MEEM Thesis Report

From Disposability to Conviviality: Investigating Planned Obsolescence and Conviviality in Smart Phones

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Abstract

This thesis investigates how sustainable modular smartphone companies integrate convivial principles into product design and production to resist planned obsolescence. Planned obsolescence in electronics leads to increased e-waste, unethical mining practices, and reduced user autonomy. By examining Fairphone and Shiftphone through interviews and literature review, the study assesses how these brands incorporate convivial principles. A survey of users further explored perceptions of technological conviviality in smartphones. The findings show that while modular smartphones offer greater autonomy and repairability, challenges such as complex supply chains hinder full alignment with convivial values. It was also found that while planned obsolescence is leading consumerism and detaching people from forming real connections in their lives, the concept of conviviality is a reminder that technology should just be a tool that provides freedom and not something that restricts freedom. The research also emphasizes the importance of evaluating smartphones through a convivial lens for a more sustainable, socially responsible future.

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List of Figures

List of Tables

Contents

1 INTRODUCTION

The 21st century is primarily distinguished by the technological advancement humans have achieved and this achievement comes with a huge price. As the population increases, its wants and needs also increase uncontrollably making our society a consumer driven society. This dispose culture is said to be forced upon us by the capitalist, profit-oriented market economy as the manufacturers discovered producing highly durable and robust products put them out of business (Oraee et al., 2024). Thus, creating a society, where Planned Obsolescence (PO) has become so universal, that it now shapes the design and production of countless products. The term 'Planned Obsolescence' (PO) was coined by London (1932) to overcome recession in the US economy caused by economic depression which reduced the consumers buying power (Cardoso Satyro et al., 2018). PO refers to designing and manufacturing products in such a way that it limits the lifespan of products (Habib, 2023). To maximize profits, producers deliberately manufacture products with predetermined life that breaks easily or are hard to repair (Rivera & Lallmahomed, 2016). This practice forces consumers to replace products more frequently thereby promoting a 'buy and dispose culture' leading to a linear model of production and consumption. Over the years many product companies have introduced PO practices in their design reducing their product lifetimes deliberately as shown in Figure 1. One of the most discussed examples include when the world's largest light bulb producers collaborated to decrease the burning hours of light bulbs from 2500 to 1000 in 1924. World famous printer manufacturers Epson printers and Hewlett Packard (HP) also settled various class-action lawsuit about inkjet printers suspending printer functions even with cartridges not empty and misleading ink cartridge indications respectively (Bisschop et al., n.d.).

In contrast, PO in some cases is viewed positively by few economists in certain contexts, particularly when it is associated with technological progress and consumer preferences. They claim PO can lead to progress by fostering a healthy dissatisfaction with existing products and encouraging innovation to improve them, contribute to the growth of the economy and align better with consumer preferences (Longmans, 1960). This linear model promoted by PO has so far proven to be unsustainable by contributing towards environmental degradation and resource depletion. Moreover, PO also encourages a culture of consumerism and materialism which in turn push people to overconsumption and thus traps them in a never-ending cycle (Panizzut et al., 2021).

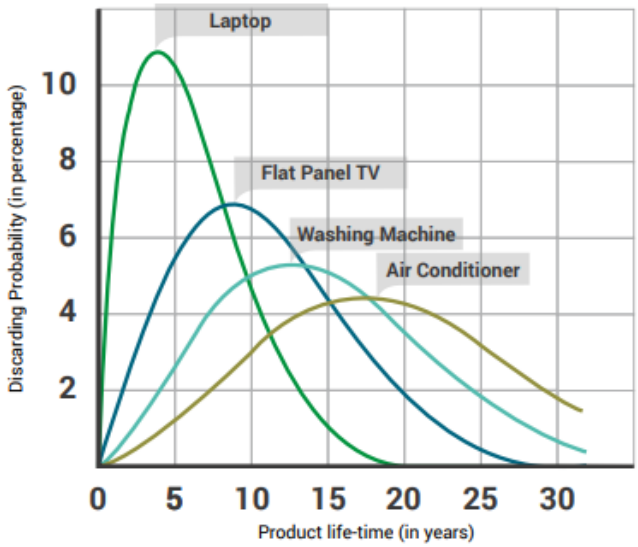

Figure 1 Product lifecycle of different consumer electronics

Thus, PO is harmful as it generates huge quantities of waste that mostly ends up in landfill due to our broken recovery and recycling system. Especially in developed nations (see Figure 2), electronic devices often end up being discarded rather than properly recycled, creating a significant environmental concern. Many of these devices are shipped to developing countries where the metal components are reclaimed under unregulated conditions, resulting in various health and sanitation issues (Rivera & Lallmahomed, 2016) while, the hunger for digital devices keeps growing inexplicably. Thereby, causing significant economic, environmental, and social risks. Among all consumer products, Information and Communication Technologies (ICTs) and devices are considered to be the world's fastest growing waste streams because it is designed to be fragile and are difficult or impossible to repair (van der Merwe & Brugger, 2021). One of the earliest examples cited by Feldman & Sandborn (2007) include the intentional lifetime design of Apple's iPod™ based on market demand which provide insight into the brand's overall product line strategy and objectives. Therefore, ICT devices and smart phones in particular being the most sought-after electronic devices by people of all kinds and age groups requires significant attention.

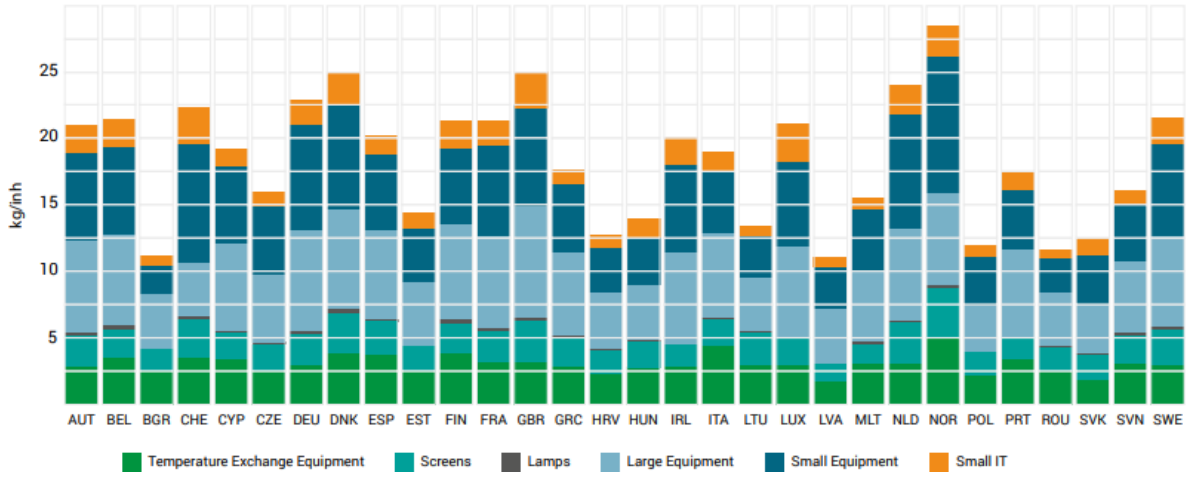

Figure 2 Waste per capita e-waste generated (Source: (Baldé et al., 2017)

To address the pressing problem of technological PO proactive solutions are required. One of such solution introduced by the European Union (2023) is the proposed 'right to repair' legislation that encourages producers to design and produce modular products and consumers to repair and reuse their products and devices for longer periods of time (van der Merwe & Brugger, 2021). Variety of economic tools and methods also exist to tackle electronic product obsolescence such as Life Cycle Assessment (LCA) which provides information about the performance of a product during its lifetime (Rivera & Lallmahomed, 2016), and Material Risk Index (MRI) Approaches and Design Refresh Planning (Singh & Sandborn, 2006). There has also been widespread call for the adoption of concepts such as 'green growth' and 'circular economy' whereas the former one places emphasis on waste as a resource the latter focuses on eco-friendly practices minimizing negative effects on the environment (Hu & Gu, 2023) while also advocating for economic growth (Belmonte-Ureña et al., 2021). But these tools do not consider the social dimension (Ralph, 2021) which is crucial in the fight against PO.

If we zoom out and take a broad look, there is a bigger dilemma hidden. The growth narrative for innovation is built on the linear model assuming economic growth, increased employment, welfare and prosperity as results of developments in science and technology (Kerschner et al., 2018). Though climate change threats popularized alternative approaches such as Green Growth and Circular Economy, these are still focused on the growth perspective. Another approach which is considered by many as radical is 'Degrowth' which calls for limits to growth by placing limitations to resource utilisations finding balance between economy and nature (Belmonte-Ureña et al., 2021). Degrowth has a complex relationship with technology and imagines technologies that align with values of sufficiency, care, autonomy, justice and conviviality rather than profit maximization (Kerschner et al., 2018). Illich (1983) emphasized

the importance of conviviality which is defined as ‘individual freedom’ within ‘personal interdependence’ and as a fundamental ‘ethical value’ and popularized the concept of convivial tools. These are technologies that promote ecosystem preservation, user autonomy, and challenges unequal power dynamics. Thus, convivial design place emphasis on designing products that are sturdy, lasts longer while also causing less environmental impacts. Illich also argued that societies with low levels of conviviality cannot meet required social needs, regardless of technological progress. Therefore, the pursuit of alternative convivial technologies is integral to envisioning a different society (Pansera & Fressoli, 2020).

In the contrast is PO which is motivated not only by economic incentives but also by a culture of mass consumption (Watanabe et al., 2019). In order for technology to decouple from growth, align with degrowth principles, and be truly sustainable, it must reduce its material and energetic impact and also address societal aspects that influence its sustainable use. This kind of technological conviviality could be nurtured through sustainable business models, organizations and social networks involving consumers, producers, researchers and technologists. Worldwide many initiatives have emerged to achieve this aim and make technology more sustainable. Notably there are smart phone manufacturers who try to address the problem of PO and social aspects of increasing user autonomy by designing modular smart phones such as Fairphone and Shiftphone. An image of modular smartphone components of Shiftphone is shown in Figure 3. Few studies investigate modular smartphone manufacturers, how they make a business case that doesn’t orient toward PO, and how users of modular smartphones interact with and perceive their phones. This study aims to look at the modular smartphones through a lens of sustainability and conviviality to see if the concept of conviviality is applied or can be applied to modern technologies.

Figure 3 Modular smartphone design of Shiftphone(2023), https://www.shift.eco/en/circular-economy-and-the-13-shiftcycles-part-3-redesign/

1.1 Problem Statement

The widespread phenomenon of PO in consumer products, driven by a culture of overconsumption and materialism, poses significant economic, environmental, and social risks. Despite the emergence of various legislative and technical solutions the current focus remains primarily on economic growth at the expense of environmental and material sustainability, while neglecting a convivial relationship with technology which is crucial in addressing PO. Whereas, the principle of conviviality gives people and the environment utmost importance, thereby promoting a just and equal society where individuals have the freedom of choice. While there are some sustainable smartphone companies that claim to offer alternatives such as modular smartphones, there is a lack of understanding regarding the extent to which convivial principles are integrated into their products and how users perceive and engage with them. Therefore, there is a pressing need to explore the transition from disposability to sustainability, focusing on the incorporation of convivial principles in technology design and production processes, and its impact on resisting PO.

1.2 Objectives

This thesis seeks to explore the transition from disposability to sustainability by investigating the phenomenon of planned obsolescence and technological conviviality. By evaluating the case of two modular smartphones, this work will investigate if and how the principles of conviviality are incorporated in technologies that claim and aim to be sustainable using a selection of the Matrix of Convivial Technology (Vetter, 2017). The user perception of modular and sustainable smartphones will also be studied to understand the potential and impact of such devices to create demand for convivial technology and social change to resist PO. Thus, this research aims to contribute to the growing literature on sustainable technology and degrowth. Through a critical analysis of case studies, this thesis seeks to shed light on the urgency of transitioning towards convivial technologies and the need for systemic change in our approach to technology and consumption.

1.3 Research Questions

Guided by the objectives, the main research question that this thesis answers is:

'How do sustainable smartphone companies integrate convivial principles in their product design and production processes and how does technological conviviality help users resist planned obsolescence?'

To adequately address the research question, the following sub-questions need to be answered:

1) How do convivial technologies challenge the principles and practices of planned obsolescence in smartphones?
2) To what extent do Fairphone and Shiftphone incorporate the core dimensions of convivial technologies (as defined by Vetter (2017)) to their product design and business strategy?
3) How do smart phone users perceive and engage with convivial smartphone technologies in comparison to ones that are designed to be obsolete?
4) What are the main barriers and challenges hindering the widespread adoption of sustainable convivial technologies as opposed to smartphones designed to be obsolete?

2 LITERATURE REVIEW

This section elaborates on the various research that has been done revolving the topic of this research. Key concepts are identified and reviewed.

2.1 Planned Obsolescence

In the past, obsolescence was predominantly linked to product failure over time or the introduction of more advanced technologies (Alzaydi, 2024). Longmans (1960) in his book *The Waste Makers* explored how as consumer culture developed and competition increased, manufacturers began employing different tactics by introducing minor changes to products to make older versions seem obsolete thus creating fashionable trends to encourage frequent upgrades. This manipulated consumer perceptions of quality and durability. Longmans also reviewed the huge role of advertising in promoting this idea of constant innovation and progress which fuelled the cycle of consumption and waste. Overall, the book highlights how planned obsolescence has evolved into a sophisticated strategy aimed at stimulating demand and maximizing profits in a competitive market.

Though PO is seen as planned strategy, there are different types of PO. Rivera & Lallmahomed (2016) in their article explained four types of PO. These include technological or functional obsolescence, psychological or style obsolescence, systemic obsolescence and obsolescence resulting from product malfunction. Firstly, technological or functional obsolescence occurs when products become outdated due to consumer preference for newer updated technology, such as video games or computer software. Secondly, psychological or style obsolescence involves the designing of products to stimulate the need for newer versions based on fashion and marketing. Thirdly, systemic obsolescence involves changing the system in which products operate to thus making it difficult to use or discontinuing maintenance services, as seen with associated products like videotape readers and CDs. Lastly, obsolescence due to product failure or breakdown occurs when devices are intentionally designed in such a way that it stops working after a pre-calculated number of cycles or are made with lower-quality materials, leading to premature disposal. Be it any kind of PO, the shorter the lifespan of a product, the faster it ends up in a landfill as a waste (Rivera & Lallmahomed, 2016).

Electronic industry is one of the most vulnerable to PO where there is rapid advancements in technology and new upgraded products enter the market continuously replacing existing products (Sierra-Fontalvo et al., 2023). According to recent studies, the volume of e-waste generated worldwide has been steadily increasing over the years, driven in part by the rapid

pace of technological innovation and consumer demand for newer electronic products (Authored By Baldé et al., 2017). For instance, a report by Baldé et al. (2017) estimated that approximately 44.7 million metric tonnes of e-waste were generated globally in 2016, representing a substantial rise from previous years. This upward trend is still continuing, posing significant challenges for waste management systems and environmental sustainability efforts.

2.2 Smartphones

Smartphones contribute significantly to carbon emissions during production and account for a substantial portion of global e-waste. Despite the potential value of raw materials in e-waste, recycling rates remain low (Chatterji, 2021). Seen as a sign of modernity, the rapid increase in smartphone production is taking toll on the environment. (Jaeger-Erben et al., 2023). Energy use during the manufacturing phase, use of rare earth metals and the long supply chains contribute highly to this environmental impact (Amend et al., 2022a). Smartphones are not just as technological device, but it also serves several complex social, technological and personal functions (Hirose & Mishima, 2019). Jaeger-Erben et al. (2023) discusses how smartphones are deeply integrated into people's everyday lives thus influencing consumer behavior by creating desires for the latest models and encouraging extensive use of various apps and functions, leading to a culture of overconsumption. A survey conducted by Hirose & Mishima (2019) among university students to find the waste factors that led to wastage of smartphones found the following reasons as top five: wanted to change display size, quality of the display was insufficient, wanted to update operating system, storage was insufficient and they found their old smartphones too slow. Many of these reasons could be addressed just be repairing or refurbishing the smartphones but only very few smartphone manufacturers provide such facilities and many times repairing or replacing one part of a smartphone costs more than buying a new one.

With sales growth amplifying resource scarcity, extending smartphone lifespan can be a crucial strategy to reduce e-waste and minimize environmental impact. Increasing smartphone life by just one year could have significant carbon emission reduction and waste reduction implications (Chatterji, 2021). Agrawal & Ülkü (2013) states that designing smartphones with modular upgradable architecture is the solution address the problem. As opposed to integral designs, modular upgradable architecture enables users to replace only the malfunctioning subsystems within a device. The authors also found that for subsystems that have high environmental impact, modular upgradability can mitigate the environmental impact by

increasing the use of subsystems with lower impact and also reduce the pace at which subsystems become obsolete.

2.3 User perception of modular smartphones

Modular smartphone perception has been a topic of considerable interest in recent years, particularly as these devices propose are marketed as the sustainable alternative to regular/traditional smartphone models. While PO is commonly blamed on producers and manufacturers, various researchers claims that product lifetime is also affected by user's decision to dispose of functioning products (Amend et al., 2022b,). One of the primary drivers of positive user perception towards modular smartphones is their potential to reduce electronic waste. Studies indicate that consumers are increasingly aware of environmental issues and appreciate products that offer sustainable solutions (Prakash et al., 2017). Modular smartphones, by design, extend the device's lifespan and reduce the frequency of complete product replacements, thus minimizing waste. This eco-friendly aspect appeals particularly to environmentally conscious consumers who prioritize sustainable consumption (Hoffmann et al., 2019).

2.4 Conviviality in technology

Often motivated by profit maximization, PO is driven by economic incentives, consumer culture (Watanabe et al., 2019) and growth, rather than meeting genuine human needs. Dale (2012) in his article 'Growth Paradigm: A Critique', argues that while economic growth is often framed as necessary for meeting human needs and improving social well-being, it is driven by capitalist agenda to accumulate capital and maximize profit. Dale also points out that growth-oriented economies place unsustainable demands on natural resources and contribute to environmental degradation, including climate change and biodiversity loss. While this growth can be 'cleaner' and 'greener' it still has resource requirements and can cause environmental impacts (Kallis et al., 2018). Hence the call for a limit to growth – be it any kind 'clean', 'green' or 'circular' – is 'Degrowth'. The Degrowth paradigm rejects economic growth as the ultimate-goal and opposes using Gross Domestic Product (GDP) as a measure of societal progress (Heikkurinen, 2018) . It aims to slow and reverse global resource consumption, decrease energy usage, and achieve sustainability through regenerative policies. Degrowth supporters also advocate for a more egalitarian distribution of income and wealth, stabilizing the global population (Boston, 2022) in which technology could play a vital role.

Bonaiuti (2018) cites degrowth as issued in a declaration in Paris in 2008, in which degrowth is defined as a "a voluntary transition towards a just, participatory and ecologically sustainable

society". This relationship between technology development and degrowth is a complex and multifaceted one, encompassing various perspectives and considerations. Degrowth criticizes the blind faith we have in technology and the belief that technological efficiency and innovation can address ecological crisis. In most cases technological efficiency and innovation leads to rebound effects (Muniz & Cruz, 2015). Kallis et al. (2018) points out that technology holds tremendous power that in the journey to achieve sustainability we need to break off from it. In his article 'Tools for Conviviality', Illich (1983) used the term conviviality to convey an idea that is against industrial productivity. Illich argues that in the current age of scientific technology, it is necessary to have convivial tools that are distributive and participatory which gives power and control to the users - the ability to repair, disassemble, reassemble (Kallis et al., 2018) by analysing the increasing threats of uncontrolled economic growth. The main threats of overgrowth as mentioned by Illich are biological degradation, radical monopoly, over – programming, polarization, obsolescence and frustration (Pansera & Fressoli, 2021). The impacts of consumerism and unsustainable consumption patterns are detrimental for both the environment and society calling for the need to investigate planned obsolescence and conviviality.

When Illich (1983) introduced the concept of conviviality and convivial tools the idea was to promote tools that foster cooperation, and fulfillment while minimizing dependency on large-scale, centralized institutions. Convivial tools were defined as those that are simple, accessible, and those that empower individuals to control their own lives. However, this definition does not suffice the need to define, develop and evaluate sustainable convivial technologies. To address this concern and to analyze technologies under conviviality principles Vetter (2017) developed The Matrix of Convivial Technology (MCT) framework that considered the production side and defined convivial technologies as those that have the following core dimensions such as relatedness, accessibility, adaptability, bio-interaction and appropriateness. The framework can be used by anyone to evaluate any kind of technology against conviviality principles.

2.5 Theoretical framework – MCT Framework

Expanding on Illich's definition, Vetter (2017) defined convivial technologies by taking the practices and summarizing the ethical values and design criteria followed by grassroot tinkerers, eco-activists and such who are part of the degrowth movement. In addition, Vetter (2017) also confirms that MCT (Appendix 1) can be used for by various groups like researchers

to study the ethics behind technology developers and users, degrowth oriented groups for self-assessment and even for political education.

The five dimensions of convivial technologies as defined by Vetter (2017) are:

Relatedness: Conviviality reflects the human nature to relate to others and technology can highly influence these relations and the way it forms. Relatedness encompasses the interconnections between individuals facilitated by technological artifacts and infrastructure. It emphasizes the potential of technology to transform society and cultivate meaningful connections.

Accessibility: Accessibility pertains to the ease of access to material and immaterial requirements to build and use a technology. This dimension emphasizes the importance of removing barriers to access and promoting equitable participation in technological innovation.

Adaptability: Adaptability refers to the freedom individuals have to decide to be linked with a technological device or to be independent without it to be part of a society. On a technological level, it refers to aspects such as modularity, scalability and suitability for 'Do It Yourself'.

Bio-interaction: Bio-interaction concerns the way in which technology interacts with the surroundings. Convivial technologies must be able to "benefit ecosystem, produce no waste and also obtain a yield".

Appropriateness: Appropriateness involves the alignment of technological solutions with user needs, societal values, and environmental sustainability. This dimension emphasizes the importance of deciding "where a technology makes sense and where not" based on the context of a technological device or infrastructure.

Many researchers have used MCT to assess and introduce conviviality in various tools. The versatility of the matrix is reflected in the fact that the tools assessed ranges from community gardening initiatives to complex technologies.

3 METHODOLOGY

This section elaborates the methodology that is being used to answer the research questions. This includes the research framework, conceptual framework and research strategy.

3.1 Research Framework

The research framework has been created following Verschuren & Doorewaard (2010). For this the different steps that need to be followed to achieve the research objective were identified. Hence the first step is to define the objective which for this project is to evaluate if and how conviviality principles are incorporated into sustainable modular smartphones and to analyze how technological conviviality help users resist planned obsolescence using the MCT. The key concepts identified from the objective constitutes the core elements of the research framework as shown in Figure 4.

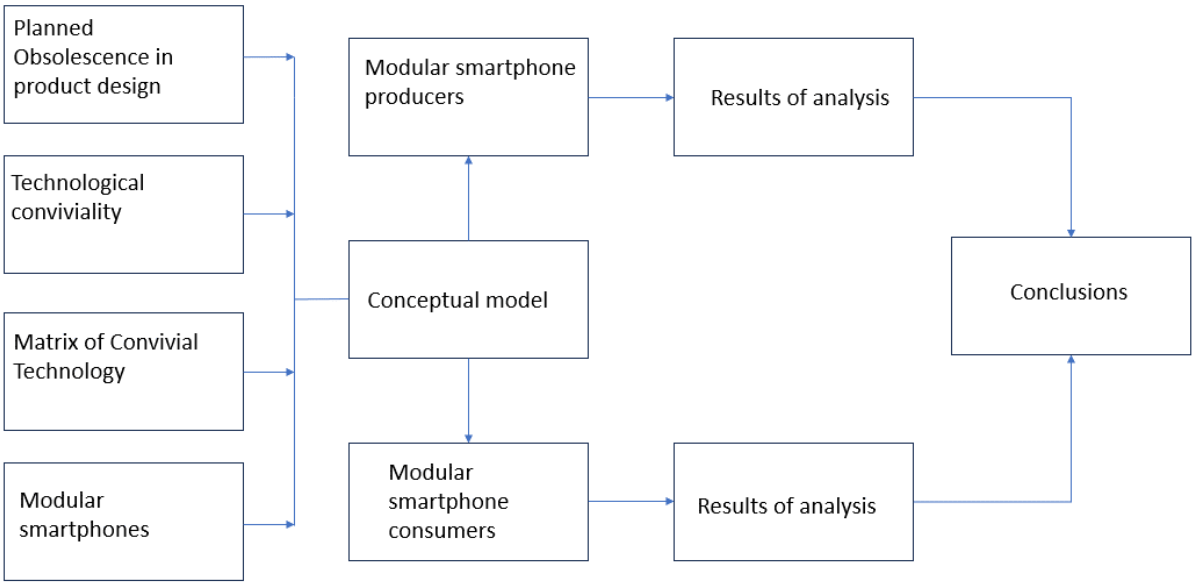

Figure 4 Research Framework

3.2 Research Strategy

This section concerns how the research object will be approached. According to Verschuren & Doorewaard (2010), research strategy involves a set of key decisions which would guide the research including choosing between the project being deep or wide (depth or breadth), quantitative or qualitative data analysis, and finally empirical or desk research data collection.

To answer the research question at hand, a slice of the MCT matrix is adopted here shown in Table 1. The dimensions and various layers are taken which are relevant to the current research topic that could evaluate the different attributes that relate to conviviality in smart phones. To assess conviviality of modular smartphones, relatedness is chosen as it would provide how well

users can relate with the technology. This could also shed light about user perception of technology. Bio-interaction is chosen as it explores the ways in which technology interacts with the natural environment throughout its various life-cycle stages. With electronic waste management being unmanageable and ICT using many valuable rare earth metals which could be recovered and reused bio-interaction is considered to be a crucial dimension. The main feature of modular smartphones are modularity which gives users the freedom to repair and reuse their own device hence making adaptability another perfect choice for assessing modular smartphones.

Table 1 MCT adopted from Vetter (2017)

Dimensions	**Materials**	**Production**	**Use**
Relatedness	• Process • Concept • Motivation • Control • Ethics	• Process • Motivation • Control • Organization • Local production	• Autonomy • Care • Camaraderie
Bio-interaction	• Environmental impact • Hazardous potential • Waste management • Sourcing • Recover and reuse materials from e-waste	• Environmental impact • Hazardous potential • Waste management • Ethics	• Environmental impact • Longevity • End of life • Waste management
Adaptability	• Special technology • Special conditions • Special materials • Expert knowledge	• Modularity • Special technology • Economical scale • Special conditions	• Modularity • Infrastructure needed • Special skills

The topic of planned obsolescence and conviviality can be very broad. Hence, to make valid and in-depth observations the scope is narrowed down to two modular smartphone companies and its users. This research uses both primary and secondary methods of data collection. Empirical data was collected through methods such as surveys and interviews. The survey sample size was determined by Slovin's formula. The formula is expressed as:

$$n = N/(1 + Ne^2)$$

Where:

- n is the required sample size.

- N is the total population size, ie. The total number of modular smartphone users in The Netherlands.

- e is the desired level of confidence which is assumed to be 90%

Since there is lack of statistics, the population size is calculated solely based on sales in The Netherlands for the past 5 years from 2018 to 2022. This taken from the Impact Report 2022 and is calculated to be 375,069. Thus the sample size is calculated as:

$$n = 375{,}069/(1+375{,}069*0.10^2)$$

$$n = 99.97$$

Moreover, secondary data through literature review and observations will be used to support findings or conclusions. In a situation where Fairphone and Shiftphone do not respond for an interview request, grey literature and other similar studies will be main source of data collection.

3.2.1 Research unit

A research unit can be any subject or object about which a researcher wants to make statements about (Verschuren & Doorewaard, 2010). As previously mentioned, the research unit studied are modular phone companies especially Fairphone and Shiftphone and their users in Netherlands.

Cases: Fairphone and Shiftphone were the first modular smartphones to enter the market (Jaeger-Erben et al., 2023). Being the frontrunners in the niche market both the companies aims to make smartphones durable and last longer. Founded in 2013, the motto of Fairphone is

“Change is in your hands”. What began as an awareness campaign has now evolved into a fully grown business. The brand has since gained recognition for its commitment to ethical manufacturing practices, repairability, and user empowerment. The company also focuses on sourcing conflict-free materials, ensuring fair wages for workers, and promoting transparency throughout the supply chain. Fairphone’s modular design approach allows users to easily repair and upgrade their devices (*Fairphone’s Impact 2022*, n.d.). According to their impact report 2022, Fairphone has sold 115,681 in the financial year 2021-2022 which is expected to increase steadily over the coming years.

Similarly, Shiftphone also places a strong emphasis on sustainability and social responsibility in its product development. The company founded in 2014 in Falkenberg with the aim to ‘maximise meaning’ instead of maximising profits, designs smartphones with emphasis on longevity and repairability by designing modular components in their smartphones. Shift GmbH is a family owned company with over 40 employees and still growing. Shiftphone also prioritizes the use of eco-friendly materials and energy-efficient manufacturing processes to minimize environmental impact (*SHIFT*, n.d.).

3.2.2 Selection of research unit

Being the first two countries in the EU that puts the most electrical and electronic waste equipments on the market, Netherlands and Germany were chosen to find sustainable consumer electronic devices. This led to identifying two sustainable modular smart phones ‘Fairphone’ and ‘Shiftphone’ from Netherlands and Germany respectively as the research units. To answer the second part of the research question, the user aspects, modular smartphone users smart phone users were surveyed.

3.2.3 Research boundary

The research was be conducted between 20 April 2024 and 15 July 2024 from Fairphone and Shiftphone producers and users in Netherlands and Germany. Modular smartphone users were surveyed through online survey platform Qualtrics™. Due to time restriction, only two representatives from each company were reached out. Interview with Shiftphone was conducted while Fairphone didn’t respond to interview request hence data collection for Fairphone is limited to their annual report.

3.3 Data Collection

To answer the different sub questions and thus the main research question of this thesis two types of qualitative data collection methods was used such as interviews and surveys. The demographics of the survey participants are given in Table 2.

Table 2 Demographics of Survey participants

Demography of survey participants		**Response % (n=100)**
Gender	Male	67%
	Female	27%
Age group	18 – 24	8%
	25 - 34	46%
	35 - 44	20%
	45 – 64	18%
	65 years and older	6%
Location	The Netherlands	34%
	Germany	24%
	UK	6%
	EU	23%
	Others	13%
Smartphone users	Modular smartphone users	83%
	Non modular smartphone users	17%

The formulation of questions for aims at understanding the concept of technological conviviality. Hence given the research questions qualitative data collection method is identified as the most suitable. The summary of data collection methods and sources for each question is given in Table 3. The interview questions for modular smartphone companies are given in Appendix 2 and survey questions in Appendix 3.

Table 3 Data collection summary

Research Questions	Desired information	Data source	Method of data collection
RQ1	Difference between the key product design aspects and business strategies that are implemented and followed	Literature	Literature review
RQ2	Key product design aspects and business strategies that are implemented and followed	Shiftphone representative, grey literature	Interviews, literature review
RQ3	User perspective of modular smartphones and regular smartphones	Modular smartphone users	Online Survey
RQ4	The reason behind less popularity of modular smartphones	Literature, Interview with Shiftphone representative, Modular smartphone users	Interview, survey, literature review

A repair café which is hosted at the Utrecht University once every month was also attended to analyse how users engage and participate in communities where the core principles of conviviality is followed.

3.4 Data Analysis

The data collected for this thesis is both qualitative and quantitative hence to capture the complexity of participants' experiences, perspectives, and narratives, mixed method data analysis is preferred. The rest of this section elaborates on the data analysis methods for all the four research questions.

For the first sub question, literature review will be conducted to identify the principles of regular smart phones under the same three dimensions and different themes as for the first question. These identified principles will then be compared with those of modular smartphones

to understand the difference between design for planned obsolescence and design for conviviality.

The second question aims to evaluate how and to what extent conviviality principles are incorporated in the product design and business strategy of both Fairphone and Shiftphone. The thematic data analysis will be based on the three dimensions and various layers. Later an assessment table will be created in which each theme under the different dimensions will be given a rating on a scale of 0-3 based on the extent to which conviviality dimensions are incorporated. The different rating scores and the rationale behind are shown in Table 4.

Table 4 Rating rationale for each dimension of MCT framework

Rating	Rationale
0 (very low)	None of the criteria in a dimension under a level are considered
1 (low)	At least one of the criteria in a dimension under a level are considered
2 (medium)	Some of the criteria in a dimension under a level are considered
3 (high)	All of the criteria in a dimension under a level are considered

To answer the third subquestion, surveys of people who are owners of either Fairphone or Shiftphone will be conducted. Similar to the first two questions, the three dimensions will be analysed against user perception to see if they recognize and experience conviviality through modular smartphones. A thematic analysis of the survey data will be done to identify how users perceive modular smartphones and engage with it to evaluate user perception.

A critical analysis of all the data collected for the previous questions must suffice to answer the fourth question.

The data collected will be triangulated by observations and literature review. And based on this data collected, conclusions will be drawn which would adequately answer the research question.

3.5 Research Ethics

To comply with the ethical requirements while conducting interviews and surveys, ethical assessment was conducted by the BMS Ethics Committee. For this purpose, the research proposal, interview and survey questions were be submitted for approval before conducting the research and preliminary data collection. The interviewees were well informed beforehand about the research topic and asked for consent to record audio/video recording of the interview. The interviewees identities are kept confidential only their job titles are be mentioned. These are applicable to survey too. All data will be managed confidentially during this research.

4 FINDINGS and DATA ANALYSIS

This chapter consolidates findings of the research questions from the various data collection methods employed. The section is divided into findings and data analysis of the four research questions explored.

4.1 How do convivial technologies challenge the principles and practices of planned obsolescence in smartphones?

Technology is linked to many imaginaries the important ones being 'technological innovation for growth' and 'techno-science for sustainability' (Kerschner et al., 2018) and is sometimes seen as the panacea for all problems (Heikkurinen, 2018). Especially the role of ICT in achieving conviviality is found to be significant as it is said to make knowledge and technology accessible to many people. This widespread access can lead to better development by reusing and mixing existing resources. Furthermore, ICT can help spread fair and environmentally friendly strategies that support reducing excessive growth, promoting a fairer and more sustainable society (Likavčan & Scholz-Wäckerle, 2018). While on the one side is technological determination and appropriation, which helps users achieve many milestones there is also a downside to technology. Being autonomous and regulated by the corporate world ICT and especially smartphones limit user freedom by forcing the users to choose products which are not even needed.

In recent years, the discourse surrounding PO in smartphones has seemingly increased. Considering the fast-paced changes in the smartphone industry, it present significant challenges to sustainable development (Haucke, 2018). Yet, mere consideration of environmental sustainability without any attention on social and ethical aspects is what is currently followed by the tech giants. The application of conviviality principles and practices which are in direct contrast to the principles and practices of PO could address this concern. While the former roots on environmental and societal sustainability the latter focuses on economic gains. From Illich's (1983) perspective the principles of conviviality include cooperation, mutual support, autonomy and dignity, fair and equal distribution and public participation (Kallis et al., 2018). Convivial society refers to a society where the different manmade tools help individuals attain their goals and fulfill their lives rather being controlled by centralized capitalist systems. On the other hand, PO which was developed and still is continued by the capitalist world focuses primarily on industrial productivity. Samerski (2018) further explains the criteria for convivial technologies as proposed by Illich which are given below:

- Tools that are simple to use or can be learned by using them.
- They should be controlled by the user and serve the user's needs, not the other way around.
- Should not require special education or certification to use, should not be something that people are forced to use by experts or societal pressures, and should allow individuals to express themselves.

While Illich in his time considered telephone to be a convivial tool, when analysing smartphones under these criteria for conviviality, most smartphones do not fulfill these criteria entirely. Samerski (2018) argues that despite being easy to use, Illich would not consider the smartphone as a tool that helps people achieve their own goals. Unlike a regular phone, a smartphone overloads the user and blurs the line between the person and the technology. It shapes the user's desires, habits, and identity so much that it can lead to addiction. Through constant feedback, it turns the user into a productive part of the technological system, rather than just a user of the tool. Following Robra et al. (2023) there are other indicators for conviviality which could be extended to smartphones such as *making knowledge freely accessible*, instead of keeping knowledge locked up for making profit. This includes open-source software and hardware standards, allowing for greater transparency, customization, and community-driven innovation thereby creating user value. Other indicators include 'modularity' characterised by *adaptability, repairability, maintenance* which are in stark contrast to the principles of PO which capitalises by hindering the possibility of self-repair in the name of technological advancements. Whereas, convivial technologies, by design itself prioritize user experience, longevity, and sustainability. They challenge planned obsolescence by incorporating features and practices that extend the lifespan of smartphones while promoting user empowerment and satisfaction. One key example of conviviality reflected in smartphones is repairability. Unlike the glued-sealed designs of many smartphones driven by planned obsolescence, convivial smartphones are modular and repair-friendly. This feature also emphasizes other core convivial principle which is autonomy by providing users with easy access to replaceable components, thereby enabling them to extend the lifespan of their devices if the users choose to.

Another way in which PO is displayed in smartphones is by capitalizing on future innovations (Robra et al., 2023). Companies capitalize on planned obsolescence by continuously introducing new products with minor incremental improvements. This strategy encourages consumers to upgrade to the latest models, driving sales and revenue for the company. Tagged

along with rapid technological advancements, The example of Apple iPhones illustrates how companies rapidly introduce new models with advanced features, making older models incompatible with newer software and hardware. This intentional obsolescence encourages consumers to replace their devices with the latest versions. Whereas Illich's (1983) alternative design approach rooted in conviviality emphasizes building social bonds through friendship and mutual support, while also acknowledging its limitations. This perspective shifts from the focus on production and consumption reduction, to creating new models that challenge capitalist systems. This means the design aims to reduce material goods and enhance connections between people (Lizarralde & Tyl, 2017). A summary of how these two concepts manifests in the realm of smartphones is given in Table 5:

Table 5 Comparison of planned obsolescence and conviviality features in smartphones

Planned Obsolescence in smartphones	**Conviviality in smartphones**
Impossibility or Unlawfulness to Repair	Adaptability, repairability, and maintenance
Hinder the possibility of self-repair by definitive assembly or specialized tools	Shared infrastructure
Rapid Technological Advancements	Social solidarity
Capitalizing on Future Innovations	Decentralized production
Obsolescence of traditional skills and means of production	Use of local materials and skills
Capital valorisation	Openly accessible knowledge

Convivial technology brings people together and support meaningful creations. Attending a repair café provided valuable and firsthand insights into the practical applications of conviviality in technology use and maintenance. This repair café which is hosted for free on the first Friday of every month witnesses over a dozen of users and few technicians. At the café, I observed a diverse group of individuals (16 users and 5 technicians), ranging from technicians to everyday users, coming together and collaborating with each other to repair various electronic devices, including TVs, headphone and even bikes. This experience illustrated the principles of conviviality in action—particularly the emphasis on community, skill-sharing, and empowerment. Participants were not only interested in fixing their devices but also in learning the repair process by engaging in conversations around the technology showing active interest in learning and thereby creating a deeper connection with their

technology. The collaborative environment of the repair café is a stark opposite to the isolating and disempowering experience of dealing with PO in mainstream consumer electronics especially smartphones. Such repair cafés serves as a small social movement against PO and shows how technology can be more user-centered, sustainable, and aligned with convivial principles, offering a real counter-narrative to the disposable culture which is spread by the design of many modern smartphones.

Figure 5 Repair café at Utrecht University on 04th June 2024

While the tech savvy technicians are well informed about PO and it consequences they notice users of these technologies are ignorant and submit themselves to be used by these technologies. They argue most smartphones nowadays are glued together which prevents any

kind of repair activities. This is systemic PO and atleast some users are increasingly becoming aware of it.

"Companies nowadays should make appliances that are easy to disassemble and repair. They are not doing that anymore. They are making everything complicated and when something stops working, we are forced to throw it away in the bin"

- User at the repair café

One technician at the repair café sees 'PO as a way to keep the manufacturers working' and wants producers to make products that are repairable along with information on how to repair. While he also admits that technological/functional obsolescence is needed to make more energy efficient and environmentally friendly products.

In conclusion, convivial technologies represent a paradigm shift away from the principles and practices of planned obsolescence in smartphones. By prioritizing environmental and social aspects convivial technologies challenge the disposability inherent in planned obsolescence, offering a more ethical and sustainable alternative for both the consumers and the environment.

4.2 To what extent do Fairphone, and Shiftphone incorporate the core dimensions of convivial technologies (according to (Vetter, 2017)) to their product design and business strategy?

The concept of convivial technologies, as articulated by Vetter (2017), revolves around various dimensions throughout the lifecycle of a product. The Matrix Convivial Tool has captured the various criteria that technologies must fulfil to be identified as convivial technology. Both Fairphone and Shiftphone have been at the forefront of integrating sustainability and conviviality-oriented principles into their product design and business strategies, aiming to challenge the dominant culture of planned obsolescence in the smartphone industry. The MCT (Vetter, 2017) was applied throughout the lifecycle of Fairphone and Shiftphone under the dimensions *relatedness, bio-interaction and adaptability* to find if and how the principles of conviviality is incorporated.

Relatedness

Relatedness brings about the interconnections between individuals which is facilitated by technological artifacts and infrastructure. It is about the meaningful connections humans form with each other and with nature. Throughout the different life cycle of smartphones, relatedness can be characterised by various indicators.

Materials phase: In their annual impact Fairphone report discloses that choosing fair materials is one of the four key impact areas where they have the 'greatest potential for maximum impact' (*Fairphone's Impact 2022*, n.d.). Whereas Shiftphone also puts emphasis on raw material sourcing in fair and ethical manner (*SHIFT*, n.d.). In spite of that, smartphone being a high-tech technology is less flexible and more complicated. While the materials sourced are claimed to be ethically and fairly sourced, the materials itself are fixed lacking autonomy and flexibility. Not to mention the long and complicated supply chain behind the sourcing (see Appendix 2). Both Fairphone and Shiftphone agrees that majority of the raw materials and rare earth metals comes from the resource rich Global South countries. The motivation behind sourcing such materials can be identified to be market driven as the consumers and other smartphone manufacturers aim for advanced updated smartphone models.

"As already mentioned, the raw materials of the components is something which we do not have control over"

-Shiftphone representative

The control of raw materials is in nobody's hands. This further makes people feel alienated from the smartphone that they are using. On the other hand, the 'ethical and fair' claims of these smartphone companies shows a strong sense of commitment as they are consciously trying to be part of creating fair and just economic relationships and are directly seeing this relatedness in their own product. They also engage and invest in improvements in mines and countries where human rights and environmental risks are present.

Production phase: Same as the materials phase, production phase also offers very less control and power to the users. Fairphone tries to involve its users through active online forums and discussion platforms. Such discussions can bring about meaningful interactions between users and makes users feel part of the system. The inputs received through the discussions can thereby influence the design and production of the smartphones too. Whereas Shiftphone does not engage in active conversations with its users through any platforms. While they do have annual meetups for users to foster relationship between their customers which can also lead to value creation. The production process of both the brands are market driven while making phone modular makes users easily relate to their smartphones and offers a sense of control and authority instead of the smartphones controlling them.

While both the modular smartphones are designed in their respective home countries, the production units of the brands are not local, but both located in China. Convivial technologies

are locally oriented promoting knowledge and skills within the local community. However, both the companies claims to work closely with its manufacturers to improve working conditions in its factories. This mirrors the concept of relatedness as they are not only concerned about the end product but also about the people and processes involved in its production.

Use: The use phase under relatedness considers the indicators *autonomy, care and camaraderie*. Being modular smartphones both Fairphone and Shiftphone makes phones that are easy to adapt, repair and maintain giving users autonomy and authority over their devices making it truly convivial. Users taking care of the device and choosing when, where and how to use it for value creation is the ultimate freedom that the concept of convivial tools must provide. When faced with a technical problem instead of throwing the whole device away users of such modular smartphones exchange knowledge and information and develops camaraderie. This leads to the true meaning of technology bringing people together.

Bio-Interaction

Bio-interaction concerns the way in which technology interact with the surroundings. Convivial technologies must be able to "benefit ecosystems, produce no waste and also obtain a yield".

Materials phase: Fairphone reports that 75kg of resources were used to produce one smartphone in the year 2022. Fairphone claims that it has increased sustainable sourcing of 14 focus materials from 31% in 2021 to 40% in 2022. Making smartphones modular also increases the recovery rate of the rare earth materials which Fairphone claims is 50-60% for their Fairphone 3 model. To reduce negative environmental impacts both Fairphone and Shiftphone claims to work with local mines in the resource rich countries. Fairphone also mitigate their material footprint through various credit systems such as Fairmined[1] gold. To avoid hazardous risk Fairphone has identified and developed a Restricted Substances List (RSL) which lists hazardous materials that needs to be avoided from their modular smartphones. Similarly, Shiftphone also acknowledges the use of conflict minerals in their products such as Gold, Tantalum etc. but fails to calculate the amount used in their phones. Whereas, Shiftphone through their active take back program declares to recover and reuse critical raw materials. The

[1]Fairmined certification guarantees gold from empowered and responsible artisanal and small-scale mining organizations that adhere to world-leading standards for responsible practices (https://fairmined.org/)

interview with Fairphone also revealed that the standards parts of mobile phones such as cameras, display glasses, chips inside are all standard parts and same for all mobile phones. Modular smartphones stands out mainly due to the modularity functionality while using the same mobile parts. He also claimed all plastic materials used are recyclable if properly recovered.

Production: Both Fairphone and Shiftphone report their manufacturing units in China is 1SO14001 certified for environment making workplace safe. Production phase accounts for the largest share of emissions due to high energy consumption during the mining and manufacturing stages. Working closely with its manufacturers to improve working conditions in its factories both Fairphone and Shiftphone runs production units following ethical conducts. By creating RSL and communicating it with the suppliers, Fairphone puts effort not to use hazardous chemicals. They also engage and invest in improvements in mines and countries where human rights and environmental risks are present. This shows that they are not only concerned about the end product but also about the processes involved in its production.

Use: The ultimate aim of modularity in smartphones is to increase the longevity of the product. Both Fairphone and Shiftphone designs its phones for longevity, aiming to maximize the lifespan of its devices. The average lifespan of modular smartphones as claimed by is 5.5 years and Shiftphone is 5 years. This compared to global average smart phone lifespan of 2.7 years is significant. This can considerable reduce GHG emissions as the number of phones produced would reduce. With solid take back programs both companies try to collect their products and create reverse supply chain which further increase resource efficiency and reduce e-waste generation both benefiting the environment.

While both companies show commitment to sourcing more responsibly mined materials and put increasing effort to use recycled materials, they are aware of the social and environmental impact of the materials used in their phones and are working towards incorporating more sustainable materials. This shows a strong sense of conviviality in their modular smartphones in terms of how it interacts with the environment during different lifecycle stages of the products.

Adaptability

Adaptability refers to the freedom individuals have to decide to be linked with a technological device or to be independent without it to be part of a society. On a technological level, it refers to aspects such as modularity, scalability and suitability for ‘Do It Yourself’.

Materials: Smartphone being a sophisticated device require special materials, tools and technology. The materials especially are not adaptable even though modular smartphones are made in modules there is very less flexibility and requires expert knowledge and skills which is true for both Fairphone and Shiftphone.

Production: Contrary to regular smartphones, Fairphone and Shiftphone are sustainable due to their modular design and production processes. On the other hand even modular smartphones require special technology to develop.

Use: During the use phase both Fairphone and Shiftphone make it easy for the user to repair their device and also helps with repair by providing support and spare parts making the device highly user friendly. Both phones feature designs that are aimed at longevity, maximizing the lifespan of its devices and minimize e-waste. The focus on repairability, allows users to maintain their devices longer. This can be seen as promoting adaptability as it encourages users to value their devices not just as products, but as part of a larger ecological and social system.

Based on the information collected and applying the MCT framework, the rating for Fairphone and Shiftphone for different dimensions through out the life cycle is provided below:

|

DIMENSION	MATERIALS	PRODUCTION	USE
RELIABILITY	1	1	2
BIO-INTERACTION	1	2	3
ADAPTABILITY	1	2	3

DIMENSION	MATERIALS	PRODUCTION	USE
RELIABILITY	1	1	1
BIO-INTERACTION	1	1	3
ADAPTABILITY	1	2	3

Figure 6 MCT rating of Fairphone and Shiftphone for the dimensions reliability, bio-interaction and adaptability

The ratings of both Fairphone and Shiftphone are comparable where Fairphone outperforms Shiftphone only in two cases. From Figure 6 it is evident that both the modular smartphones score poorly on the material phase of the lifecycle. This can be due to the fact that being a complex high technological device, smartphones uses many rare earth and precious metals which while increasing the performance of the device itself compromises on many other socio-environmental aspects. Furthermore, use phase scores highly as this stage gives more power to the hands of the user through the feature of modularity which helps users connect with technology better. The end-of-life product recollection initiatives after use phase also lead to better recovery and recycling rates of these smartphones.

4.3 How do smart phone users perceive and engage with modular smartphone technologies in comparison to ones that are designed to be obsolete?

Understanding of user behaviour and experience with modular smartphones is crucial to determine the sustainability and conviviality of modular smartphones. For technology and for that matter any product to become successful user centric perspective needs to be adopted. The survey results conducted in this research sheds light into how smartphone users perceive and engage with modular smartphones.

People's consciousness about environmental sustainability and social responsibility is showed to significantly impact their purchasing decisions. This is evidenced by the fact that all participants identified these aspects as important considerations, with 58% of them deeming the environmental and social aspects of products as extremely important.

This fact is also further reflected in the choice of modular smartphones, as evidenced by 85.2% and 80.8% of individuals who regard environmental and social aspects as very important and extremely important respectively, having owned or currently owning a modular smartphone. This observation suggests a strong correlation between the importance placed on environmental and social factors and the ownership of modular smartphones. This could indicate a shift in consumer behaviour towards more sustainable and socially responsible products, suggesting that increasing awareness about environmental and social matters could bring about real change against PO and consumerism.

User Perception

To learn about user perception about modular smartphones, various questions were asked. The answers are found to be different for modular smartphone users and non-modular smartphone

users. For non-modular smartphone users, the primary appeal of modular smartphones was its potential to reduce environmental impact. This was followed by cost-effectiveness and the autonomy they offer to users over their devices. Interestingly, modularity, often considered the defining feature of these devices, was ranked second by many participants. This was on par with the prioritization of social responsibility and environmental impact reduction.

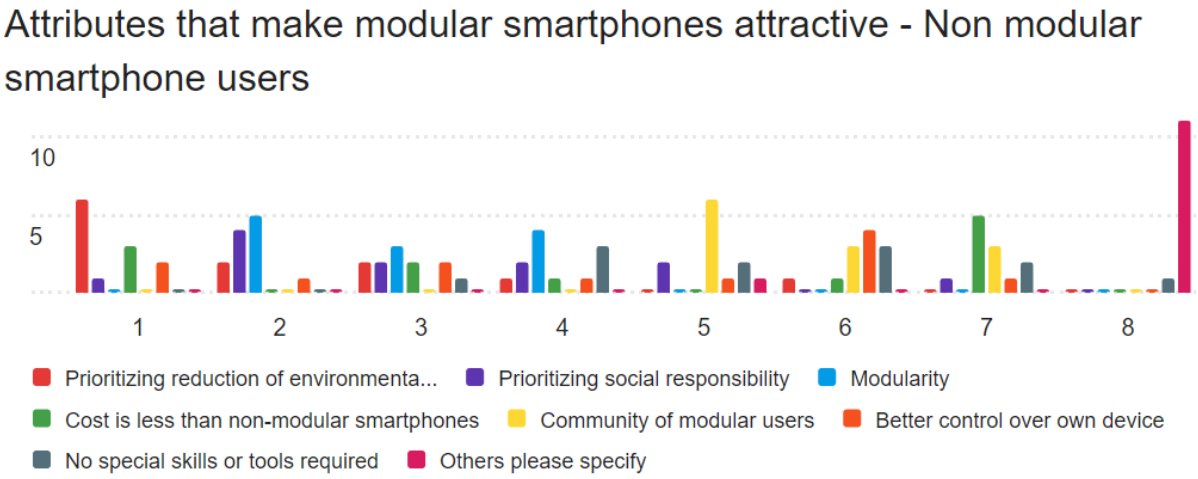

Figure 7 Survey responses from non-modular smartphone users showing the attributes that make modular smartphones attractive

On the other hand, modular smartphone users, who have firsthand experience with these devices, also ranked the reduction of environmental impact as the most attractive feature with close to 30 respondents ranking it first. However, for them, modularity and the prioritization of social responsibility followed closely behind with over 20 participants ranking both the attributes second.

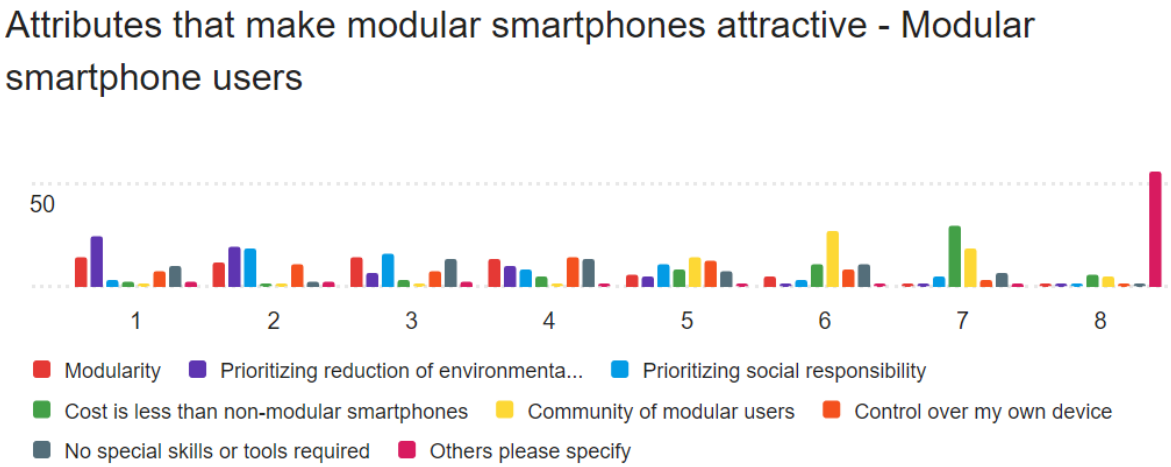

Figure 8 Survey responses from modular smartphone users showing the attributes that modular smartphones attractive

It can be inferred from the findings that both groups recognize and value the environmental benefits of modular smartphones. However, the experience of using a modular smartphone

seems to enhance the appreciation of its inherent modularity and social responsibility aspects. This could be due to the hands-on experience allowing users to directly perceive the benefits of these features. It is also noteworthy that non-modular smartphone users place a high value on cost-effectiveness, suggesting that pricing could be a significant factor in their decision to switch to modular smartphones. Meanwhile, the importance placed on autonomy suggests that users value the ability to customize and control their devices.

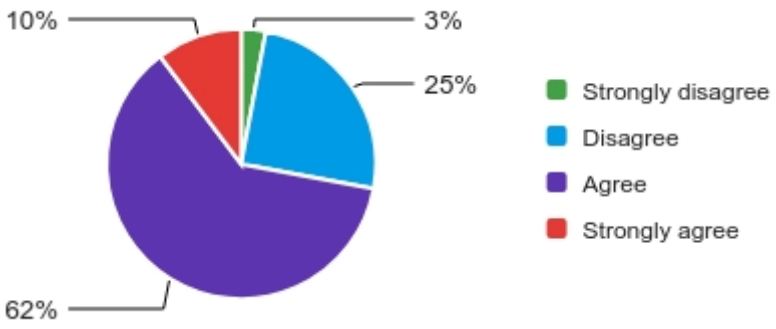

Figure 9 User perception of modularity features

Recognized as a salient characteristic of modular smartphones, modularity is perceived by users to provide a significant degree of autonomy. This suggests that the ability to exert control over technology is a highly valued attribute among users which is a highly valued indicator of conviviality. Users are increasingly seeking control and autonomy in their technological interactions. This may reflect a broader societal shift towards personalization and customization in consumer products but also a collective consciousness against planned obsolescence to regain control from technology.

Furthermore, the sustainability of modular smartphones is believed to be enhanced by factors such as device longevity, ethical sourcing, and repairability. The emphasis on sustainability factors indicates a growing awareness and concern for ethical consumption and environmental stewardship among smartphone users. This could strongly influence design and manufacturing practices and processes in the smartphone industry.

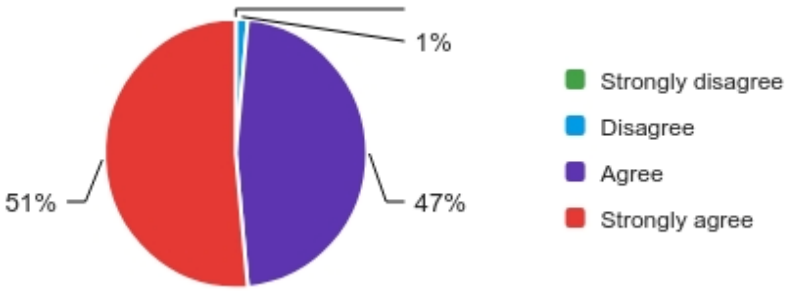

Figure 10 User perception of sustainability of modular smartphones

Modular smartphones are predominantly perceived as a more environmentally conscious choice in contrast to their non-modular counterparts. This perspective is supported by a substantial agreement among respondents, with 98% expressing agreement with this viewpoint. This can be indicative of the fact that there is increased awareness and concern for environmental sustainability among the respondents. This high level of agreement could also suggest a growing trend towards the adoption of modular smartphones, driven by their perceived environmental benefits.

At the repair café the technicians seemed to find the concept of modular smartphones a 'cool idea'. While perception about modular smartphones is positive owing to factors such as 'repairability' and 'environmental consciousness' they admit people don't really want to use such technology as the 'new generation is not used to the idea of repairing and reusing'. *"This generation lacks awareness and has the habit of throw away engraved"* quoted a technician.

User Engagement

User engagement with modular smartphones refers to the extent and manner in which users interact with these devices. This engagement can be characterized by several factors such as usage duration, repairability, community participation, upgradability, learning and exploration:

Usage duration

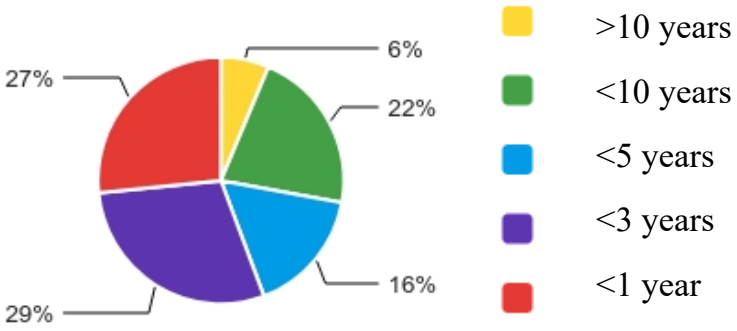

Figure 11 Usage duration of modular smartphones

It is evident that a majority of users (56%) have been using modular smartphones for less than 3 years. This could be indicative of the relatively recent rise in popularity of modular smartphones. The fact that 27% of users have been using these devices for less than a year suggests that the trend towards modular technology is still growing.

On the other end of the spectrum, the 6% of users who have been using modular smartphones for more than 10 years represent early adopters of this technology. Their continued use over a decade demonstrates the potential longevity and durability of modular smartphones. The 22% of users who have been using modular smartphones for less than 10 years but more than 5 years represent a group that has experienced the evolution of this technology. Their sustained use indicates a satisfaction with the benefits of modularity, such as customization and repairability.

Repairability

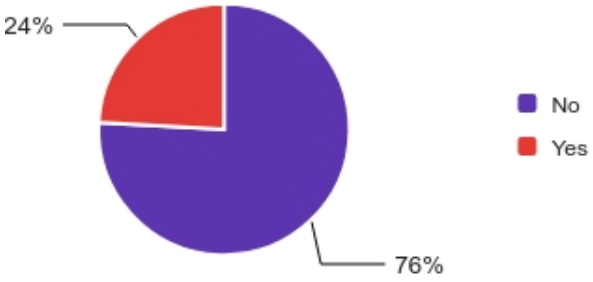

Figure 12 Repairability feature used by modular smartphone users

A significant aspect of user engagement with modular smartphones is the ability to repair individual components. This not only extends the device's lifespan but also contributes to its sustainability. While 24% of respondents answered positively, majority (76%) responded negatively. This suggests that while a quarter of modular smartphone users have taken advantage of the repairability feature inherent in these devices, the majority have not yet had to or chosen to do so, which could be interpreted in several ways. It may indicate that modular smartphones are robust and less prone to requiring repairs. Alternatively, it could suggest that users are not fully utilizing the potential benefits of modularity, possibly due to a lack of awareness or confidence in their ability to perform repairs. It might also reflect a relatively shorter duration of ownership, as devices may not have needed repairs yet.

Community participation

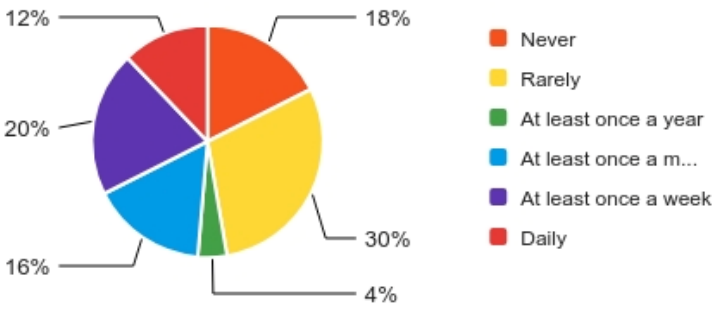

Figure 13 User engagement through community participation

Many modular smartphone companies encourage their users to participate in a broader community. This can involve sharing module designs, providing feedback, and contributing to the development of new modules. With over 80% participants agreeing to participating in online and offline communities where modular technologies are discussed and shared this shows that modular smartphones offer users the opportunity to understand the technology they use on a deeper level. This can lead to increased technological literacy and a greater sense of ownership.

Upgradability

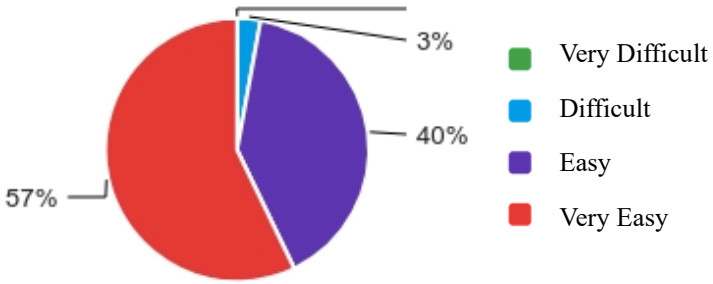

Figure 14 User engagement through upgrading and working with their modular smartphones

Engagement is also reflected in the user's ability to upgrade individual components of their device. Instead of replacing the entire phone, users can simply upgrade the specific module that needs improvement. 97% of the respondents found it easy to work with modular smartphones with over 57% finding the process very easy. This shows that users feel more connected to their devices as they have the flexibility to customize and improve their phones according to their need suggesting that the design and interface of these phones are user-friendly and intuitive. Upgrading specific components of a device could be considered as more cost-effective for users in the long run, as they may not need to invest in a completely new device when only one part needs improvement, giving users complete autonomy.

Care and maintenance

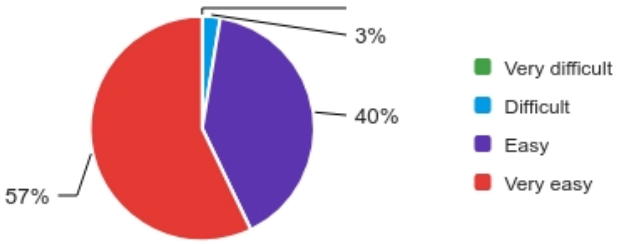

Figure 15 User engagement through care and maintenance

This pie chart shows user perceptions of the ease of care and maintenance for modular smartphones, showing that a majority find the process manageable. With 57% of users report that maintaining and caring for their modular smartphones is very easy, while 40% find it easy. Only a small fraction of users, 3% and less than 1%, respectively, rate the process as difficult or very difficult suggesting that modular smartphones significantly enhance user engagement by offering a comfortable maintenance experience. Compared to non-modular

smartphones, which often require specialized tools and professional assistance for repairs, modular smartphones empower users with greater autonomy over their devices by also increasing technological literacy.

Although the overall user experience with modular smartphones is positive, an analysis conducted using Qualtrics found no statistically significant relationship between this positive experience and the likelihood of users recommending these devices to others. This pattern was the same for non-modular smartphone users as well. It was anticipated that a positive perception of sustainable modular smartphones would encourage individuals to consider purchasing one. However, the Qualtrics analysis revealed no significant correlation between these perceptions and the intention to buy a modular smartphone.

Another noteworthy aspect of the analysis focused on the sense of community and connectedness, a key principle of conviviality. It was hypothesized that longer use of modular smartphones would lead users to engage more actively in community forums and discussions related to reuse and repair. While 88% of respondents indicated they participate in online or offline modular smartphone communities, the analysis revealed no statistically significant relationship between the length of modular smartphone usage and community engagement.

Observations from Repair Cafe

Participant 1 (Technician): The technician is a modular smartphone (Old Samsung model) user which he has been using over 10 years. During this time, he has repaired the phone multiple times and also even changed the software to open source. He is a regular attendee at the repair café and is interested in making technology sustainable. He says *'I only use my phone for my needs and I prefer to keep using the same phone for another 10 years more if possible. The smartphone companies nowadays are making it difficult by launching newer model and updates every month forcing users to keep updated. It has become a lifestyle now.'*

Participant 2 (Attending repair café for the first time): The participant attended the repair café to repair and headphone as suggested by a friend. As he attended the café, he had casual conversation about the device with the technician and he was left with a new found appreciation for repairing devices and reusing it. He was also impressed by the small community of sustainability enthusiasts and wants to be an active part of the same.

In conclusion, user engagement with modular smartphones goes beyond just usage. It involves a more active and participatory relationship with the technology, promoting a sense of autonomy, personalization, and control. This engagement could potentially lead to more sustainable and user-centered practices in the smartphone industry. The more engaged a user is with their modular device, the more likely they are to be satisfied with it. This is because engagement allows users to have a more personalized experience with their device.

4.4 What are the main barriers and challenges hindering the widespread adoption of modular smartphones as opposed to smartphones designed to be obsolete?

Modular smartphones, while gaining increased popularity still remains a niche product. Many smartphone users are highly sceptical about the functioning and durability of modular smartphones which prevents them from choosing modular smartphones. From a user perspective the barriers and challenges include:

Non-Modular Smartphone Users

The responses from non-modular smartphone users highlight the following key barriers:

Limited Availability and Variety (17.78%): Non-modular users identify limited availability and variety of modular smartphone models as a key barrier. This suggests that these users perceive a lack of choices when considering a switch to modular smartphones. While this reason contradicts the whole concept of conviviality and living within the limits.

Higher Upfront Cost (15.56%): The higher initial cost of modular smartphones is a significant factor for non-modular users, reflecting there is a kind of sensitivity toward the price barrier for those who have not adopted this technology. Whereas, many people are still buying comparatively even more expensive non-modular smartphones such as Apple iphones and Samsung premium models. Thus it just seems to be a mindset.

Concerns About Compatibility (15.56%): Concerns about the compatibility of modular components is a substantial issue for non-modular users. The fear of potential incompatibility may discourage them from considering modular devices. Especially when there are application updates every now and then, software compatibility can be a serious barrier.

Preference for Sleek and Slim Designs (13.33%): Some non-modular users prefer sleek and slim designs, which they associate with non - modular smartphones. They may view modular

phones as bulkier or less visually appealing. This is style obsolescence where appearance matters more than functionality.

Lack of Awareness and Understanding (11.11%): While not the most significant barrier, a portion of non-modular users cite the lack of awareness and understanding about modular smartphones as an obstacle. This indicates that many are either unfamiliar with modular technology or unclear on its benefits. The same argument was also raised in the repair café were technicians agreed that there is lack of awareness about such devices and the positive benefits of it.

Skepticism About Durability (2.22%): A small percentage of non-modular users expressed concerns about the durability and reliability of modular smartphones, suggesting that this factor is less of a major issue for this group. On the contrary participants at the repair café suggested that the idea of repairing and reusing has become foreign today and to top it of labour costs are far expensive especially in the western countries. This results in the huge amounts of e-waste being generated.

Modular Smartphone Users

The responses from modular smartphone users offer the following insights:

Higher Upfront Cost (19%): Modular smartphone users highlight cost as the most significant barrier. Despite the long-term benefits of modular phones, the high initial investment remains a key concern for these users.

Limited Availability and Variety (17%): Similar to non-modular users, modular smartphone users also see the limited variety and availability of modular models as a major barrier, indicating that even those who use these phones recognize this issue.

Lack of Awareness and Understanding (15%): Interestingly, modular smartphone users still cite a lack of awareness as a notable barrier, despite being more familiar with these devices. This may reflect a broader concern about the need for increased public education and outreach.

Concerns About Compatibility (14%): Concerns about compatibility are similarly significant for modular smartphone users, underscoring that even those experienced with these devices see this as an ongoing challenge. While of tech enthusiasts it might not be a concern, elderly people and others who are not well versed with such technologies might succumb to any software compatibility issues.

Preference for Sleek and Slim Designs (8%): Modular users are found to be less likely to focus on the need for sleek designs. This might be due to the trade-offs they accept in exchange for the customizability and sustainability of modular devices.

Skepticism About Durability (4%): Compared to non-modular users, modular smartphone users also express some skepticism about the durability of modular devices, although this concern is more significant among non-modular users.

5 DISCUSSIONS

Convivial tools are characterized by its ability to bring people together while also giving them the freedom to be independent from the capitalist world. They are expected to promote human dignity, foster autonomy, and encourage collaborative and participatory interactions among people. While today's world has become so focused on creating value in everything, technology has become an integral part of it. But to truly achieve a just and sustainable society it is only justifiable to analyse technology from the lens of conviviality. Through a detailed analysis of the data analysis this section provides insight into the conviviality in smartphones, user perception of modular smartphones and the barriers and challenges in switching to modular smartphones.

5.1 Technological Conviviality and Planned Obsolescence in smartphones

Since the 1970s, scholars have raised concerns about the environmental impact of endless economic growth and resource use. Robra et al. (2023) points out that the way technological innovation is perceived and managed has been moving towards economic growth and away from socially and environmentally beneficial outcomes. This conscious/unconscious move towards economic growth is what leads to overconsumption facilitated by process and product design that are unethical and unsustainable in many ways. Technology is widely being considered as element of "sustainable socio-technical systems". Innovation should not keep technologies in isolation away from socio-technical systems. Instead, we should consider both the positive benefits they bring and any negative consequences they might have for society as a whole. It's important to evaluate how these new technologies fit into the bigger picture and their overall impact on people's lives (Lizarralde & Tyl, 2017). Especially in high technical and complex equipment such as smartphones.

The concept of PO is deeply ingrained in the smartphone industry, affecting both the lifespan of devices and consumer behaviors. It manifests in smartphones in various ways such as focusing on impossibility or unlawfulness to repair, rapid technological advancements, capitalizing on future innovations, obsolescence of traditional skills and means of production, and capital valorization (Robra et al., 2023).

One of the most prominent ways in which PO is incorporated in smartphones is the hindrance of self-repair capabilities (Systemic PO). Manufacturers mostly design smartphones with non-removable batteries, use proprietary screws, and employ extensive use of adhesives to make disassembly challenging without specialized tools. This definitive assembly approach means

that consumers cannot easily replace a broken screen, a failing battery, or other components, pushing them towards purchasing a new device instead of repairing the existing one. Moreover, legal and warranty constraints often discourage third-party repairs also making it legally difficult for consumers to seek alternative repair options without warranties. Systemic PO can be tackled through the convivial principle of modularity. Making modular products, providing free and open access to information on repair and maintenance and continuous aftercare services even after discontinuation of products can help users resist Systemic PO.

Another key factor influencing PO is strategical smartphones designs with a short lifespan to capitalize on future innovations (Psychological PO). By limiting the durability and longevity of current models, companies ensure they have a steady market for their future products. This practice not only guarantees continuous revenue but also ensures that consumers are locked into a cycle of regular upgrades especially seen in the case of software updates. The shift towards highly specialized manufacturing techniques and components has also led to the obsolescence of traditional repair skills and means of production. Older methods of fixing and maintaining electronic devices have become less relevant as smartphones become more complex. This complexity discourages consumers and independent repair shops from attempting repairs, further increasing the need to replace rather than repair. As a result, the knowledge and skills required to maintain older devices are gradually lost.

On the contrary, the principle of conviviality is found to be supported by the concept of modularity. Modularity can address many of the issues of PO by enabling repairs and technological upgrades, thereby extending the use-time of devices. This approach not only extends the lifespan of the device but also reduces electronic waste, and empowers consumers to maintain their own devices. Thus it also addresses obsolescence of repair skills. Convivial technologies advocate for shared infrastructure, which includes community repair spaces, tool libraries, and different co-operative ownership models. When smartphones are made in modules thus making it possible to repair it brings together users where knowledge and resources are shared. By creating and supporting shared resources, communities can collectively maintain and repair their devices, reducing individual costs and fostering a culture of sustainability. This approach challenges the consumerist model promoted by planned obsolescence, where each individual is encouraged to own and frequently replace their own devices. However, achieving an optimal level of modularity is essential to avoid over-provisioning with add-on modules, as it can also lead to potential rebound effects (Proske et al., 2019).

Other principles of conviviality which are not necessarily reflected in modular smartphones include decentralized production and use of local materials and skills. Decentralized production calls for a move away from centralized, mass production towards localized, small-scale manufacturing. This shift supports the use of local materials and skills, reducing the environmental footprint associated with global supply chains. In the smartphone industry, decentralized production can lead to more sustainable practices by reducing transportation emissions, and supporting local economies. The use of local materials and skills is considered integral to the convivial approach as it also discourages the over exploitation and unethical practices being carried out by big corporations in resource rich but economically poor global south countries.

5.2 The case of Fairphone and Shiftphone

To answer the second research question, the modular smartphone brands Fairphone and Shiftphone are evaluated through the lens of the MCT framework proposed by (Vetter, 2017). For this research only part of the framework is utilized examining the different lifecycle stages—material, production, and use—to determine the extent to which these devices align with the principles of conviviality. Although modular smartphones are often considered as sustainable, their alignment with convivial principles varies across these three stages.

The material phase is arguably the most challenging aspect for both Fairphone and Shiftphone concerning conviviality. While modularity feature itself is better compared to conventional glued in smartphones, it requires additional necessities and extra materials to accommodate various modules. It also demands more connectors which can lead to an excess supply of modules sometimes, such as pre-manufactured replacement parts (Proske et al., 2019). Convivial technologies emphasize the use of local materials and skills, aiming to reduce the ecological footprint and support local economies. However, the materials used in Fairphone and Shiftphone, such as rare earth metals and other components, are sourced from global supply chains. These supply chains are often long and complex, involving multiple intermediaries and are mostly associated with unethical practices, including poor labor conditions and environmental degradation. The complexity and ethical concerns surrounding these supply chains starkly contrast with the convivial principle of using local materials and ensuring ethical sourcing. This is true for the production phase as well, as the manufacturing and assembly units of both the brands are not in their mother country, but in Asia where labor is comparatively cheap. Convivial technologies calls for decentralized production, leveraging local skills and reducing dependence on centralized manufacturing processes that are typically associated with

mass production. Despite efforts made by both the brands to source conflict-free minerals and promote fair labor practices, the reality is that the materials used are far from local and often sourced unethically.

Another concern is that smartphones are highly complicated technologies using highly sophisticated materials and special conditions. Examples of convivial technologies often cited include bicycles and composting toilets (Kerschner et al., 2018; Vetter, 2017), which can be produced and repaired with relatively simple tools and local materials, which uses local resources and foster social interaction. These technologies are low-tech, meaning they do not require advanced scientific knowledge or specialized equipment to produce, maintain, or repair. They are adaptable to local conditions and can be managed by individuals or small communities without significant technical knowledge and other complexities. In contrast, the production of smartphones cannot easily be decentralized or simplified to fit a local, low-tech model. This dependency on high-tech processes does not align with conviviality. A graph representing conviviality and technological complexity of tools are shown in Figure 16.

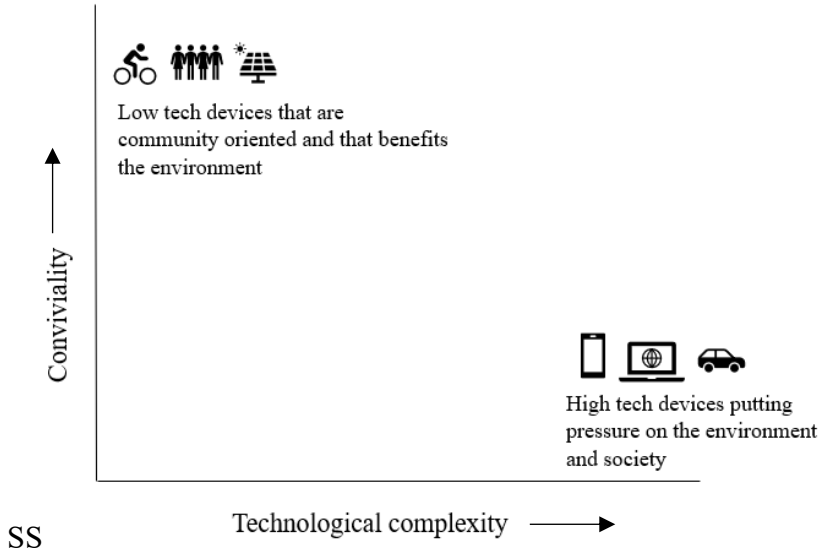

Figure 16 Graph representing different devices on a scale of conviviality versus technological complexity

Moreover, while both Fairphone and Shiftphone emphasizes repairability and modularity, which are positive steps towards sustainability, the overall production process still aligns more closely with conventional industrial practices than with the decentralized, locally-oriented approach advocated by conviviality.

The use phase is where Fairphone and Shiftphone mostly align with convivial principles. Convivial technologies emphasize user autonomy, repairability, and the ability to maintain and adapt devices according to individual needs. Both Fairphone and Shiftphone excel in this

regard by designing their smartphones to be easily repairable and upgradeable. Users can replace batteries, screens, and other components without needing specialized tools or extensive technical knowledge. This not only increases the lifespan of the devices but also empowers users to take control of their technology, fostering a deeper connection between the user and the device. Additionally, the modular nature of these smartphones promotes meaningful connections among users, who often share tips, repair guides, and support within the community. This aspect of user engagement and community building is an important principle of conviviality.

Both the brands provide detailed repair manuals making sure the users understand their smartphones and connect more with it. This is aimed at encouraging users to maintain and adapt their devices, aligning closely with convivial principles. This user-centric approach contrasts sharply with the disposable culture promoted by many regular smartphone manufacturers, showing an important aspect where modular smartphones follow true conviviality.

While Fairphone and Shiftphone incorporate several aspects of convivial technologies, their alignment with these principles is not the same across all lifecycle stages. The material phase reveals significant shortcomings, with global supply chains and unethical sourcing practices clashing with the convivial ideal of local, ethically-sourced materials. The production phase also shows a mixed picture, with centralized manufacturing and not using local skills. However, the use phase stands out as a strong example of conviviality in action.

Overall, while modular smartphones like Fairphone and Shiftphone make important steps towards sustainability and try to follow some convivial principles, there remains considerable room for improvement, particularly in the material and production phases. Achieving full alignment with convivial technologies will require a more radical transformation of their practices. As a high-tech device, the complexity of smartphones raises a critical question: can smartphones ever truly be convivial? Given the sophisticated materials and high-tech processes required, it might be argued that smartphones, by their very nature, are incompatible with the core principles of conviviality. The high-tech demands and global dependencies of smartphone production makes it difficult to achieve the level of simplicity, localism that convivial technologies stand for. But, this does not mean that efforts towards making smartphones more convivial should be completely neglected. Companies like Fairphone and Shiftphone are

making improvements in promoting ethical sourcing and improving repairability, which can be considered as steps in the right direction.

5.3 User perceptions

The data shows that environmental sustainability and social responsibility significantly influence users' purchasing decisions. With 58% of participants considering these aspects as "very important" and 28% as "extremely important," it is clear that there is a strong preference for products that align with these personal values. It was anticipated that this preference might also be reflected in their modular smartphone purchasing decisions as well. But the statistical analysis revealed no significant relationship between the two variables. This might be because of the fact that while people are becoming more conscious about environmental and sustainability matters, smartphones are seen as a product which reflects a persons status in the society. Even though people long for sustainable products, corporate marketing makes people believe that they need all the latest updated product available. It has become a lifestyle to keep everything updated even though there is absolutely no need for upgradation.

The survey data confirms that both modular and non-modular smartphone users recognize the environmental benefits of modular devices. For non-modular smartphone users, the primary factor is the potential to reduce negative environmental impact, followed by cost-effectiveness and user autonomy. Interestingly, while modularity is a key feature of these devices, it was ranked second, same as with social responsibility and environmental impact reduction. This shows that non-modular users value the many benefits of modular smartphones, particularly their contribution to sustainability and ethical consumption. For modular smartphone users, owning a modular smartphone and using it first-hand adds on their appreciation of the devices' inherent modularity and social responsibility. The ability to repair and upgrade their phones, together with the satisfaction obtained from making environmentally conscious choices, strengthens their commitment to these devices. This suggests that the experiential aspect of using modular smartphones can play a crucial role to deepen users understanding and valuing of their benefits.

Community participation is another crucial aspect of user engagement with modular smartphones. Over 80% of participants are involved in online and offline communities, indicating a strong sense of community among the users. This community engagement not only supports users in understanding and using their devices better but also encourages a collaborative environment where users can share valuable insights, designs, provide feedback,

and thereby also contribute to the development of new modules. This shows a strong sense of conviviality where technology brings people together but also detach them from being controlled by the same technology. While there are many active users who enjoy the community of similar users some also agrees that they only engage once or twice before never accessing these online communities. This might suggest that only people who have strong affinity towards sustainability and who see social values are interested in this aspect of conviviality. The corporate companies are continuously keeping people engaged in the constant loop of productivity by hooking people into technology all the time thus leading to people not wanting to have real life meaningful connections anymore. In this case it lets us to rethink if the core values of conviviality is even something today's society needs.

Modular devices can be found to give the freedom of choice to its users as opposed to conventional non-modular phones. The ability to upgrade individual components is also a significant feature of modular smartphones, with 97% of respondents finding it easy to upgrade their devices. This ease of upgrading allows users to customise their smartphones to their changing needs and interests without the expense and waste generated with replacing the entire device. The high satisfaction with upgradability suggests that modular smartphones offer a user-friendly and experience further strengthening the sense of autonomy and control that users value. On the other hand, as the technicians at the repair café said the new generations are so out of touch with the habits of repairing that they don't even want to learn about it and do it. Even if there are very many sustainable options in the market which can help people to resist PO, still customers are only attracted to the products that provide them status in the society. In such a society, no matter how many products offer technology that really care about people and planet before profit, it is never going to be mainstream.

The data also implies that the ability to repair and upgrade devices, along with active community participation, contributes to the overall care and longevity of modular smartphones. This engagement promotes a more sustainable and user-centered approach to technology, encouraging users to maintain their devices over the long term and reducing the environmental impact associated with continues and prolong replacements. While there is a strong appreciation for their environmental and social benefits, increased efforts are needed to educate users about repairability and to support community participation. Helping users with confidence in performing repairs and promoting the long-term benefits of modular features could further increase the adoption of modular smartphones.

5.4 Barriers and Challenges

While there is increasing interest in modular smartphones, it still continues to be a niche market. This discussion explores the primary barriers and challenges that prevent modular smartphones from achieving widespread adoption, based on user perspectives and survey data. One significant barrier is the limited availability and variety of modular smartphone models and brands. The data shows that over 18% of respondents identified this as a major issue. This can restrict consumer choice, making it difficult for potential users to find a modular smartphone that meets their specific needs and requirements. Traditional smartphones offer a wide range of models catering to various user requirements, from budget-friendly options to high-end devices. Another challenge is the higher upfront cost associated with modular smartphones. This is particularly important for cost-sensitive consumers who might prefer the more affordable options even if they care about environmental and social concerns. While modular smartphones offer long-term cost benefits through repairability and upgradability, the initial investment can be an important reason. The higher upfront cost can also limit the potential savings from an increased device lifespan and reduced need for replacements, making non-modular smartphones a more attractive option even with their planned obsolescence.

The survey also shows a general lack of awareness and understanding about modular smartphone technology among consumers. Even though there is easy availability to online resources and well-developed customer service from modular smartphone brands, many users remain unaware of these benefits. This knowledge gap can lead to hesitation in adopting new technology, as consumers often prefer to stick with familiar products. There are also concerns about the compatibility and operability of different modular components which also hinders adoption. Users may be worried about the potential issues from mixing and matching components from different manufacturers or models especially or software compatibility, where certain devices restrict the installation of open-source software. There is a perception related to complexity of assembly and customization processes in modular smartphones which can be intimidating for some users. Non modular smartphones offer the convenience of a pre-assembled, ready-to-use device, while modular smartphones require users to understand and engage with the assembly of various components.

Furthermore, there is scepticism about the durability and reliability of modular smartphone designs. Consumers may question whether a smartphone made up of multiple detachable parts can be as durable and dependable as a non-modular, single-unit smartphone. Finally, the

potentially bulkier design of modular smartphones is found to be concerning for some users. Many consumers prefer sleek and slim designs, which are often associated with high-end, non-modular smartphones. Modular designs, which usually require additional space for its different modular components that are detachable, can appear less attractive to users.

While modular smartphones present a sustainable alternative to traditional devices, several barriers and challenges hinder their widespread adoption. While some of these align with the concept of conviviality such as autonomy, it seems that users are increasingly being controlled by technology. Being always in the lookout for more innovations in smartphones. It is unsure if just by modularity can make smartphones convivial but does point to the fact that these can be seen as baby steps towards the resistance against planned obsolescence.

5.5 Limitations of the study

While efforts were taken to conduct thorough research there were few limitations which affected the study. A significant limitation was the time constraint to collect a large data set. The survey was open for only 45 days. A longer time period which would have helped to collect more survey responses and there by resulting in more credible insights. The survey was limited to 100 respondents which was calculated based on the available information of Fairphone users in The Netherlands. The subset of modular smartphone users could be even higher or lower. Another significant limitation was availability of data source from Fairphone and Shiftphone, as most of the data collected are only from their annual reports which might lead to a positive bias in the research itself.

6 CONCLUSIONS

This thesis performed a critical examination of the integration of convivial principles in sustainable smartphone design and production, with a particular focus on Fairphone and Shiftphone. Through the lens of Illich's concept of conviviality and Vetter's framework, the study highlights the potential and challenges of modular smartphones in resisting planned obsolescence. The analysis shows that convivial principles can significantly challenge the principles and practices of planned obsolescence. In smartphones these include the emphasis on repairability, user autonomy, community forums etc. Fairphone and Shiftphone, as pioneers in this field, is found to have incorporated core convivial dimensions in their modular smart phones through modularity and ethical sourcing to varying extents. Their efforts also encourages user engagement and technological literacy, as users benefit from the opportunity to customize, upgrade, and repair their own devices. While conviviality principles can be incorporated to some extent, highly technical technologies might not be truly convivial because of the inherent complex nature of these devices. But any feature that puts planet and people over profit can are contributing towards convivial societies as well as convivial technologies.

However, the study also identifies critical barriers to the widespread adoption of these modular smartphone technologies. Limited model variety, higher upfront costs, and a general lack of consumer awareness. Moreover, the complexity of supply chains for sourcing materials is against the principles of using local materials and skills, presenting significant challenges to achieving full conviviality in modular smartphones. User perceptions indicate that there is a growing interest for the environmental and social benefits of modular smartphones, but also shows some amount of skepticism regarding their durability and complexity. The findings suggest that while there is a strong correlation between environmental consciousness and the adoption of modular smartphones, overcoming the perception of these devices as niche or experimental is very important.

In conclusion, modular smartphone companies are making notable strides towards integrating convivial principles, but further efforts are needed to address the identified barriers. By creating a deeper connection between users and their devices, and promoting sustainable consumption patterns, convivial smartphones have the potential to play a crucial role in reducing electronic waste and thus countering the negative effects of planned obsolescence.

6.1 Future Research

This study has tried to explore the intersection of PO and conviviality in smartphones. It also highlights several areas that needs further investigation. The following research directions are proposed to deepen the understanding of how sustainable technologies and practices can be advanced and how conviviality can further challenge growing trends of PO.

- Expanding the Scope of Conviviality in Technologies

While this research has focused on smartphones, the concept of conviviality could be extended to any technology, be it consumer electronics or automotives or any other. For smartphones the concept of conviviality is reflected mainly in the feature of modularity. Future studies could explore what conviviality means for different technologies and the present society in a world where mindless living and over consumption is the norm.

- Social Dimensions of Conviviality

There is a need for research that delves into the cultural and social dimensions of conviviality in technology. This includes understanding how social movements and grassroots initiatives can drive the demand for sustainable, user-friendly technologies. Future research could also examine how social dimensions can be included in the design phase of products by making conviviality an important design principle.

References

SHIFT. (n.d.). Retrieved April 5, 2024, from https://www.shift.eco/hilfe/ueber-shift/

Agrawal, V. V., & Ülkü, S. (2013). The role of modular upgradability as a green design strategy. *Manufacturing and Service Operations Management*, *15*(4), 640–648. https://doi.org/10.1287/msom.1120.0396

Alzaydi, A. (2024). Balancing creativity and longevity: The ambiguous role of obsolescence in product design. *Journal of Cleaner Production*, *445*, 141239. https://doi.org/10.1016/j.jclepro.2024.141239

Amend, C., Revellio, F., Tenner, I., & Schaltegger, S. (2022a). The potential of modular product design on repair behavior and user experience – Evidence from the smartphone industry. *Journal of Cleaner Production*, *367*. https://doi.org/10.1016/j.jclepro.2022.132770

Amend, C., Revellio, F., Tenner, I., & Schaltegger, S. (2022b). The potential of modular product design on repair behavior and user experience – Evidence from the smartphone industry. *Journal of Cleaner Production*, *367*, 132770. https://doi.org/10.1016/j.jclepro.2022.132770

Authored By Baldé, C. P., Forti, V., Gray, V., Kuehr, R., & Stegmann, P. (2017). *The Global E-waste Monitor 2017. Quantities, Flows, and Resources The Global E-waste*. www.unu.edu

Belmonte-Ureña, L. J., Plaza-Úbeda, J. A., Vazquez-Brust, D., & Yakovleva, N. (2021). Circular economy, degrowth and green growth as pathways for research on sustainable development goals: A global analysis and future agenda. *Ecological Economics*, *185*, 107050. https://doi.org/10.1016/J.ECOLECON.2021.107050

Bisschop, L., Hendlin, Y., & Jaspers, · Jelle. (n.d.). *Designed to break: planned obsolescence as corporate environmental crime*. https://doi.org/10.1007/s10611-022-10023-4

Bonaiuti, M. (2018). Are we entering the age of involuntary degrowth? Promethean technologies and declining returns of innovation. *Journal of Cleaner Production*, *197*, 1800–1809. https://doi.org/10.1016/j.jclepro.2017.02.196

Boston, J. (2022). View of Living Within Biophysical Limits: green growth versus degrowth. *Policy Quarterly*, *18*(2), 81–92. https://ojs.victoria.ac.nz/pq/article/view/7578/6733

Cardoso Satyro, W., Benedito Sacomano, J., Celso Contador, J., & Telles, R. (2018). *Planned obsolescence or planned resource depletion? A sustainable approach*. https://doi.org/10.1016/j.jclepro.2018.05.222

Chatterji, M. (2021, July 19). *Repairing – not recycling – is the first step to tackling e-waste from smartphones. Here's why*. https://www.weforum.org/agenda/2021/07/repair-not-recycle-tackle-ewaste-circular-economy-smartphones/

Dale, G. (2012). *The growth paradigm: a critique*. International Socialism. https://isj.org.uk/the-growth-paradigm-a-critique/

Fairphone's impact 2022. (n.d.). Retrieved August 5, 2024, from https://www.fairphone.com/wp-content/uploads/2023/05/Fairphone-Impact-Report-2022.pdf

Feldman, K., & Sandborn, P. (2007). *INTEGRATING TECHNOLOGY OBSOLESCENCE CONSIDERATIONS INTO PRODUCT DESIGN PLANNING*. http://www.asme.o

Habib, K. (2023). Can planned obsolescence ever be obsolete? Trade-offs between consumer safety, product performance and lifetime. *Resources, Conservation and Recycling*, *190*, 106858. https://doi.org/10.1016/J.RESCONREC.2022.106858

Haucke, F. V. (2018). Smartphone-enabled social change: Evidence from the Fairphone case? *Journal of Cleaner Production*, *197*, 1719–1730. https://doi.org/10.1016/J.JCLEPRO.2017.07.014

Heikkurinen, P. (2018). Degrowth by means of technology? A treatise for an ethos of releasement. *Journal of Cleaner Production*, *197*, 1654–1665. https://doi.org/10.1016/J.JCLEPRO.2016.07.070

Hirose, K., & Mishima, N. (2019). Eco-efficiency evaluation of modular design smartphones. *Procedia CIRP*, *84*, 1054–1058. https://doi.org/10.1016/j.procir.2019.04.189

Hu, Q., & Gu, Y. (2023). *Copper economic dynamics: Navigating resource scarcity, price volatility, and green growth*. https://doi.org/10.1016/j.resourpol.2023.104462

Illich, I. (1983). *Tools for Conviviality*.

Jaeger-Erben, M., Proske, M., & Hielscher, S. (2023). *8. Scalability and durability, or: is modular the new durable? The case of smartphones*.

Kallis, G., Kostakis, V., Lange, S., Muraca, B., Paulson, S., & Schmelzer, M. (2018). Research on Degrowth. *Annual Review of Environment and Resources*, *43*, 291–316. https://doi.org/10.1146/annurev-environ-102017-025941

Kerschner, C., Nierling, L., & Ehlers, M.-H. (2018). *Degrowth and Technology: Towards feasible, viable, appropriate and convivial imaginaries*. https://doi.org/10.1016/j.jclepro.2018.07.147

Likavčan, L., & Scholz-Wäckerle, M. (2018). Technology appropriation in a de-growing economy. *Journal of Cleaner Production*, *197*, 1666–1675. https://doi.org/10.1016/J.JCLEPRO.2016.12.134

Lizarralde, I., & Tyl, B. (2017). *A framework for the integration of the conviviality concept in the design process*. https://doi.org/10.1016/j.jclepro.2017.03.108

London, B. (1932). *Ending the Depression Through Planned Obsolescence*.

Longmans, V. P. (1960). *The Waste Makers*.

Muniz, R., & Cruz, M. J. (2015). Making Nature Valuable, Not Profitable: Are Payments for Ecosystem Services Suitable for Degrowth? *Sustainability 2015, Vol. 7, Pages 10895-10921*, *7*(8), 10895–10921. https://doi.org/10.3390/SU70810895

Oraee, A., Pohl, L., Geurts, D., & Reichel, M. (2024). *Overcoming Premature Smartphone Obsolescence amongst Young Adults*. https://doi.org/10.1016/j.clrc.2024.100174

Panizzut, N., Muhammad Rafi-ul-Shan, P., Amar, H., Sher, F., Usman Mazhar, M., & rí Jaromír Kleme, J. (2021). *Exploring relationship between environmentalism and consumerism in a market economy society: A structured systematic literature review*. https://doi.org/10.1016/j.clet.2021.100047

Pansera, M., & Fressoli, M. (2020). Innovation without growth: Frameworks for understanding technological change in a post-growth era. *Https://Doi.Org/10.1177/1350508420973631*, *28*(3), 380–404. https://doi.org/10.1177/1350508420973631

Pansera, M., & Fressoli, M. (2021). Innovation without growth: Frameworks for understanding technological change in a post-growth era. *Organization*, *28*(3), 380–404. https://doi.org/10.1177/1350508420973631

Proske, M., Jaeger-Erben, M., & Berlin, T. U. (2019). *Decreasing obsolescence with modular smartphones? e An interdisciplinary perspective on lifecycles*. https://doi.org/10.1016/j.jclepro.2019.03.116

Ralph, N. (2021). A conceptual merging of circular economy, degrowth and conviviality design approaches applied to renewable energy technology. *Journal of Cleaner Production*, *319*, 128549. https://doi.org/10.1016/J.JCLEPRO.2021.128549

Right to repair: Making repair easier for consumers. (2023). https://ec.europa.eu/commission/presscorner/detail/en/ip_23_1794

Rivera, J. L., & Lallmahomed, A. (2016). Environmental implications of planned obsolescence and product lifetime: a literature review. *International Journal of Sustainable Engineering*, *9*(2), 119–129. https://doi.org/10.1080/19397038.2015.1099757

Robra, B., Pazaitis, A., Giotitsas, C., & Pansera, M. (2023). From creative destruction to convivial innovation-A post-growth perspective. *Technovation*, *125*, 102760. https://doi.org/10.1016/j.technovation.2023.102760

Samerski, S. (2018). Tools for degrowth? Ivan Illich's critique of technology revisited. *Journal of Cleaner Production*, *197*, 1637–1646. https://doi.org/10.1016/J.JCLEPRO.2016.10.039

Sierra-Fontalvo, L., Gonzalez-Quiroga, A., & Mesa, J. A. (2023). A deep dive into addressing obsolescence in product design: A review. *Heliyon*, *9*(11), e21856. https://doi.org/10.1016/J.HELIYON.2023.E21856

Singh, P., & Sandborn, P. (2006). Obsolescence driven design refresh planning for sustainment-dominated systems. *Engineering Economist*, *51*(2), 115–139. https://doi.org/10.1080/00137910600695643

van der Merwe, A., & Brugger, F. (2021). Case study: The digital device life cycle: From mining to e-waste. In *Development Co-operation Report 2021: Shaping a Just Digital Transformation*. OECD. https://doi.org/10.1787/CE08832F-EN

Verschuren, P., & Doorewaard, H. (2010). *Designing a ReseaRch PRoject*.

Vetter, A. (2017). *The Matrix of Convivial Technology e Assessing technologies for degrowth*. https://doi.org/10.1016/j.jclepro.2017.02.195

Watanabe, C., Naveed, N., & Neittaanmäki, P. (2019). Digitalized bioeconomy: Planned obsolescence-driven circular economy enabled by Co-Evolutionary coupling. *Technology in Society*, *56*, 8–30. https://doi.org/10.1016/j.techsoc.2018.09.002

Appendix 1 Matrix of Convivial Technologies (Vetter 2018

Dimensions // Levels →	Materials *Harvesting, processing and disposal of raw matter*	Production *Assembling raw materials and preproducts*	Use *Procuring the task it was built for*	Infrastructure *Needed environment for using*
Remarks on Levels -->				
Relatedness *What does it bring about between people?*	Process fixed -- Right to creative input Fixed world concepts -- Learning from different sources Market-driven -- Need-driven Top down control -- Bottom-up control Organization centralized -- Organization distributed Alien implementation -- Respects local traditions	Fosters competition -- Supports trust Distance-creating -- Conjoint experience Market-driven -- Need-driven Top down control -- Bottom-up control Organization centralized -- Organization distributed Process fixed -- Right to creative input Creates borders -- Integrates Alien implementation -- Respects local traditions Creates senselessness -- Creates art Uglifying -- Creates beauty	Fosters competition -- Supports trust Fosters individual advantage -- Supports community Prefigured use only -- Allows creativity One solution fits all -- Respects local traditions Discourages care -- Simplifies care Uglifying -- Creates beauty Creates senselessness -- Creates art Alienating from own body -- Useful body enhancement Heteronomy -- Self-determination Compulsory -- Voluntarily	Fosters competition -- Sustains trust Distance-creating -- Connects with eco processes Market-driven -- Need-driven Top down control -- Bottom-up control Fosters individual advantage -- Supports community Creates senselessness -- Creates art Uglifying -- Creates beauty Humans as inferior part of a system -- Humans as equal part of a complex system Discourages care -- Simplifies care
Access *Who can produce/use it where and how?*	Elitist -- Open to anyone Investor-owned -- Producer-owned Cost-intensive -- Low-cost Secret or patented -- Knowledge freely accessible Need of foreign expert -- Use of local knowledge Specialized processes -- Standardized processes Hinders skill building -- Supports skill building Abstract -- Comprehensible	Elitist -- Open to anyone Investor-owned -- Producer-owned Cost intensive -- Low Cost Secret or patented -- Knowledge freely accessible Hinders skill building -- Sustains skill building Need of foreign expert -- Use of local knowledge Abstract -- Comprehensible Not able to fulfill needs -- Fulfilling basic needs Opaque organization -- Transparent communication Specialized processes -- Standardized processes	Usable by an elite -- Usable by anyone Investor-controlled -- Open Cost intensive -- Low Cost Need of foreign expert -- Use of local knowledge Not able to fulfill needs -- Fulfilling basic needs Abstract -- Comprehensible Repugnant -- Attractive Enforces cultural restraints -- Transforms cultural restraints	Usable by an elite -- Usable by anyone Cost intensive -- Low Cost Abstract -- Comprehensible Enforces cultural restraints -- Transforms cultural restraints Not able to fulfill needs -- Fulfilling basic needs
Adaptability *How independent and linkable is it?*	Special machines -- Everyday tools Big scale economical -- Small scale economical Special conditions -- Everywhere possible Special materials -- Standardized materials	Fixed once finished -- Permanently changeable Isolated -- Interoperable Size fixed -- Scalable Special machines -- Everyday tools Big scale economical -- Small scale economical Heteronomous -- Self-determined One way processes -- Dis-/reassembly possible Special conditions -- Everywhere possible One piece -- Modular	Fixed once finished -- Permanently changeable Isolated -- Interoperable Size fixed -- Scalable One-dimensional -- Multi-functional Infrastructure needed -- Independent use possible Repairable by experts -- Repairable by skilled Close survey needed -- Uses self-regulation Monolithic -- Interchangeable One solution fits all -- Encourages diversity One piece -- Modular	Fixed once finished -- Permanently changeable Isolated -- Interoperable Size fixed -- Scalable One-dimensional -- Multi-functional Centralized -- Distributed One solution fits all -- Encourages diversity Compulsory -- Voluntarily Linear systems -- Non-linear systems Repairable by experts -- Repairable by skilled Operable only from distance -- Locally operable
Bio-Interaction *How does it interact with living organisms?*	Illness/death -- Supports health Deteriorating soil -- Improving soil Water-polluting -- Improving water quality Air-polluting -- Supports clean air Violent -- Nonviolent Hazardous potential -- Safety proven and tested Toxic waste -- Biodegradable Suppresses organic processes -- Allows co-productivity	Illness/death -- Supports health Deteriorating soil -- Improving soil Water-polluting -- Improving water quality Air-polluting -- Supports clean air Violent -- Nonviolent Hazardous potential -- Safety proven and tested Suppresses organic processes -- Allows co-productivity	Illness/death -- Supports health Deteriorating soil -- Improving soil Water-polluting -- Improving water quality Air-polluting -- Supports clean air Violent -- Nonviolent Hazardous potential -- Safety proven and tested Toxic waste -- Biodegradable Suppresses organic processes -- Allows co-productivitys	Illness/death -- Supports health Deteriorating soil -- Improving soil Water-polluting -- Improving water quality Air-polluting -- Supports clean air Violent -- Nonviolent Hazardous potential -- Safety proven and tested Toxic waste -- Biodegradable Suppresses organic processes -- Allows co-productivity
Appropriateness *What is the relation between input and output considering the context?*	Non renewable -- Renewable Far away -- Locally available New -- Re-used Non recyclable -- Easily recyclable Nondurable -- Durable Needs painful worktime -- Allows joyful worktime Fossil energy -- Renewable energy	Thriftless material use -- Frugal material use Special tools -- Standardized tools Against local settings -- Uses local settings Needs painful worktime -- Allows joyful worktime Fossil energy -- Renewable energy Creates waste -- Byproducts are used	Encourages waste -- Sustains sufficiency New -- Re-used Nondurable -- Durable Against local settings -- Uses local settings Needs painful time- -- Allows joyful time Fossil energy -- Renewable energy Creates waste -- Byproducts are used	Thriftless material use -- Frugal material use Encourages waste -- Sustains sufficiency New -- Re-used Nondurable -- Durable Against local settings -- Uses local settings Needs painful time- -- Allows joyful time Fossil energy -- Renewable energy Creates waste -- Byproducts are used
	Materials	**Manufacturing**	**Use**	**Infrastructure**

Appendix 2 Interview Questions for modular smartphone companies

1. Are the different materials used in your phones the same as those used in regular smart phones or do you use any materials after learning that such materials hinder the long-term sustainability of the product?
2. What are the environmental impacts of your products, throughout its lifecycle and at the end of life?
3. What kind of hazardous potential does it have?
4. How are the materials sourced? How do you ensure ethical sourcing and production?
5. Is there any special technology, special conditions or special materials required during the life cycle of the product which makes it hard for users to choose your phones?
6. What is the motivation behind using such materials/business, is it market driven or need driven?
7. What values or perspectives drive the innovation process?
8. Where does profit-making sit in the list of priorities when considering production and innovation?
9. How do you capture (or not) feedback from users?
10. How does your organization prioritize user feedback and engagement in the development and improvement of its products?
11. What does autonomy mean for your phone and its users?
12. Does users create communities in which they discuss your product? Does your company take an active role in creating those communities?
13. Could you provide examples of how your products challenge traditional principles and practices of planned obsolescence?
14. How does users perceive and engage with the devices?
15. What is the economical scale of your production units?
16. Is this scale ideal? Are you looking to expand?
17. Is there a limit to the number of phones you want to produce? How do you balance the need for sustainability and profit making?
18. In your opinion, what are the main barriers and challenges hindering the widespread adoption of sustainable technologies in the smartphone industry?
19. What steps are taken to overcome these barriers and promote the adoption of sustainable technologies?

20. Can you discuss any initiatives or partnerships aimed at raising awareness and educating consumers about the benefits of sustainable smartphone practices?
21. Looking ahead, what are your organizations future plans and goals regarding the integration of convivial principles in its products and business operations?
22. By making the smartphone modular do you see any increase in the life of smartphones? Which is 3.5 years currently.

Appendix 3

The survey questions and responses are available upon request. Please email at r.thomasgomez@student.utwente.nl

Appendix 4 Complex supply chain of modular smartphones