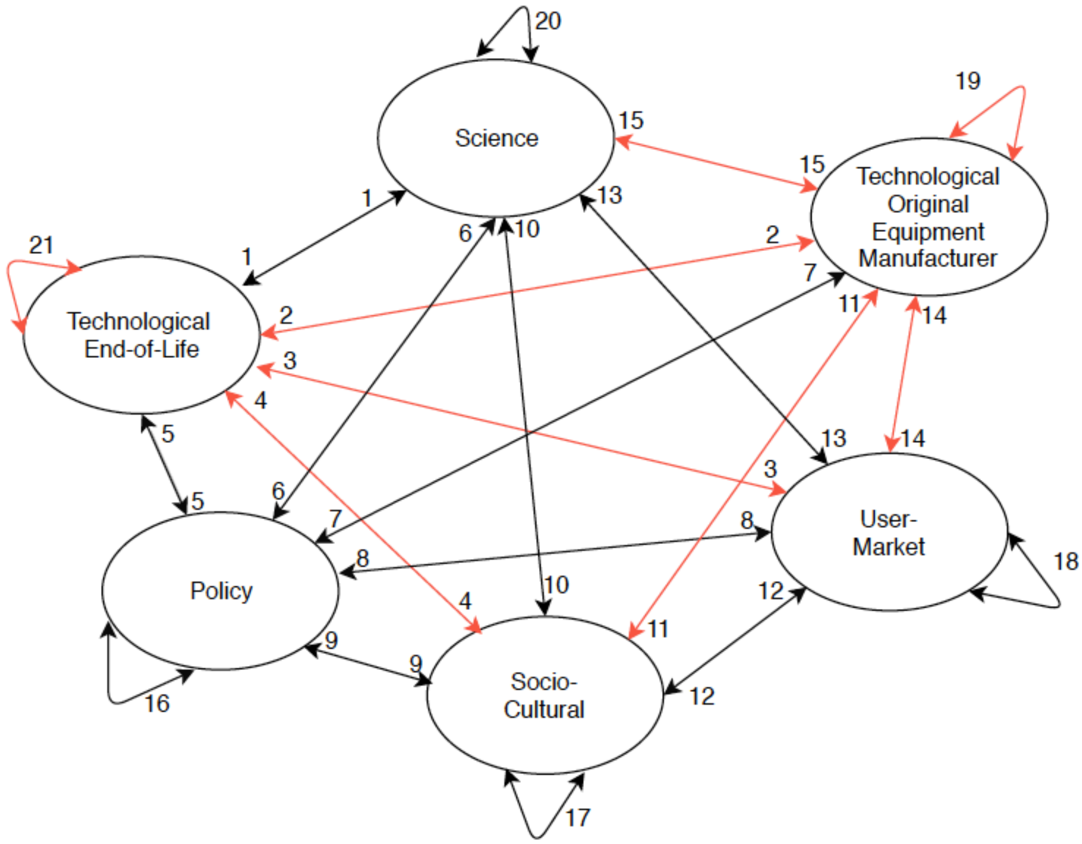

Figure 5 Misaligned relations presented in chapter 5.3

5.3.1. Cultural barriers

Current capitalist conditions require companies to maximize shareholders' value as the main performance. This results in a lack of transition to the CE, as this requires investments into 'unknown territory' affecting profits at least for a few years in the transition period (PC6; PC7; PC8).

> *"The make and break industry has a head start by numerous years. So we still need to invest in stuff you're doing, making some scientific sense of a future business model."(PC6)*

As noted by scientists and interviewees, real circular business models are currently not in place; hence science and technological OEM are misaligned (e.g. Bocken et al., 2014; Franco, 2017). OEMs, however, raise the question whether it is their responsibility to integrate the EoL treatment of their products:

> *"I mean, this is where I go both ways, is it the manufacturer's job to recycle it, or to design it for recycling. They're not in this business of recycling." (PC2)*

Arguably, as it appears from multiple sources that it is the OEM that needs to play the guiding role in the transition towards CE (PC5; PC6; Zoeteman et al., 2009). Their view, however, is still misaligned with the socio-cultural regime, and within the OEM regime. The normative rules from the socio-cultural regime states the cultural values, which are, as previously mentioned, capitalist conditions. This is still misaligned with how the technological OEM normative (what business are we in), and cognitive (guiding principles, routines etc) rules should be to engage with the CE. While within the technological OEM regime, normative rules differ between companies around the question 'what business are we in?'. Some mobile phone manufacturers include EoL treatment processes into their business model (PC2; PC6; Deahl, 2018; Fickling, 2018), while others don't (PC2; PC8; PC9; Cook & Jardim, 2017; McCann & Wittman, 2015). Pressures from other regimes and landscapes need to be present for companies to stimulate the transition to the CE, which come forth later in this analysis.

While there is a lack of thought of OEMs what to do with their products after-use, there is a similar lack of vision within the EoL technological regime. Some companies from this regime are purely focused on making money quickly, while other more progressing companies are actually taking into account where their processed parts or materials can be reintroduced into the supply chain (PC2, PC8, PC9). For the CE, this more systemic focus is crucial to facilitate materials actually being reintroduced. In addition, there is no shared definition of recycling or CE in the technological EoL regime, which causes so-called blurriness previously noted (Ghisellini et al., 2016; Kirchherr et al., 2017). As one interviewee notes:

> *"With recycling everybody has a different definition. Even within my company, you know someone says recycling I immediately think EoL, but it can also mean parts harvesting, or refurbished reselling, number of things."(PC2).*

Although no implications are noted (PC2; PC9) due to this issue, it should be taken into account for mutual understanding of activities. Hence, the technological EoL regime is misaligned within the regime, and with the socio-cultural regime.

5.3.2. Refurbishment and other business models

Another misalignment arguably linked with capitalist conditions is the fact that many OEMs oppose the refurbishment of their products. They perceive this as competition (PC2; PC7; PC8; PC9), and are afraid that the customer experience of their product is jeopardized due to a loss of quality (PC7; PC9). So, the technological EoL, more specifically resellers and refurbishers, and the technological OEMs are misaligned here on their normative and cognitive rules, i.e. what activities they are in, and what the expectations are.

Interestingly, however, the refurbished mobile phone market is growing rapidly (PC1; PC8; PC9; Webber, 2017) and future demand does not seem to stop growing (PC1; PC8; Consumentenbond, 2018). A few OEMs are trying to positively influence the refurbishment process to ensure a decent device, although on small scale and without too much effort (PC8, PC9). One interviewee noted the benefits OEMs receive from their refurbished products:

> *"I've spoken with –OEM- (confidential) once, and they noted that they support repair and refurbishment companies as long as they are qualitative, as these extend their product experience, while it increases their market share…. And a lot of money is made from the service like application stores, cloud services etc. on the mobile phones, and not only on the purchase of the phone itself." (PC8)*

Other research shows similar results, where a growing share of EU citizens is choosing alternatives to buying products, in the form of sharing, buying remanufactured, or leasing (Hollins et al., 2017). So, an additional misalignment is identified here where not all actors from the technological OEMs are aligned with the user-market, where user preferences (cognitive rule) are increasingly moving to alternative business models. Alternative business models such as buying refurbished products depend on consumer's willingness to engage with such new consumption models (Bocken et al., 2014; Hollins et al., 2017). Information plays and important role in awareness creation, while in these alternative models quality needs to be ensured towards consumers. As a result, again, transparency about what the consumer is buying becomes more crucial and facilitates awareness creation and issues regarding wrong information (PC5; PC8; PC9; Hamzaoui Essoussi & Linton, 2010).

In a research for the EU, Aznal (2014) states that: "the consumer will have shared responsibility for using goods appropriately and efficiently as regards their performance (following instructions carefully, maintenance, repairs, etc.), so that they can be re-used through the requisite life cycles in a collaborative and connected manner." (p. 6). These assumptions of relative easiness of consumers' will to engage with sustainability in their consumption appears to be present within the socio-cultural (e.g. Young et al., 2010) and the science regime (e.g. Lane & Watson, 2012). In reality, however, the consumer does not necessarily chose for sustainable or circular products. One study found that the majority of consumers lack awareness of refurbished products, and those who are aware perceive a negative trade-off between risks and benefits (van Weelden, Mugge, & Bakker, 2016). Hence, to be able to sell refurbished products companies need different ways of proposing value. In the end, the value proposition for consumers is crucial, and companies need to engage with effective sustainable business models to enable economically viable ways of CE (Bocken et al., 2014). In reality however, there is scarce evidence of real circular business models, apart from some furniture companies (Franco, 2017).

Hence, although some consumers already engage with more sustainable consumption, the majority of consumers need a decent value proposition. For buying refurbishment mobile phones, for example, performance is guaranteed with a two-year warranty. While not the newest mobile phone, for an increasing group of consumers this value proposition is favourable above buying a brand new mobile phone (PC1; PC8; PC9; Consumentenbond, 2018; Webber, 2017).

Hence, normative rules of technological OEM have not yet resulted in the business models unlocking cognitive rules of the socio-cultural regime to engage with the CE.

5.3.3. Product Design

The goal of EPR was to induce product designs that facilitate after-use treatment. And although policy makers and scientists misinterpreted the incentives through EPR, an additional finding came forth from the interviews. Obviously, if mobile phones are designed for CE this facilitates repair, refurbishment, recycling etc. However, the degree of necessity for DfC appears to be somewhat lower than pressed by scientists and policy makers. The interviewees did support DfC, however stated as well that it is not crucial (PC2, PC3, PC6, PC7, PC8, PC9). As a bottleneck in recycling (PC2, PC7), and most changed part in refurbishment (PC8, PC9), the battery is the only aspect of design that is mentioned as important to be easily disassembled. For the rest, trial and errors process of mechanics and engineers in the EoL regime is not a major issue for the companies to overcome design difficulties (PC2, PC3, PC6, PC8). So, yes DfC is important and facilitates EoL treatment, however it is not as important as previously pressed by scientists (e.g. Atasu & Subramanian, 2012; Huisman, 2013; Massaruto, 2014), and policy makers (EU, 2012).

In addition, it does appear from interviews, and from desk and literature that DfC for recycling is less important compared to refurbishment or repair processes. This is due to the fact that recycling starts with shredding of the products, and although batteries need to be removed due to safety issues, design for the rest of the device is therefore less important (PC2; PC3; Rujanavech, 2016; Tanskanen, 2013). In repair and refurbishment, it's intuitive that easier to disassembly designs like similar screws such as in the Fairphone, facilitates the process compared to glued batteries with non-working stickers for removal like in the iPhone. However, as the EoL and OEM technological regimes are separated, EoL regime is not in the right position to incentivise OEMs to include DfC (Söderholm & Tilton, 2012). So, these regimes are misaligned on technical standards under the formal rules of these regimes.

Moreover, the incentive to not include DfC is higher for OEMs, as product design and performance are crucial characteristics off their mobile phones. Implementing DfC is a large trade-off with design for consumer experience (PC2; PC3; Rujanavech, 2016).

> *"But, can they design for recycling. Absolutely. But a) at what cost and b) what is the consumer going to go without in order to make it that way. And*

> *is it going to be the same size, or is it going to be a bit bigger because they have to build in something to ehhh, to hold the battery." (PC3).*

Hence, OEMs generally are in the business of selling as much phones as possible. As a result, even though DfC is included in the WEEED, OEMs neglect this aspect as it jeopardizes their core business. Fairphone included DfC to allow its users to repair the phone and its design lacks quality for customer experience (e.g. Consumentenbond, 2018; Vincent, 2016).

> *"Once you put the Fairphone 2 together, the first thing you notice is how big it is. It's 11 millimeters thick, and its plastic case is as squared off as an '80s hatchback." (Vincent, 2016).*

Hence, besides the missing link between OEMs and EoL regimes, the user-market regime's preferences under its cognitive rules are misaligned with the technical standards of the technological OEM regime regarding the trade-off of DfC. Therefore, OEMs lack to engage with DfC and some of the OEMs instead get involved with pre-processing activities to show some goodwill (PC6; PC8).

It must be noted that product design is one of the pillars of the CE to close the loop (e.g. Ellen MacArthur Foundation, 2013; Franco, 2017; Ghisellini et al., 2016). And although the technological EoL currently perceives it as not crucial, in theory DfC is crucial to allow for the best performing CE. Hence, the EoL regime needs to move to the right position to allow the right incentive, correspondingly with Söderholm and Tilton's remark on the previous page (2012). This 'right' position should be one of the core aspects of the new circular business models, and is important in the next two sections as well, to overcome market transactions and the barrier to access of used phones.

5.3.4. Market transactions

Three market transactions emerged from the interviews: costs, information, and reintroducing secondary products, parts, or materials into the market. These transactions occur between the user-market, technological OEMs, and the technological EoL regimes.

First, in the current WEEE environment some OEMs instruct companies from the EoL to supply them with recycled material, or supply the recycler with a waste stream of their products and get some of the materials out of this stream. OEMs underestimate the associated costs with this process, and expect that recyclers can do this for almost no additional costs on top of the value of the recycled materials (PC2; PC3; PC6). There is a key turning point happening regarding this aspect at the moment, as urban mining becomes more cost effective. This landscape pressure is discussed in section 5.5. Controversially, costs of recycling do increase when there is no DfC or information available from OEMs to EoL regarding used-materials, as this demands for more labour necessary in the recycling process (PC2; PC3). In this sense, OEMs are basically 'shooting in their own foot' by not including DfC or sharing information leading to higher costs for EoL Hence, the OEMs technological regime is misaligned with the technological EoL regarding the cost of recycling.

Secondly, the information stream from OEMs to EoL is missing, which is an additional misalignment between the two. Correspondingly with product design, EoL companies do gain the information through trial and error (PC6; PC8). It is stated in the WEEED that OEMs must share this information (EU, 2012), however this is not happening in reality (PC3; PC4; PC6; PC7; PC8; PC9). Information regarding the material that is in a product would facilitate the EoL process, making it less labour intensive and therefore cheaper (PC3; PC6; PC7; PC8; PC9); avoiding safety issues (PC3; PC7), and increasing the purity of recycled materials (PC3). A platform (https://i4r-platform.eu/) for accessing information for recycling is available in the EU and supported by the OEMs, however this platform is currently still ineffective (PC3; PC6; PC7).

Thirdly, both the technological OEMs (PC1; PC2; PC5; PC6; PC7; PC9) and technological EoL (PC1; PC2; PC3; PC5; PC6; PC7) are misaligned with the user-market regime for the reintroduction of materials, parts or products. As mentioned previously, this market is not stimulated through policy either. As a result, the loop of the CE in this regard is not closed. Some OEMs do use recycled materials, however they demand only a few specific materials (PC2; PC6) leaving the rest out which conflicts with comprehensive view of the CE. Important in this reintroduction aspect is linking companies of the two regimes to ensure that supply and demand is stimulated through the market mechanism (PC1; PC2; PC5). This, again, demands a business model with a circular mind-set:

> *"I've always been on the opinion that to create a CE, there are only a few companies out there that are capable to do that. Because you need to get everybody on your supply chain on board all the way down to smelters, whatever the commodities are. Everybody needs to be on board to recapture all that materials. And it's gonna take somebody who has the ability to bring all those people together." (PC2).*

A global scale operation in this regard is more or less inevitable due to the global nature of the mobile phone market. This relates back to the issue with regulations on trans-boundary shipments that form an additional barrier for closing this loop. Also, transparent information about the quality and ingredients of the flows play a facilitating role in getting the supply where demand is present.

5.3.5. Infrastructure: Access to used phones

Another effect argued to be related to the separation of the EoL and OEM technological regimes is regarding the collection infrastructure. Within the current WEEE environment collection operations are through PROs and municipal collection sites while refurbishers and resellers initiate buy-back programs. In addition, in the B2B market similar buy-back or trade-in programs are in place where organisations in the EoL regime have agreements with large business customers and therefore receive large quantities of the same products. The streams from buy-back and trade-in schemes are of higher value and relatively easy to refurbish or re-sell, and to obtain them a business model is in place (PC1; PC2; PC8; PC9).

> *"So from the volume that is the very interesting waste stream -similar and large batches in B2B-. And the opportunity for reuse over and over again is much bigger with the B2B sector. When it ends up at the collection of the municipal site in a container then there is no value for refurbishment anymore." (PC1)*

As discussed in previous sections, the issue of 'mobile phone in people's drawers as a back up' is a major issue for the CE. Even experts in the field retain old phones in their drawer; three of the interviewees acknowledged to have some old mobile phones at home (PC3; PC5; PC7). The decision to recycle is largely dependant on consumer behaviour and creative ways for high return rates are necessary (O'Connor et al., 2016). This tendency to just keep old phones is found to follow from the cognitive rule of the socio-cultural regime defining the symbolic meaning of the phone, and a lack of idea of impact of initiating a new life cycle by handing it in (PC1; PC7; PC8; Ongondo & Williams, 2011a; b; Parker et al., 2015; Tanskanen & Butler, 2007). This misaligns with the normative rules of municipal and PROs collection processes in EoL regime, which is the majority of current EoL collection methods. As previously mentioned, a cash incentive in combination with strong messaging and ease of use (Ghoreishi et al. 2011; Ongondo & Williams, 2011a; Tanskanen & Butler, 2007) are necessary to overcome the symbolic meaning of the phone and the lack of idea of impact of the consumer. PROs in some countries do have collection boxes on strategic positions for ease of use (e.g. supermarkets in the Netherlands), and spend all their subsidies on marketing and raising awareness (PC7), however cash incentives are lacking from these organisation. WeCycle in the Netherlands states on their website you can hand e-waste in for free, while in Germany only containers are present on collection sites (PC5; PC7). Hence, PROs lack the right strategy to engage with the creative ways needed to incentivise consumers to hand in their old phones. Contrarily, in Flanders reuse and refurbishment is actively promoted. PROs in that region give back, among other stimulus, cash for working mobile phones. And in this region the reuse market has quadrupled between 2001-2012.

Another important aspect of the CE was the waste hierarchy, and as previously mentioned policy lacks promoting this, requiring PROs to perform according target recycling quota. As a result, reuse and refurbishment organisations are side-lined (e.g. van Barneveld et al., 2016). One interviewee experienced this where the PRO responded with a general lack of interest in collaboration with refurbishers (PC8). This collaboration is necessary if collected products from municipal sites are potentials for reuse or refurbishment, as the collection occurs in big waste containers. Even if products have some quality, handling it as waste results in value decrease and the need for sorting 'working phones' out of the containers (PC5; PC7; PC8). In addition, even for recycling, the collective WEEE containers require separation to increase material purity, so the output of the recycling process is of higher value (PC3; PC7; Rujanavech et al., 2016; Reck & Graedel, 2012). So, an intra-group misalignment within the defined technological EoL regime is present regarding processing stimulating the waste hierarchy. Researchers, consultants, and parliamentary researchers confirm these issues regarding the waste infrastructure (van Barneveld et al., 2016; Hollins et al., 2017; Sarath et al., 2015; Tanskanen, 2012). Hence, there is a lack of infrastructure, and there are no incentives for the providers of this infrastructure to retain the value of collected mobile phones.

There are some collection models in place organised by refurbishers, resellers, and even OEMs (PC5; PC6; PC8; PC9). Typically the missing cash incentive mentioned previously is included and these take-back systems are more successful in retaining quality, while there is information about the status of the device to be disclosed by the consumer. This allows direct reuse, refurbishment, and better pre-separation of broken devices for more efficient treatment. This type of infrastructure does require a higher effort and investment for lower volumes of return, although with higher quality (PC2; PC8; PC9).

So, the majority of the infrastructure in place lacks access to old phones due to wrong strategies and lacks to retain the quality of individual devices in the collection process. Underlying reasons appear to be following the WEEE legislation, while collection procedures organised from business models (i.e. refurbishers and resellers) are more successful.

5.3.6. The case for transparent information

In the present economic system companies have become complex global supply chains. Under Section 1502 of the Dodd-Frank Wall Street Reform and Consumer Protection act, US stock listed companies report on the use of conflict minerals in their products. However, due to the complexity of supply chains almost 80% of 1.300 researched companies are unable to detect whether conflict minerals are present in their supply chain. For EEE manufacturers, this number is up to almost 90% (Kim & Davis, 2016). Companies research and report in retrospect on this issue. Hence, managing controllability in current global supply chains presently proves a very difficult task.

As argued previously, information sharing between EoL and OEMs regimes, and information for the buyers of refurbished products are facilitating aspects for the CE. As noted by Söderholm & Tilton (2012), if asymmetric information is present between OEMs and EoL, the sellers of secondary products or materials are incapable of transferring information to the buyers since the quality is (partly) unobserved. Hence, the information stream is required to supply knowledge of location, condition, and availability of an asset throughout its life cycles to allow the CE (Ellen MacArthur Foundation, 2016; Franco, 2017; Geng & Doberstein, 2017; Lieder & Rashid, 2016). Information regarding the conditions meets the need for the information transaction between OEM and EoL, and buyers in the reintroduction and refurbishment markets. Location and availability meets the need for controllability of the materials and products in the system. This controllability is necessary to be able to retain the materials in the loop (PC3; PC6; PC9).

Moreover, as mentioned under policy issues, banning trans boundary shipments opposes best practice in the technological EoL regime and therefore opposes the CE. The Basel Convention is closing in to amend the legislation and incorporate an outright ban on hazardous waste, further increasing legal and administrative burden for export (Elliot, 2018). As stated, this ban might backfire implementing the CE by increasing difficulties with export to better practice EoL facilities and second hand markets. The need for this ban disappears when OEMs transparency and traceability allow controllability of the material flows, hence being able to prevent dumping in developing countries.

Finally, the EoL treatment process is largely dependent on the consumer's choice to hand-in their old devices (e.g. Apple. Inc, 2018; Sarath et al., 2015; O'Connor et al., 2016), while consumer awareness plays an important role in European policies (e.g Ghisellini et al., 2016). Hence, the rules in the socio-cultural regime play an important role in pressing the policy and technological OEMs regimes towards CE. Interviewees note that traceability and transparency can play an important role in creating consumer awareness, specifically in the form of storytelling (PC6; PC7; PC8), which is suggested by researchers as well (Aznal, 2014; Ghoreishi et al., 2011; Mugge, Jockin & Bocken, 2017). Hence, consumer behavior and public awareness initiated through traceability and transparency can influence companies and policy to become more circular.

5.4. Further Misalignments

In this subchapter the remaining identified misalignments are presented. These are more individual issues not specifically to be integrated with the previous presented groups of misalignments. Figure 5 is the visual representation of the misaligned relations in this sub chapter.

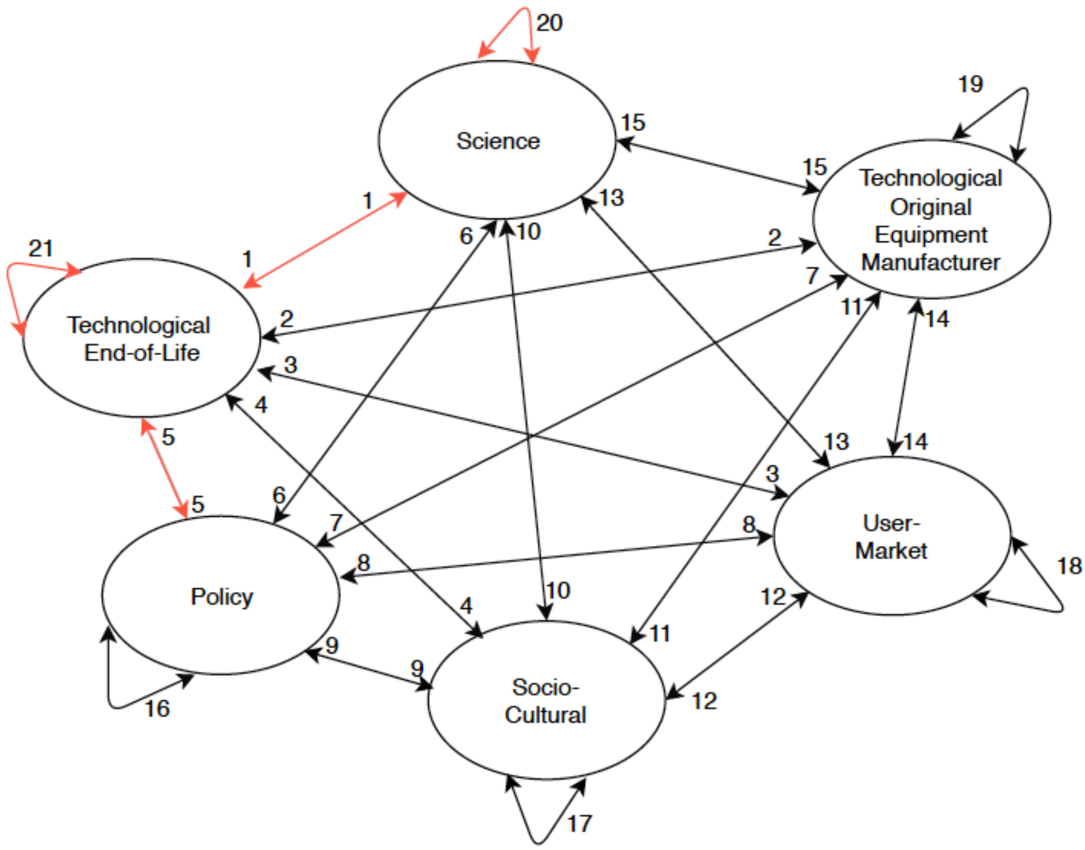

Figure 5 Misaligned relations presented in chapter 5.4

5.4.1. Waste stream competition

Although argued in the previous chapter by Mayers & Butler (2013), there are no indications of competition between resellers, refurbishers and recyclers for the current WEEE streams (PC2, PC3, PC7, PC8, PC9). There is more collaboration between the different organisations; recyclers selling working devices to refurbishers as this brings in more money while refurbishers need recycling partners for non-repairable phones for downstream waste management (PC2, PC3, PC7).

Mayers & Butler (2013) did a case study on PRO systems in different EU countries. In some countries multiple PROs are present and compete with one another. This results in lower pricing, and continuous reviews to remain competitive. On the other hand, it requires extra enforcement (which is not present) to control unwanted PRO strategies to increase market share. These strategies involve over-collection to raise the price of ones excess WEEE when balancing with other PROs. On the other hand, PROs can deliberately under-collect and be rewarded with lower costs (Mayers & Butler, 2013).

Finally, so-called scavengers obtain valuable parts or materials from WEEE devices before processing. This illegal process is a major issue in the industry of WEEE and a focus point for some large research and policy institutions (PC7; Baldé et al., 2017; EUWID, 2018; Huisman et al., 2018). Key point in scavenging is the fact that it is uncontrolled and illegal. Non-reporting of WEEE results in a reduction of 20% of operational costs, while this illegal processing has negative environmental effects and is costing EU recyclers an estimated €170 million annually (Baldé et al., 2017; Huisman et al., 2018). It is unclear however, to what extent this issue is present in the mobile phone industry. Most scavenged WEEE are refrigerators and air-conditions, while for all IT equipment 26% is scavenged (Huisman et al., 2018). Scavenging is opposing the CE due to the activity of seizing only 'the good parts' while the subsequent process is without depollution (PC7; Huisman et al., 2018). It is a result of the strict regulations regarding treatment and export activities (see policy section). Hence, misalignments within the technological EoL regime are present between illegal scavengers and the official industry, and between PROs as the competition in some countries results in unwanted strategies.

5.4.2 Lack of shared definitions

Subsequently on the case of scavengers, other researchers argue that scavengers can actually perform a valuable role in the CE and require additional research (Geng & Côté, 2002; Ghisellini et al., 2016). The definition of scavenging in this argument, however, is "companies capable to extract resources out of waste by applying innovative recovery technologies". Hence scavenging, as promoted by the latter researchers, is mentioned as the harvesting of useful parts that is valuable for the waste hierarchy for CE (e.g. PC2; PC3; Watson et al., 2017). This is not correspondingly the former 'illegal scavenging'. As a result, cognitive rules within the science regime are misaligned, and these different definitions cause 'so-called blurriness', as noted by Kirchherr et al. (2017) previously. A similar lack of shared definitions is found among the EoL technological regime, as presented in section 5.3.1.

5.4.3 Engineering limitations

Hollins et al. (2017) observed stagnation in the amount of patents concluding stagnation in the technological development in waste management technologies. They suggest new framework conditions or new financial investments into new technologies in their Science and Technology Options Assessment for the European Parliament.

Interviewees, however, note that this stagnation of patents is not due to any issues. In the lab, scientists are able to separate almost all materials but this does not represent reality. Patents are focused on this specific kind of material separation. However, these need to be implemented on large scale by engineers. And even though a difficult task, to be recycled streams contain dozens of materials in all different types of configurations. Hence lab-proven technologies are not 'a secret sauce (PC2). Improvements of the performance of recycling processes are a learning experience, and depend on the abilities of engineering (PC1, PC2, PC3, PC6). Hence, science is misaligned with the technological EoL.

Patents are not really the clue issue. Patents don't really help you. You need to improve technology by learning. (PC3)

Learning by doing requires volumes of collected mobile phones, or waste in general. As confirmed by Tanskanen (2013), the major factor hindering the development of advanced recycling technologies is the low collection volume. Hence, instead of additional investments in research, the EU is better off in supporting engineering and collection processes. Based on this, Hollins et al. (2017) set the wrong problem-agenda in the policy regime's cognitive rules, misaligning with the R&D subsidies under formal rules of the technological EoL.

5.4.4. Recycling scaling versus efficiency

In section 5.3.4. it is noted that the fact that some OEMs are demanding for a few specific recycled materials only is jeopardizing the comprehensive view of the CE (PC2; PC6). This relates to an issue in the technological EoL regime, where there is a trade-off existent between the scale of recycling and the efficiency of recovery of precious and specialty metals. Targeted disassembly prior to shredding substantially increases the recovery of precious metals and REE, but is labour intensive affecting the total scale (Reck & Graedel, 2012). This misalignment between technical standards and rules for profitability under the formal rules of the EoL regime is, however, partially mitigated by initiatives for pre-processing such as the Apple robots Liam and Daisy (Apple Inc., 2018; Rujanavech, 2016).

5.5. Landscape level

Landscape level changes can put pressure on regimes and cause internal restructuring (Burns & Flam, 1987). Some events and trends related to WEEE, and to mobile phones specifically have put pressure on regimes, causing them to restructure. As a result other regimes adapt, while on the other hand niche innovations have occurred. One of the best-known landscape pressures is climate change, which is pressurizing many ST-systems globally (Geels, 2004).

Another landscape pressures initiating a change of thought about raw materials was the global outrage due to the use of conflict minerals in mobile phones. The socio-cultural regime created a new norm of disgust towards conflict minerals. The political regime was to react first, with the United Nations renewing an arms embargo for Congo and supporting recommendations of due-diligence guidelines for importers, processing industries, and consumers of conflict mineral products (Epstein & Yuthas, 2011). Subsequently the US adopted regulations for stock-listed companies to report on their supply chain regarding conflict minerals, and the EU is following in the future. Due to the changes in policy regime, companies had to react. In the technological regime, the regulative procedure for reporting changed and implemented conflict minerals (Kim and

Davis, 2016). In the user-market regime user preferences changed, for at least a part of the consumers valuing social well being of the fate of the Congo population. So, the regimes reacted to the landscape pressure and became misaligned. In addition, especially due to the change in user preferences of last mentioned regime, a niche innovation broke through to the regime level with Fairphone introducing a conflict-free mobile phone in 2013 (Fairphone, 2018). For the established OEMs this landscape pressure is one of the drivers to exploit possibilities with recycling and the CE to overcome supply issues from conflict materials (PC2, PC6; Apple Inc, 2018; Epstein & Yuthas, 2011; Fickling, 2018).

> *"Congo is by far the biggest cobalt producer in the world and is also one of the most controversial and dangerous places. You don't get much to say down there. So as those resources become scarce, companies would rather figure it out now than when they are scarce." (PC2)*

Subsequently, the increasing economical power of China and its near monopoly on REE pressurizes the ST-system of WEEE. This increases the EU's need for more resource security, and the need for alternative economic systems in the union, as there is almost no REE in the ground. Therefore, this landscape pressure is one of the drivers for adopting the WEEE legislation and the circular economy package. With these policies the EU is increasing its resource security for REM (Gavin, 2013, Golev et al., 2014; Hollins et al., 2017). In addition, China imported a lot of waste from the US and the EU for its large scale recycling facilities; among these streams were WEEE and plastics. However recently, China implemented its 'national sword program' that puts import bans on WEEE and plastic waste. As a result, increased administrative burden and bans for a large part of the waste streams in general pressurize the EU (and the US) (PC1; PC2; PC6; Staub, 2018). Although there is still some lack of response, organisations in the EU are pressing the European Commission to take this as an opportunity to implement the CE (PC7; Zonneveld, 2017).

Finally, until recently the price of recycled materials was per definition higher compared to raw materials mining. This had several reasons such as the low quantities and difficult configurations of WEEE (e.g. Tanskanen, 2013), and the large scale of virgin material mining with cheap energy (Reck & Graedel, 2012). Currently, there is a reversal as waste treatment technologies become more developed and urban mining becomes more cost effective. When recycling multiple metals from WEEE streams, while correcting for government subsidies urban mining is now starting to become more cost-effective than virgin mining. This is the case for gold and metal, and a 'basket of materials' in China (Zeng et al., 2018).

6. Theoretical implications and limitations

The MLP allows a holistic analysis over a period of time from when an innovation is first deployed in a niche market until it is the new standard. In the mobile phone ST-system, the niche level has been broken and it is the current misalignments of regimes that are hampering the CE implementation. Hence, this part of the MLP theory is applied. This part of the theory proved helpful in conceptualizing issues according these regime misalignments. It structured the research in a coherent and transparent way.

Some other publications adopted the same approach are observed, although the point of analysis in time differed. This thesis forms an example for analyzing the status of any ST-system at a similar point in the MLP time line. That is, a partial adoption of a new innovation at a moment that the windows of opportunity occurred, a niche development broke out the niche level, and regimes are misaligned with both the former standard and the new. Such analyses create a clear overview of where extra attention is needed to foster the re-alignment of regimes so that the adoption of a new standard can be facilitated. Hence, the application of this theory forms an empirical contribution to the MLP theory.

In the introduction some examples are presented regarding misalignments of certain stakeholders in the ST-system of mobile phones. These actual examples support the decision adopting the misalignment of regimes as a theoretical framework. A gap was identified where a holistic view identifying misalignments involving all the different actors in the ST-system regarding the CE for mobile phones is not yet published. This thesis provides this analysis about the different perceptions following from social environments of the involved stakeholders. Hence, the gap in literature is covered with this state-of-the-art analysis of how the implementation of the CE in this industrial sector is performing.

An additional goal of this research was to provide the scientific community with a basis to overcome the gap between theory and practice, allowing more implementable research directions valuable for practitioners. Any of the found misalignments form avenues for further research. To retain this practical suitability further research must be conducted in a similar holistic and interdisciplinary setting. I.e., as discussed in the introduction, the EPR establishment through single disciplinary viewpoints resulted in unforeseen consequences and EPR is deemed as 'being to academic'.

Some examples for further research are presented based on the first two broader topics of misalignment, and the case for more transparency. A first research avenue is what happens with a shift of policy focus. As discussed, the policy regime enforced EPR on OEMs, however the reintroduction of materials or parts back into the supply chain is ineffective and 'not their turf'. A gap for further research is to analyse best-practice methods to stimulate this reintroduction market. What if policy would take a step back and play a supportive role? What would happen if VAT on secondary materials is repealed and the market could further guide itself? What are the effects for OEMs, EoL organisations? And the effects on the administrative and enforcement burden for the policy regime? Another research direction is the effect of the current market transactions between the OEM and EoL regimes on the CE. If these two regimes are integrated under one regime, e.g. one circular business model, what is the effect on product design, information sharing and the speed of disassembling used mobile phones, and the general costs of refurbishment and recycling. A final proposed further research avenue is regarding the OEM regime's role in creating awareness in the socio-cultural regime. Can OEMs use transparency and traceability to change public opinion? If products can always be traced, will the Basel Convention and other boundaries for shipments of WEEE become unneeded? And if OEMs supply information incorporated in the phone, does that affect consumer behaviour?

Some limitations in this thesis are present. First, the interdisciplinary and holistic nature is its strength, but also forms some limitations. Due to a vast amount of data covering multiple disciplines of this ST-system some potential restrictions appear due to cognitive biases of the author, interviewees, and in desk and scientific literature**.** This is the core of this thesis as social groups points of view are dependent on one's corresponding regime but it does impose some limits to objectiveness. Hence, relations between regimes can in some sense be subject to interpretation. Second, the appointment of social groups to the regimes is arbitrary to some degree. For example, in this analysis all treatment processes are grouped under the EoL technological regime. Alternatively, a regime could have been determined for every different process, i.e. recycling, refurbishment, reuse, reverse logistics regimes etc. This would, however, have resulted in a far more complex data set with a lot more relations. Hence, to retain clarity and overview these different processes are all grouped under the technological EoL regime. Third, in this thesis it is assumed that the CE for the mobile phone industry is the eventual goal. It can be argued, however, that the goal might change due to future technological developments overcoming the need for implementing a CE, or simply the fact that to many actors oppose the CE. Support for adopting the CE as eventual new standard in the landscape is, however, already discussed and CE aspects are already adopted in some of the regimes (e.g. EU Circular Economy Package). Moreover, the definition of CE differs between actors, mostly lacking a systems perspective and neglecting the waste hierarchy. The interviewees all shared the definition as posed in the theory section, and readers of this thesis must adopt this holistic definition as well. Finally, no EU level politician interviewee was available. This does not pose any serious issues, as with the applied data collection sufficient experience and knowledge about relations with the policy regime are uncovered. However, if an interview was conducted this could have allowed some additional insight in especially the cognitive rules of the policy regime, such as the 'ideas about the effectiveness of instruments'.

No new misalignments appeared after 5 interviews, hence theoretical saturation is argued as achieved. Reliability and validity are incorporated in this thesis. Transparency about the interview guide, interviewees' background, and the coding process ensure reliability of the research process. The interviews itself, however, are not published due to a non-disclosure agreement. Subsequently, theoretical applicability is present as there is a distinct match between the theory of regime misalignment from the MLP and the observations in reality. Also, this research forms an example for applying this theory on implementation process within any ST-system. Hence, validity of the theory is ensured in this thesis.

7. Conclusion

This thesis aimed to analyse the alignment of perspectives and viewpoints of different stakeholders about the mobile phone's industry implementation of the circular economy. For this purpose, misalignment of regimes is adopted from the MLP theory. This facilitated a structured, holistic and interdisciplinary analysis of this ST-system and how the misalignments between the regimes hinder the CE implementation. Figure 6 presents all the identified relations that are misaligned in this ST-system. Following categorization in the coding process, three broader topics were identified where multiple misalignments are to some extent related.

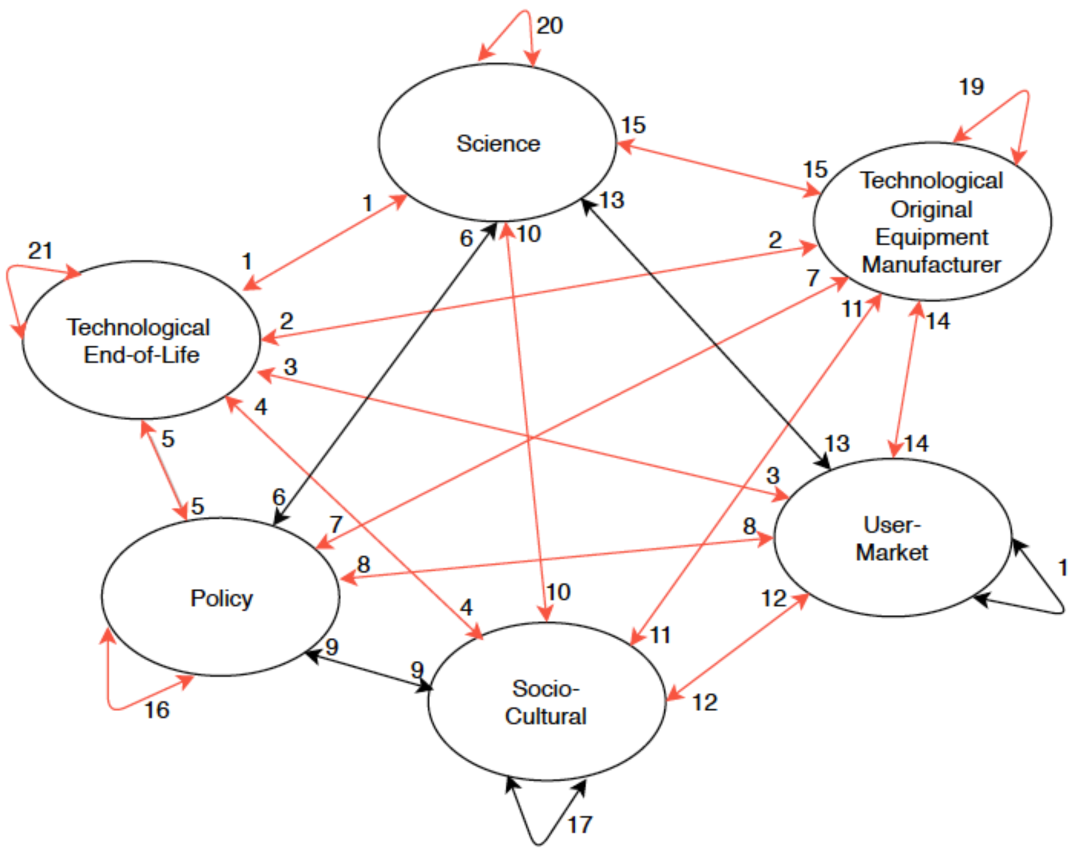

Figure 6 All the misaligned relations between regimes regarding the implementation of the CE in the ST-system of mobile phones

The first topic encompasses issues resulting from the policy regime, and how current policies conflict with the CE implementation. Some of the current policies are opposing the waste hierarchy crucial in the CE, which is a result of misalignment in relation 5 between technological EoL and policy (figure 6). The one best policy case promoting the waste hierarchy is the Flemish waste policy where reuse and refurbishment is clearly stimulated while providing jobs for low-skilled unemployed people. In general, however, there is a lack of knowledge and willingness to implement the CE among a majority of policy makers. As presented in table 5, this results in multiple issues such as the misinterpretation of the industry response on EPR, lack of EU law enforcement due to its transposition and differences in ambition, a lack of awareness in the socio-cultural regime, and knowledge and role of policy makers. Out of these 9 misaligned relations, it is noteworthy that the policy regime is misaligned on two topics with technological EoL, two with technological OEM, and once with the user-market. Hence, it appears that policy regime indeed should adopt a different role as their distance from the market opposes their understanding of how to support the CE. Under the current policy regime regulation there is too much conflict between EU and national levels. Also, although some good intentions appear (i.e. CE package), EPR in general as the basis of waste legislation gives no incentives for the CE. Hence, as stated by interviewees and some researchers, the policy regime should take a step back. Policy should adopt a supportive role instead while businesses should have the guiding role. This does demand the right pressures on businesses to overcome unwanted behavior due to their goal of profit maximization, hence the supporting role of policy and the importance of consumer awareness. For example, the reintroduction market can be supported by the repeal of VAT on secondary materials. As a result, these materials become more attractive and businesses can further guide the necessary developments.

Topic	Misaligned relations
Formal policy goals opposing the 'real' CE	5
Misinterpreting extended producer responsibility	7 & 15
Lack of enforcement	7 & 16
Public awareness	12 & 10
Policy knowledge and role	5 & 8

Table 5 Misaligned relations encompassing issues with the policy regime conflicting with the CE.

The second topic converges issues around the lack of connection between EoL and OEM regimes, representing a lack of circular business models. The science regime states circular business models are enablers for the implementation and performance of CE, as stated in the adopted definition for this thesis. Most OEMs, however, retain capitalist conditions and are pursuing business as usual by complying with WEEED and financing EoL activities. They do not see themselves in the business of recycling. In addition, OEMs tend to perceive resellers and refurbishers of the OEMs brand as competition, while assuming these activities jeopardize the quality of their products. The market for these refurbished mobile phones is growing both in developing and developed countries. Although, a majority of the consumers still avoids refurbished and second hand phones, which appears to be due to a lack of awareness. Some EoL companies, on the other hand, are purely in the EoL business for the money. These companies tend to lack a systemic view opposing best practice CE.

Besides the lack of right policy, the current system does not incentivise DfC due to the trade-off between product quality and DfC. Besides, the EoL cannot impose an incentive for such a design on OEMs due to the disconnection between OEM and EoL. Additional market transactions due to this disconnection are the ambiguity between perceived costs of refurbishment or recycling by OEMs and the actual costs, information streams from OEM to EoL regarding product disassembly and ingredients, and a lack of refurbished or recycled return flows into the supply chain. This final issue, the lack of return flows, is the reintroduction market that lacks incentives and could facilitate market solutions if corrected. Also, the majority of the current EoL infrastructure does not involve the right processes to retain quality of the return flows, and lacks incentives to overcome barriers for consumers to initiate the reverse logistics process. On the other hand private EoL companies, mostly resellers and refurbishers, have their own infrastructure in place that solves both these issues. If the gap between OEM and EoL regimes is increasingly integrated, and circular business models are deployed, the misaligned relations 2 and 14 can become aligned potentially solving three of the five topics (table 6). Also, when OEMs want their own products returned for EoL after first life cycle, the issues with incentives around the topic infrastructure is improved (table 6).

Landscape pressures and pressures from other regimes are already strong enough to initiate some of the OEMs to adopt (parts of) the CE. Hence, if these 'first-mover' OEMs continue to adopt 'real' circular business models closing the gap between EoL and OEMs, the cultural barriers can be partly overcome as the concept is proven and competitors can learn from it.

Topics	Misaligned relations
Cultural barriers	4, 11, 15, 19 & 21
Refurbishment and other business models	2, 11 & 14
Product design	2 & 14
Market transactions	2, 3 & 14
Infrastructure: access to used phones	4 & 21

Table 6 Misaligned relations encompassing issues with lack of connection between EoL and OEM regimes

The third topic presents residual misalignments. Incidentally three out of four of these topics involve the EoL regime (relations 1, 5, & 21 in table 7). The first is due to some competition in the EoL regime between PROs, which in some cases results in unwanted behaviour. Second, technological development in the EoL regime is not caused by anything other than the process of learning by doing to improve engineering processes. Hence, stagnation in patents for waste treatment processes is no sign of technological stagnation as this is rather caused by current engineering limitations. And third, currently there is some trade-off between the scale of recycling and the purity of the output of the process. This is partly the result of the engineering limitations and is expected to diminish over time. Finally, the lack of shared definition in science affects communication and therefore implementations. Researchers need to take this issue into account, as it can jeopardize the eventual performance of the CE.

Topics	Misaligned relations
Waste stream competition	21
Lack of shared definitions	20
Engineering limitations	1 & 5
Recycling scaling versus efficiency	21

Table 7 Residual misaligned relations

Finally, some landscape pressures are identified. These pressures are important drivers in the alignment of regimes towards the new landscape, the CE for mobile phones in this case. First, climate change is one affecting this, and many other ST-systems. Second, social effects of the use of conflict materials are an important driver for OEMs resulting from shifts in the policy and socio-cultural regimes. Third, China's near monopoly on REE play a big role for policy and OEM regimes to increase resource security. And finally, due to technological development in the science and technological EoL regimes, urban mining of WEEE is becoming more cost-effective compared to virgin mining.

In the adopted CE definition in this thesis, two enablers are included: novel business models and responsible consumers. Following this research, an additional enabler is proposed to add to this definition. The concept of transparency and traceability is identified as an enabler to ensure symmetric information sharing between the regimes resulting in more alignment. First, this ensures trust between the EoL, OEM, and user-market regimes. This facilitates circular business models, and therefore the reintroduction market allowing material loops to be closed. Hence it supports the already identified enabler of novel business models. Second, for the policy regime it ensures controllability, hence no new CE opposing bans on shipments are necessary. These regulations oppose shipments, even within the EU, opposing best-practice treatment and flows to secondary markets. Finally, an information system benefits to consumer behavior and public awareness in the socio-cultural regime. Awareness is created when phone users have direct access to information about why and where they need to hand in their phones. Storytelling plays an important role in this respect. This, in turn, contributes to the already included enabler of the adopted CE definition: responsible consumers. Hence, with transparency and traceability in place all regimes have access to information facilitating regime alignment and enabling the enablers from the adopted definition.

8. Recommendations

Transparency and traceability will play a major facilitating role in the circular economy for mobile phones for reasons concluded from this research. In addition, it is argued that the gap between the OEM and EoL market hinders the CE representing a lack of circularity in the business models. Transparency creates mutual trust between organisations, hence it benefits closing this gap. 4Square Return (4SR) is potentially able to play a facilitating role in these two aspects due to a unique position in a network of OEMs and EoL providers. At the same time, a unique knowledge base is present in the organisation regarding the CE, WEEE legislation, WEEE separation enabling market reintroduction, and WEEE recycling technologies. Based on these observations and assumptions some recommendations are presented to 4SR to be able to play this role. First, important aspects of leadership for implementing large-scale sustainable practices are emphasized. This recommendation does not follow directly from this thesis, however leadership in organisational change is crucial for success. Second, an elaboration on circular business models is provided and how these can be achieved. Finally, two ideas on how to implement information systems for transparency and traceability are presented.

8.1 Leadership

Implementing circular business models requires close collaboration throughout the supply chain. Managing such (inter-) organisational change and strong leadership are closely linked according scientific literature across disciplines (Crews, 2010; Hamner et al., 2008). Crews (2010) reports on stakeholder engagement, creating the culture, holistic thinking, organizational learning, and measurement and reporting as key leadership challenges for sustainability. A summary of the results is provided in table 8.

Challenge	Important aspects of the challenge
Stakeholder engagement	Integrate (not 'just' satisfy) needs and interests of all stakeholders through continuous dialogue
Creating the culture	Sustainability (or circular economy) must become core value; change mission, vision, strategies etc.
Holistic thinking	Think of the supply chain as a whole system where everything interacts
Organizational learning	Manage learning of all actors throughout the system, hence not only top management
Measurement and reporting	There is no silver bullet, choose the appropriate measurement and reporting system based on strategy and culture.

Table 8 Leaderships challenges adopted from Crews (2010).

Hamner et al. (2008) emphasize the importance of so-called ‘bridge builders’ as effective and successful organisational change agents. They are transformational leaders focusing on progress, are future oriented, and inspire others. The study conducted a four-year study on six case studies identifying these change agents, and under what circumstances they operate best. They found that bridge builders are characterized by having a leadership position, they are networkers, team players, have a clear primary goal, are flexible in their role, like building formal and informal relations, take risks, assume constant change, and are experienced in the specific field (Hamner et al., 2008).

> *“Bridge-builders looked at the big picture to keep up with the field and they collected information locally. They were action-oriented: when they knew action was necessary, they moved forward without hesitation. When turf issues or incompatibilities arose, bridge-builders analysed ways to combat the obstacles. They built informal collaborations around a common goal by opening up a dialogue, establishing legitimacy, and connecting with the community. The bridge-builder had a vision and created that vision through persistence, passion, and creativity.”* (Hamner et al., 2008, p. 165).

Optimized conditions facilitating these change agents are identified in this research as well. It is important that everyone in the environment agrees that change is necessary. This is crucial, as the change agents do not operate on their own; rather they are part of a team that pursues a common goal. Also, it is important to regard the work not as a short-term program, but a more basic change in how systems operate (Hamner et al., 2008).

8.2 Circular business model

To achieve resource sustainability through the CE, it is crucial to leave the comfort zone of neo-classical and capitalistic economic assumptions. The CE thinking requires different viewpoints on the economy, and is achieved by adopting circular business models. Adopting circular business models is a relatively new business field, and will ensure the integration, or alignment, of the EoL and the OEM regimes. In this section, some relevant literature regarding CE business models is summarized.

One popular scientific publication about sustainable business models reviewed literature and practice to establish business model archetypes that incorporate sustainability (Bocken et al., 2014). The circular economy business model falls under the ‘create value from waste’ archetype. This archetype is distinct from ‘simply’ increasing efficiency in that it seeks to create new value from what is currently perceived as waste. It shares similarities with the natural world where the concept of waste does not exist, as waste of one species becomes feedstock for another (Bocken et al., 2014).

The value proposition of this business models archetype is eliminating the concept of waste by turning existing waste streams into useful and valuable input (Bocken et al., 2014). This is achieved by closing the loop of a company's supply chain. This requires a different view on product ownership to overcome the issue of stockpiling mobile phones by consumers. Another option is to use waste from another company as input for the production process. This is the case under industrial symbiosis, e.g. on so-called eco-industrial parks. Practical example is the park in Kalundborg, Denmark (Chertow, 2008), or projects described in the book the Blue Economy (Pauli, 2010).

Value creation and delivery involves activities and partnerships to eliminate life cycle waste, close material loops, and make use of under-utilised capacity of a product. It requires the introduction of partnerships, potentially across industries, to capture and transfer waste streams (Bocken et al., 2014). Here the need for systems thinking appears. Besides re-establishing product ownership with the consumer, partnerships with organisations lead to closing the gap between the EoL and OEM regimes. All activities that are necessary to ensure a closed material loop need to be managed under this single business model to avoid material loss. Making use of under-utilised capacity relates to the so-called shared economy. For mobile phones this is assumed as not applicable, as the mobile number is one's personal communication channel.

Value capture is achieved, as economic and environmental costs are reduced through reusing materials and turning waste into value. Positive contribution to society and environment are achieved through a reduced footprint, reduced waste, and reduced virgin material use (Bocken et al., 2014). Hence, after investments for implementing the CE, economic value capture is present through reduced material use and waste-to-value. This forms an important argument in persuading hesitant managers or other actors in an organisation.

Integrating this circular economy business model into an organisation involves a new type of innovation, business model innovation. With the established partnerships and network 4SR is able to be the facilitator (the 'wedding planner') between the organisations that need to connect to close the loop. Hence, consult and support on developing the business model and establish the necessary partnerships in its network. Osterwalder & Pigneur (2010) published a widely utilized handbook on business model innovation. The business model forms the blueprint for a strategy to be implemented through organisational structure, processes, and systems. The handbook provides nine building blocks that together form a business model canvas.

Building a new business model for new mobile phones could start by adopting a leasing model. In such a way the value proposition for the customer is the service of using a mobile phone, instead of the physical unit itself. Such a proposition completely changes the business model in all its aspects or building blocks, and the OEM maintains ownership of the physical unit. This ensures an OEM that it will recover the mobile phone after one or multiple user cycles. This could therefore be argued to be the ultimate form of EPR. Mobile phones already out there, intentionally or unintentionally stockpiled, need an additional approach to ensure that material is recaptured. Some form of cash incentive in combination with storytelling, and easy to use infrastructure is the best strategy for this. In this strategy, a good marketing story appears to be more important compared to the height of the financial incentive. Such a story emphasizes environmental and social benefits, and the reward for the consumer. Goal of this marketing story is to mobilize the consumer to start the process of reverse logistics.

One final aspect facilitating the CE is the extension of a product use cycle for a consumer. Currently, consumers in western countries have an average use cycle of a mobile phone of 18 months. If this user cycle is extended and product introduction frequency is lowered the CE becomes easier to achieve. It is, however, likely that OEMs are not in favour of such an approach due to capitalist mind-sets. At the same time, online services such as application stores and cloud services generate revenue as well, while the costs for these services are lower compared to production costs. In addition, refurbishment activities contribute to extending the life cycle, however currently this is not under the OEMs business model. Hence, changing the mind-set regarding such aspects is an important issue in realizing the CE in this industry.

8.3 Transparency and traceability

As concluded from the thesis transparency and traceability will play a major supportive role in establishing the CE for mobile phones and controlling the material flows. The fact that mobile phones are connected to the Internet enables such a system to be an application in the software on the phone. Such a system facilitates the process of regime alignments. Two potential versions then are possible.

First, already produced phones can be supplied with a software update installing an information application in the operating system. This version is able to supply information to the consumer why and where to hand in the phone at end of use initiating the reverse logistics. This overcomes the issue of stockpiling phones, and can stimulate the waste hierarchy by informing about alternative options instead of handing it in at a PRO. Also, OEMs have control over the material stream in their new circular business model. EoL companies have access to valuable information when the phone arrives at their company. In addition, this information can entail details about product or parts performance, disassembly processes, materials inside, etc. As a result, refurbishment and reuse activities are enhanced and less phones are bound for recycling retaining more value. Another aspect is the controllability and traceability to avoid dumping in third world countries. As long as the phone is still online, it can be traced and checked whether illegal activities occur. Moreover, with a predetermined destination in a third world country, the large second hand and repair markets in this part of the world can be supplied with the second hand, high-end devices. In that case, CE is promoted through a double-edged sword. Used phones unfit for more 'high-end' markets can then be shipped and reused in less demanding markets. At the same time low quality alternatives (e.g. from India) shipped as new phones to developing nations can be avoided. And it is these phones that tend to have even shorter life cycles and therefore result in more waste. Finally, with the available information the reintroduction market is facilitated, as control on the materials is realized.

Second version of the information system in a mobile phone might in addition include a GPS tracker that is working while the phone is not connected to the Internet. This further enhances controllability of the material streams when the phone in question is offline. This controllability supports the circular business model to be able to catch all the material and reintroduce into the loop within the company's circular supply chain. In addition, it further improves controllability for the policy regime (i.e. the Basel Action Network) regarding the issues of WEEE dumping. This final aspect, in turn, can be used to overcome CE opposing legislation on the trans boundary shipments of WEEE.

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Appendix

Appendix A. Interview Guide

Interview #
Name
Job
Date
Place

NOTES

Introduction
I signed NDA; all information is anonymous in the public version. All outcomes are for research purposes; if there is something specific you still want to 'keep for yourself' let me know.

Commissioner: 4SR
Goal of the research: Analysis of the current WEEE environment, focused on mobile phones, and the implementation of a circular economy.
Analysis is based on the theory that a socio-technical system needs to co-evolve with an innovation for it to become successful. The socio-technical system of WEEE looks like this figure. All the social groups can be grouped under so-called regimes, like this. Each regime is the set of rules, beliefs, and perspectives etc., shared by social groups.
Co-evolution of these groups is dependent on their alignment, when these groups are misaligned the adoption of the new 'norm' (=circular economy) is obstructed.

So, in this interview determining the differences between you and your regime, and you and the other regimes.
REMEMBER THERE ARE NO WRONG ANSWERS! WHEN YOU DON'T HAVE AN ANSWER THAT IS A RESULT FOR ME AS WELL!

1) *To create some background, what is your day-to-day job?*

2) *How do you see yourself in the regime-system? With what regime are you affiliated?*

3) *How do you envision the circular economy? (Waste hierarchy!)?*

4) *How do you consider yourself/organisation as consciously contributing to the circular economy for mobile phones? (or just compliant with)*

Inter regime (Start question: Take a minute to think about…..)

5) *From your 'regime' what do you see as barrier(s) regarding the relation to the … regime, when moving towards a circular economy? (What are your expectations of … regime?; Where are you misaligned, leading to conflicting views and behaviour?)*

6) *How should the relation with other regimes change to improve the adoption of CE? Or, how should other regimes or how should your regime change?*

Intra regime

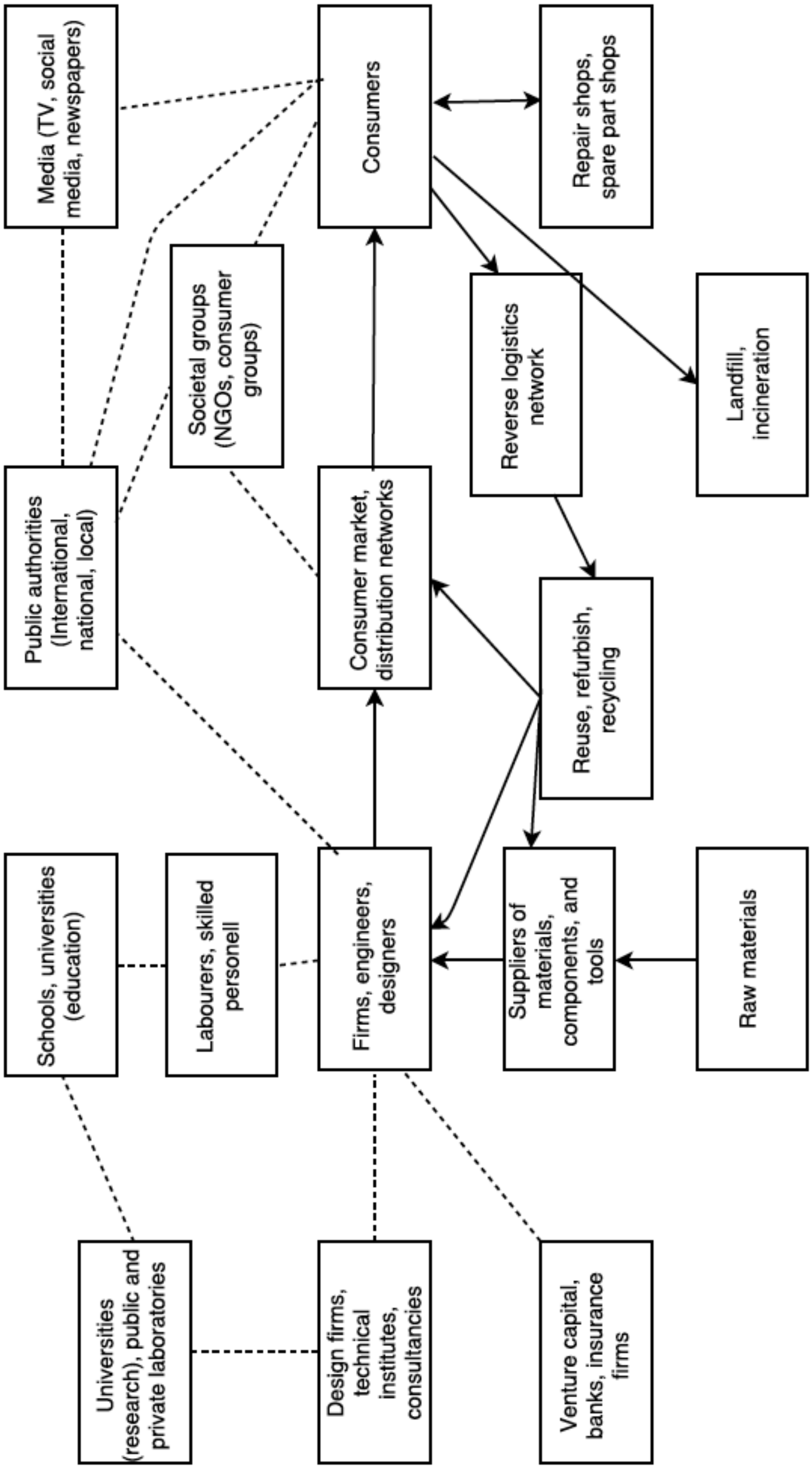
7) *Is every one in your regime on the same line in the process to CE? (Are the actors in your regime aligned in the process towards CE?)*

8) *How can your regime improve?*

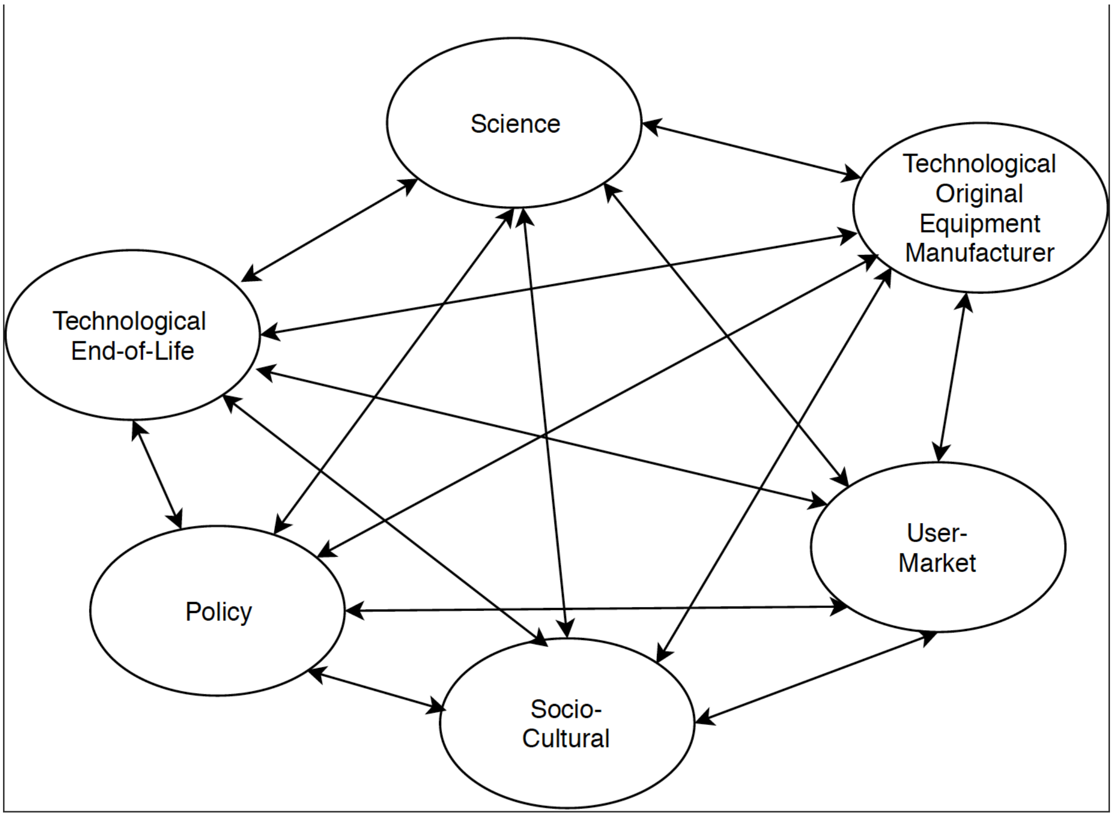
9) *Do you see differences between actors in other regimes?*

The following three figures provided some background information for the interviewees when theoretical aspects are unclear.

Social groups in the socio-technical system



Regimes


Science
Technological Original Equipment Manufacturer
Technological End-of-Life
User-Market
Policy
Socio-Cultural

Regimes and their formal, regulative, and cognitive rules

	Formal/Regulative	Normative	Cognitive
Technological	Technical standards, product specifications (e.g. emission or weight), functional requirements (articulated by customers), accounting rules to establish profitability, ROI, R&D subsidies	Companies own sense of itself (what company are we? What business are we in?), authority structures in technical communities or firms, testing procedures.	Search heuristics, routines, exemplars, guiding principles, expectations, technological guideposts, technical problem agenda, presumptive anomalies, problem solving strategies, technical recipes, ‘user representations’, interpretative flexibility and technological frame, classifications
Science	Formal research programs (in research groups, governments), professional boundaries, rules for government subsidies.	Review procedures for publication, norms for citation, academic values and norms	Paradigms, exemplars, criteria and methods of knowledge production.
Policy	Administrative regulations and procedures that structure the legislative process, formal regulations of technology (e.g. safety standards, emission norms), subsidy programs, procurement programs.	Policy goals, interaction patterns between industry and government (e.g. corporatism), institutional commitment to existing systems, role perceptions of government.	Ideas about the effectiveness of instruments, guiding principles (e.g. liberalization), problem-agendas.
Socio-cultural	Rules that structure the spread of information production of cultural symbols (e.g. media laws).	Cultural values in society or sectors, ways in which users interact with firms.	Symbolic meanings of technologies, ideas about impacts, cultural categories.

User-market	Construction of markets through laws and rules, property rights, product quality laws, liability rules, market subsidies, tax credits to users, competition rules, safety requirements	Interlocking role relationships between users and firms, mutual perceptions and expectations	User practices, user preferences, user competencies, interpretation of functionalities of technologies, beliefs about the efficiency of (free) markets, perceptions of what 'the market' wants (i.e. selection criteria, user preferences).

Appendix B. NVivo Codebook

Name	Files	References
1. Technological EoL and Science	0	0
1. Technological EoL and Science\Engineering limitations	4	9
2. Technological EoL and technological OEM	0	0
2. Technological EoL and technological OEM\Market transactions	0	0
2. Technological EoL and technological OEM\Market transactions\Costs of Recycling	3	4
2. Technological EoL and technological OEM\Market transactions\Information sharing	6	15
2. Technological EoL and technological OEM\Product Design	6	8
2. Technological EoL and technological OEM\Refurbishment and other BMs	2	2
3. Technological EoL and User-Market	0	0
3. Technological EoL and User-Market\Market Transactions	0	0
3. Technological EoL and User-Market\Market Transactions\Reintroduction Market	6	9
4. Technological EoL and Socio-cultural	0	0
4. Technological EoL and Socio-cultural\Cultural Barriers	2	3
4. Technological EoL and Socio-cultural\Infrastructure	7	12
5. Technological EoL and Policy	0	0
5. Technological EoL and Policy\Engineering Limitations	0	0
5. Technological EoL and Policy\Formal policy goals opposing CE	0	0
5. Technological EoL and Policy\Formal policy goals opposing CE\Double VAT	3	3
5. Technological EoL and Policy\Formal policy goals opposing CE\Transboundary	6	12
5. Technological EoL and Policy\Formal policy goals opposing CE\Waste hierarchy	6	12
5. Technological EoL and Policy\Policy Knowledge and Role	7	22
6. Policy and Science	0	0
7. Policy and Technological OEM	0	0
7. Policy and Technological OEM\Lack of Enforcement	5	11
7. Policy and Technological OEM\Misintepreting EPR	8	12
7. Policy and Technological OEM\Policy Knowledge and Role	5	8
8. Policy and User-Market	0	0
8. Policy and User-Market\Policy Knowledge and Role	2	3
9. Policy and Socio-cultural	1	1
Intra group	0	0
Intra group\16. Policy	0	0
Intra group\16. Policy\Lack of Enforcement	4	5
Intra group\17. Socio-cultural	0	0
Intra group\18. User Market	0	0
Intra group\19. OEM	0	0
Intra group\19. OEM\Cultural Barriers	1	2
Intra group\20. Science	0	0
Intra group\20. Science\Lack of Shared Definition	2	2

Intra group\21. EoL	0	0
Intra group\21. EoL\Cultural Barriers	3	4
Intra group\21. EoL\Infrastructure	6	7
Intra group\21. EoL\Recycling Scale vs Efficiency	2	2
Intra group\21. EoL\Waste Stream Competition	5	16
Landscape	0	0
Landscape\China economic	3	3
Landscape\Conflict mineral	2	2
Transparent information	5	9
10. Socio-cultural and science	0	0
10. Socio-cultural and science\Public Awareness	0	0
11. Socio-cultural and technological OEM	0	0
11. Socio-cultural and technological OEM\Cultural Barriers	5	8
11. Socio-cultural and technological OEM\Refurbishment and other BMs	0	0
12. Socio-cultural and user-market	0	0
12. Socio-cultural and user-market\Public Awareness	5	5
13. User-market and science	1	1
14. User-market and technological OEM	0	0
14. User-market and technological OEM\Market Transactions	0	0
14. User-market and technological OEM\Market Transactions\Reintroduction Market	6	15
14. User-market and technological OEM\Product Design	3	4
14. User-market and technological OEM\Refurbishment and other BMs	6	13
15. Technological OEM and science	0	0
15. Technological OEM and science\Cultural Barriers	0	0
15. Technological OEM and science\Misintepreting EPR	2	2