Unveiling Consumer Preferences for Sustainable and Circular Smartphones: A Conjoint Analysis Approach.

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AFFIDAVIT

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ABSTRACT

Since the release of the first iPhone in 2007, smartphones have undergone remarkable rapid development and have become a cornerstone of modern society. Their societal importance originates from the transformative impact on basically all areas of modern life: communication, information access, economics, social connectivity, empowerment, healthcare, and education. The continuous development of smartphones shapes the way individuals live, work, and interact with the world, underscoring their enduring significance in modern society. However, as demand for smartphones grows and their environmental impact becomes increasingly evident, there is a critical need to address sustainability concerns while maintaining user satisfaction.

This thesis starts with an in-depth review of current sustainability concepts, particularly the idea of a Circular Economy. It then continues by examining sustainability attributes in smartphone design and their significance, such as material selection, energy efficiency, recyclability, and ethical sourcing. The fundamental purpose of this research is to investigate consumer preferences towards sustainable smartphones. To achieve this goal. An adaptive Conjoint Analysis methodology is used, utilizing online surveys to capture consumer preferences and choices among various product features. Furthermore, environmental awareness and key performance indicators concerning individual smartphone usage were considered.

Based on data collected from 16 European countries, the investigation unfolded that the price of the product is the primary argument for the product decision, closely followed by the argument of extensive warranty. Repairability was also deemed a crucial feature, but interestingly, the type of phone (new or used) ranked fourth in importance. Also, rather unexpected, the local production argument was favored over a sustainability label.

The expectation from the research findings are to offer guidance on how to prioritize sustainability attributes and integrate them into smartphone design. Applying these results, the goal is to develop strategies for closing the gap between sustainability and user satisfaction in the constantly evolving smartphone industry. Such strategies should facilitate to change consumer preferences and technological advancements. Ultimately, this approach might contribute to the development of more environmentally responsible smartphone products.

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1 INTRODUCTION

Resulting from production and consumption habits that are most sustainable, resource depletion, biodiversity loss, and pollution of the water air and soil are urgent challenges of our time. Sustainability is therefore a widespread discussion both in the theoretical and commercial worlds.

The exponential expansion of the electronics industry, mainly in the domain of smartphones, has sparked concerns regarding its ecological impact and sustainability. With the worldwide surge in demand for smartphones, there is an increasing need for adopting sustainable and circular practices within the industry. The production, utilization, and disposal of smartphones contribute to various environmental predicaments such as resource depletion, electronic waste accumulation, and carbon emission. To address these challenges, there is a growing emphasis on developing sustainable and circular approaches to manufacturing, consumption, and end-of-life management of smartphones.

The idea of sustainability involves ensuring that the current generation meets its needs without compromising the ability of future generations to do the same. For smartphones, sustainability covers every aspect of the product lifecycle, including the sourcing of raw materials, manufacturing processes, energy efficiency during usage, and end-of-life strategies like recycling and refurbishment. Circularity, on the other hand, focuses on reducing waste, prolonging product lifespans, and promoting resource recovery by encouraging repair, reuse, and recycling. By combining sustainability and circularity in smartphone design, production, and usage, we can make significant strides toward protecting the environment and creating a more sustainable future.

Understanding consumer preferences for sustainable and circular smartphones is crucial in driving change within the industry. Consumers have a significant impact on shaping market demands and manufacturers' practices. However, despite positive attitudes toward sustainability, there often exists a gap between consumers' attitudes and their actual buying behaviours. This gap presents a considerable obstacle in achieving widespread adoption of sustainable and circular smartphones. To overcome this challenge, deeper insights into the factors that influence consumer choices and the underlying motivations that drive their decision-making processes are necessary.

This thesis utilizes a conjoint analysis approach to understand consumer preferences regarding sustainable and circular smartphones. Conjoint analysis is a useful research method that presents individuals with product profiles composed of various attributes and levels, allowing for the systematic examination of consumer preferences. By varying these attributes, the analysis can quantify consumers' relative preferences for different features of sustainable and circular smartphones. This approach provides valuable insights into the trade-offs consumers make when selecting smartphones and can guide manufacturers and policymakers in aligning their offerings with consumer desires.

Furthermore, this study aims to investigate consumers' willingness to pay a premium for sustainable smartphones. It seeks to explore the factors that influence consumers' decision-making processes and the extent to which sustainability considerations play a role in their purchasing behavior. By delving into the drivers and barriers that affect WTP for sustainable smartphones, this research will provide valuable insights to manufacturers, policymakers, and other stakeholders involved in the smartphone industry.

Additionally, this thesis explores consumer preferences and investigates the attitude-behaviour gap in sustainable and circular smartphone consumption. Although many consumers are aware of sustainability issues, they may find it challenging to turn their positive attitudes into actions when purchasing a smartphone. To address this issue, this research will evaluate the alignment between consumers' attitudes, intentions, and their actual behaviours concerning sustainable and circular smartphones. The study aims to identify the factors that contribute to the attitude-behaviour gap and develop strategies to bridge this gap and promote sustainable and circular smartphone practices.

The results of this study will offer valuable insights to smartphone manufacturers, policymakers, and other stakeholders in the electronics industry, enabling them to develop sustainable and circular solutions that align with consumer preferences. The goal is to promote sustainable and circular smartphone practices and foster a more responsible electronics industry that meets the evolving demands of consumers and contributes to a sustainable future.

1.1 Context and previous research

The issue of sustainable and circular smartphones is a part of the larger global conversation about environmental sustainability and the electronics industry. As smartphones continue to be produced and replaced at a rapid pace, it is crucial to address the environmental impact of these devices throughout their lifecycle. This involves examining not only the extraction of raw materials and manufacturing processes but also the usage patterns and disposal practices associated with smartphones.

Numerous studies have delved into consumer behavior and preferences regarding sustainable consumption. These studies have explored the factors that influence sustainable product choices in various industries such as fashion (Fuchs & Hovemann, 2022), food (Chen et al., 2020), and household appliances. However, research on sustainable and circular smartphones has been limited, despite their growing significance in our daily routine.

When it comes to sustainable smartphones, numerous studies have delved into different aspects like eco-labeling, energy efficiency, and material sourcing. For instance, researchers have analyzed how consumers perceive and prefer eco-labels and certifications that signify the sustainability of smartphones (Grankvist et al., 2019). Other studies have explored the impact of energy efficiency ratings and energy-saving features on consumers' choices (Si-dai et al., 2021). Moreover, there has been research on the use of environmentally friendly materials and sustainable design's role in smartphone selection.

To fully comprehend consumers' preferences and attitudes towards sustainable smartphone features, it is necessary to have a thorough understanding of their preferences for circular and sustainable smartphones. Additionally, exploring the attitude-behavior gap in sustainable consumption, which refers to the difference between consumers' positive attitudes and their actual purchasing behaviors, is an important area to investigate. Closing this gap is essential in promoting the adoption of sustainable and circular smartphone practices. This thesis aims to address these research gaps.

1.2 Research aims and objectives

The purpose of this thesis is to conduct an in-depth analysis of consumer preferences regarding sustainable smartphones, as well as to identify the discrepancies between their attitudes and behaviours when it comes to purchasing these devices. The goal is to gain valuable insights into consumer decision-making processes and bridge the gap between their positive attitudes towards sustainability and their actual buying behaviours. With that, this paper provides the industry with fresh insights into how customers perceive socially sustainable products. The central inquiry of this thesis is whether European consumers are open to purchasing circular smartphones.

The main research objective of this thesis is to identify and quantify consumer preferences for sustainable smartphones. Following the main research questions is as follows.

RQ: What are consumer preferences for sustainable Smartphones?

Through the use of an Adaptive Conjoint design, this study aims to quantify the most influential factors and levels that impact consumer choices. By exploring attributes such as price, warranty, phone type, repairability, sustainability labels, and place of production, we can measure their significance and gain further insights into consumer behavior. Examining consumers' willingness-to-pay for each feature will provide even deeper insights. However, it is important to first understand the concept of sustainability before deciding on product attributes. Therefore, this study will be grounded in the theoretical foundation of a Circular Economy, which offers an alternative to the current economic model.

RQ2: What are sustainable smartphone attributes according to the notion of a circular economy?

RQ3: What are the specific sustainability attributes that consumers prioritize when considering a sustainable smartphone?

Furthermore, the author's objective is to analyse how information and environmental awareness impact consumer preferences for sustainable and circular smartphones. This study will evaluate how these factors affect consumer choices for smartphones. By comprehending the influence of information and awareness, the research can provide valuable insights into the effectiveness of communication strategies and education campaigns in promoting sustainable smartphone consumption.

Explore the attitude-behaviour gap: The third objective is to conduct a thorough investigation of the disparity between consumer attitudes and actions towards sustainable smartphone consumption. The research aims to identify the underlying factors that contribute to this gap by comparing attitudes, intentions, and actual behaviours in relation to sustainable and circular smartphones. Through this inquiry, valuable insights into the barriers and motivations that influence decision-making processes are hoped to be gained. Ultimately, the findings will assist in bridging this gap and encouraging more sustainable purchasing behaviours.

This thesis intends to add to the current understanding of consumer preferences for sustainable and circular smartphones. Achieving these research objectives will have practical implications for the industry by guiding the development of sustainable and circular smartphone practices and promoting responsible smartphone consumption. Ultimately, the goal is to accelerate the transition towards a greener and more sustainable electronics industry for a better future.

1.3 Structure of thesis

This thesis is thoughtfully structured to thoroughly examine consumer preferences for sustainable and circular smartphones and to explore the attitude-behaviour gap. It is divided into a series of chapters that flow coherently, offering a comprehensive analysis of the research subject. The structure of the thesis is as follows:

The opening chapter of the thesis establishes the foundation by giving a brief on the research topic, its importance, and the objectives of the study. Additionally, it presents the concept of sustainable and circular smartphones, emphasizes the gap between attitude and behaviour, and proposes research questions that steer the investigation.

In the chapter on literature review, various scholarly works and research related to sustainable consumption, consumer behaviour, and sustainable and circular smartphones are examined. Theoretical frameworks such as the Theory of Planned Behaviour are also analysed. Additionally, the literature review identifies gaps in the current research and justifies the need for the present study.

The methodology chapter contains a comprehensive explanation of the research design, data collection methods, and data analysis techniques used in the study. The reasoning behind selecting conjoint analysis as the primary research approach is clarified, and the attributes and levels chosen for the conjoint analysis survey are elaborated upon. Additionally, the chapter covers the additional measures implemented to evaluate information and environmental awareness, and it outlines the sampling procedure and data analysis plan.

In this chapter the process of collecting and analysing data is presented. It covers the recruitment of participants, conducting the conjoint analysis survey, and data collection. Statistical techniques used for analysing the conjoint analysis data and measures related to information and environmental awareness are also outlined. Finally, the results obtained from the data analysis are presented and interpreted comprehensively.

In the final chapter, the study's main discoveries and their implications are summarized. The research objectives and questions are restated, while also discussing how they have been tackled throughout the study. Additionally, the chapter reflects on the research's limitations and provides recommendations for future sustainable and circular smartphone research.

2 HISTORICAL BACKGROUND ON SUSTAINABILITY

Before delving into the sustainability challenges faced by the Smartphone industry, it's essential to establish a clear understanding of the fundamental concepts of sustainability and sustainable development.

The idea of sustainability traces back to the forest industry of the 18th century, specifically to Hans Carl von Carlowitz's book "sylvicultura oeconomica" published in 1713. According to Carlowitz it is advisable for the business to limit its wood-cutting activities to the amount that can be regenerated to promote sustainable practices in the long run. Building on this idea, the notion of sustainable forestry was introduced in 1804 through the publication of "Instructions for the Taxation of Forests." It has been acknowledged that the success of sustainable forestry practices is contingent upon the implementation of sustainable logging practices within the forest. The concept is developed based on four essential elements. Durability is prioritized to guarantee the preservation of resources and ecosystem functions for the long-term. Responsibility to society acknowledges the need for certain restrictions to align with societal interests. Economics is emphasized to secure economic benefits through systematic protection efforts. Lastly, it aims to preserve the forest for the benefit of future generations. In the subsequent decades, the initial concept of sustainability was applied to numerous environmental concerns (Spindler, 2013).

During the 1960s and 1970s, the public became increasingly aware of the negative impact that technological advancements of the previous decade had on the environment. The progress made during this time resulted in an increase in energy consumption, pollutant emissions, and waste accumulation.

In 1962, Rachel Carson's published the boot "Silent Spring", which played a pivotal role in shaping the history of sustainability. The book raised public awareness about the harmful effects of pesticides, particularly DDT, on the environment and human health. It sparked a global environmental movement, leading to increased regulations on pesticides, the establishment of environmental agencies, and a greater emphasis on ecological principles in environmental management. "Silent Spring" is widely regarded as a catalyst for the modern environmental movement and a foundational text that highlighted the interconnectedness of ecosystems and the need for responsible stewardship of the natural world.

During the 1960s, the world was captivated by the space race, while various social and cultural movements, such as environmentalism, were emerging. In 1968, NASA shared a picture of the earth from space, which raised awareness among the public about the need to protect our planet (Grober, 2013). Notably, in 1966, three years before the moon landing, British economist Kenneth Boulding wrote a book where he reflects on *"The Economics of the Coming spaceship Earth"*. Boulding's work provides a strong defense for what he calls the "*spaceman economy*" against the "*cowboy economy*". The phrase "cowboy economy" refers to the economic methods used by cowboys in the Wild West of the 19th century. Typically, they would settle in a specific area, make use of the resources available, and then move on to a new location once those resources were exhausted. This cycle was often repeated. In the spaceman economy, effective management of scarce resources is essential to prevent excessive exploitation and contamination. The concept likens Earth to a spaceship that carries millions of living organisms through the boundless expanse of space within a sealed system. Therefore, there is no room for waste disposal or acquisition of new resources. The success of our mission depends on the implementation of models such as the circular economy, which are supported by these theoretical contributions.

In 1969, sustainability became a prominent topic in policy-making. The US government's enactment of the "National Environmental Policy Act" was a pivotal moment, requiring extensive "Environmental Impact Assessments" for major projects and emphasizing public involvement. This approach was subsequently adopted by many nations worldwide (Jenkins & Schröder, 2013).

Within the academic community, there are two well-established frameworks that have gained widespread acceptance due to recent advancements. The first is the "Planetary Boundaries" concept, which places a central focus on ecological considerations. Secondly, the "Sustainable Development Goals" established by the United Nations serve as a universal reference point for assessing and comparing progress on a global scale. These frameworks have earned a high degree of regard for their effectiveness in addressing challenges and setting goals.

Many sustainability issues are linked to alterations in the planet's ecosystems. It's generally acknowledged that human beings play the most significant role in shaping the environment. In fact, some experts have proposed renaming the current geological epoch as the Anthropocene to underscore this impact (Steffen et al., 2015).

In 1972, the Club of Rome published "The Limits to Growth," which represented a crucial milestone. This groundbreaking approach employed computer simulations to explore the long-term consequences of exponential economic and population growth on the finite resources of the planet. The study's findings revealed that within the next hundred years, our planet will reach its limits concerning population, industrialization, pollution, food production, and resource depletion. As a result, there'll be an uncontrollable decline in both population and industrial output(Meadows et al., 1972). The publication of this report in 1973 generated a considerable amount of public attention and stimulated a global discussion on the need for ecological balance, and the importance of considering the carrying capacity of the earth´s ecosystem[1]. This attention is probably because it coincided with the first oil crisis, which revealed the world's excessive reliance on non-renewable energy sources (Schrott, 2015). The idea presented in "The Limits to Growth" is that human actions are part of a global system, and to ensure a sustainable future, it's imperative to comprehend and regulate complex, interconnected systems. By employing computer simulations, the book explored a range of scenarios and demonstrated the possible outcomes of unsustainable practices. This played a significant role in the advancement of systems thinking and the utilization of models in sustainability research and policymaking.

During the second half of the 1980s, public awareness was drawn to five pressing environmental issues of significant magnitude that gained widespread media attention and led to raised awareness about the impact of global warming (Clark, 2010). During the year 1984, India encountered an unprecedented disaster known as the Bhopal gas leak. The subsequent year, the discovery of the ozone hole over Antarctica added to the increasing apprehension for the environment. The Chernobyl nuclear incident in 1986, the scorching heatwave and wildfires in the Western United States in 1988, and the Exxon Valdez oil spill in 1989 further aggravated the series of environmental calamities during that era. Moreover, there was an increasing trend of the continuously rising global population and consumption rates. In the same year, a significant environmental conference was held in Stockholm under the auspices of the United Nations. This conference was attended and backed by 113 nations, including the United States. The conference was successful in passing a crucial declaration that establishes global protocols for managing the environment. The declaration also includes a detailed action plan that emphasizes cooperation to safeguard the environment. Furthermore, the creation of the "United Nations Environmental Program" was announced to enhance environmental efforts and collaboration within the organization (Newman, 2011).

The Brundtland Report, also referred to as "Our Common Future", was published by the United Nations Global Commission on Environment and Development in 1987. This report introduced the current widely recognized categories for sustainable development. The report defines sustainable development as: *“meeting the needs of present generations without endangering the ability of future generations to meet their own needs”*. There are two crucial concepts to consider. Firstly, the environment's ability to meet current and future needs is restricted by the level of technology and social organization. Secondly, social structures and technological progress are constraining the environment's capacity to fulfill present and future requirements. Therefore,

[1] The concept of "carrying capacity" refers to the maximum population size that an ecosystem can sustain for a prolonged period without causing any significant ecological or resource harm. It requires a careful equilibrium between the available resources within an ecosystem and the requirements of the organisms dwelling in it.

the report strongly recommended that all countries prioritize sustainability when defining their social and economic objectives (Brundtland, 1987). The Triple-bottom-line of sustainability was first introduced as a concept that is now widely applied today. It encompasses economic, environmental, and societal factors, all of which contribute to the overall well-being of individuals. Businesses strive to enhance their economic performance while also making positive contributions to the environment and society.

In 1992, the United Nations Conference on Environment and Development, which was based on Brundtland's principles, was held in Rio. This conference, led by Ernst Ulrich von Weizsäcker, established the foundation for worldwide governance in "Earth Politics". During the conference, six declarations were adopted. The first was Agenda 21, a plan aimed at promoting sustainable development. The second was a declaration on environment and development, which lays out a set of principles governing the responsibilities and rights of states. The third was the Forest Principles, which include ethical guidelines for the sustainable management of forests worldwide. The fourth, fifth, and sixth declarations are legally binding instruments, namely the United Nations Framework Convention on Climate Change, the Convention on Biological Diversity, and the Convention to Combat Desertification. The declarations have helped bring sustainability into the limelight of policy discussions. Nevertheless, there are concerns that the documents rely too heavily on voluntary commitments rather than imposing verifiable obligations on representative states, which some have criticized.

In 1997, the Kyoto Protocol was created with the aim of setting greenhouse gas emissions reduction targets for various countries. As a result, each developed nation was assigned its own unique target to work towards. However, the agreement's effectiveness was hindered by the absence of participation from both the USA and China when it was enforced in 2005.

In the year 2000, the United Nations established eight Millennium Goals to be accomplished by 2015. One of these goals, Goal 7, focuses on "Sustainability" and involves various endeavours such as conserving forests, safeguarding biodiversity, enhancing energy efficiency by augmenting GDP per energy unit consumption, decreasing carbon dioxide emissions, and ensuring sustainable access to water, sanitation, and hygiene for more nations (U.N., 2001).

In 2002's "World Summit for Sustainable Development in Johannesburg," the concept of sustainability shifted from solely environmental concerns to encompassing economic development, social development, and environmental protection as interdependent and mutually reinforcing pillars. This declaration by the United Nations highlighted the importance of integrating all three components for sustainable development (U.N., 2002).

The year 2012 saw the convening of the United Nations Conference on Sustainable Development in Rio, which gave rise to a political document that set forth pragmatic solutions for the implementation of sustainable development. The document placed a primary emphasis on Agenda 21 originating from 1992. Regrettably, a vast majority of the critical issues from the bygone era remained unsettled, and the antecedent objectives exert a significant influence even to this day (Kropp, 2019).

In 2015, the United Nations officially adopted the 2030 agenda in New York. This agenda comprises 17 sustainable development goals and 169 sub-goals, with the aim of creating a universally applicable target system for all countries in terms of development and sustainability issues (Kropp, 2019). The sustainable development goals included areas such as poverty eradication, zero hunger, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequality, sustainable cities and communities, responsible consumption and production, climate action, life below water, life on land, peace and justice strong institutions, and partnerships to achieve the goal (U.N, n.d.). The success of these sustainable development efforts to protect and preserve our planet will largely depend on the extent to which countries implement these measures (Schrott, 2015b).

One of the most widely discussed topics in the sustainability conversation is the looming threat of global warming. The 2014 IPCC report identified greenhouse gas CO_2 as a major contributor to this issue. Moreover, CO_2 is regarded as the most significant challenge in the "Planetary Boundaries" framework.

<u>Visual Representations:</u>

The use of visual aids is essential in effectively communicating and comprehending sustainability concepts. These tools are a potent means of conveying intricate sustainability ideas, promoting understanding, inspiring action, and facilitating informed decision-making. They have the ability to engage and empower individuals and communities to contribute towards sustainable practices. The first graphical representations of sustainability were one and two column models, with most attention on the three objectives of ecology, economy, and social affairs.

Figure Triangle of sustainability:

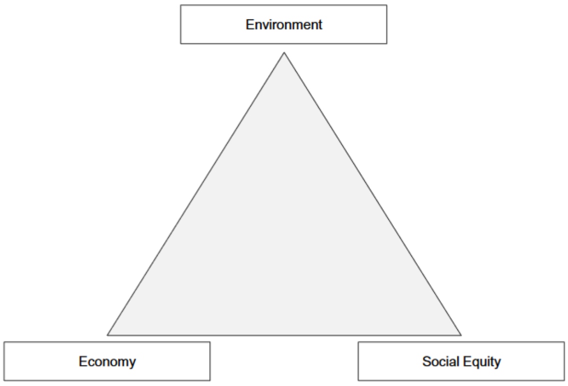


Figure 1: "The Triangle of Sustainability" (adopted from Spindler, 2013, p. 21)

The triangle of sustainability suggests that achieving sustainability requires a balance and integration of these three dimensions. Each corner of the triangle represents one dimension, and the goal is to find the intersection or "sweet spot" where all three dimensions are optimized. the environmental corner emphasizes the conservation of natural resources, protection of ecosystems, and the reduction of negative impacts on the environment. The economic corner focuses on the financial viability and economic prosperity of sustainable practices. It emphasizes the importance of sustainable business models, responsible consumption and production, and the efficient use of resources.

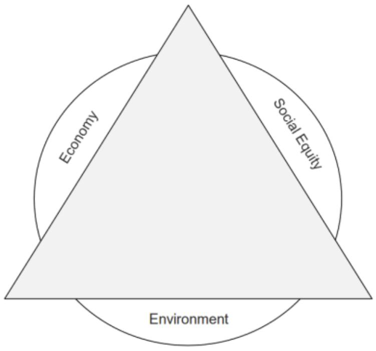


Figure 2: "Dimensions of Sustainability" (adopted from Spindler et. al., 2013, p. 22)

The three-pillar model, which has become widely adopted, was conceptualized based on the three-dimensional nature of sustainability within the realm of design.

The Triple Bottom Line, also known as the three-pillar model, is a framework that underscores the importance of balancing three interdependent dimensions to achieve sustainability. These dimensions are Environmental, Social, and Economic Sustainability. The environmental pillar, in particular, emphasizes the significance of preserving the health and integrity of the natural environment. It prioritizes safeguarding ecosystems, conserving natural resources, reducing pollution and waste, and mitigating the adverse effects of human activities on the environment. Its ultimate goal is to ensure the long-term sustainability of the planet and its ecosystems for future generations.

Social sustainability pertains to the well-being and standard of living of individuals and communities. It encompasses principles of fairness, social justice, inclusivity, and human rights, with the aim of creating equitable and just societies. This includes access to fundamental needs, education, healthcare, safe working conditions, and cultural diversity. Furthermore, social sustainability acknowledges the significance of social cohesion, empowerment, and participatory decision-making processes.

The pillar of economic sustainability aims to achieve responsible, long-term economic development that takes into account social and environmental concerns. It strives to balance economic growth with social well-being and environmental preservation, through the promotion of sustainable business practices, innovation, equitable resource distribution, and responsible consumption and production patterns. The goal is to ensure that economic activities do not compromise the ability of future generations to meet their needs.

While the Triangle of Sustainability is a well-known and widely used visual representation, it is important to note that there are various other visual models and frameworks in the scientific discussion of sustainability. These models may focus on different aspects or dimensions of sustainability, depending on the specific context or research focus. Nonetheless, the Triple Bottom Line concept remains a prominent and influential visualization in the scientific discourse surrounding sustainability.

3 LITERATURE REVIEW

3.1 Circular Economy

This section delves deeply into the "Circular Economy" (CE) concept, exploring its historical development, definitions, various models, and advantages and challenges.

The idea of the circular economy has theoretical foundations in various fields, such as industrial ecology, systems thinking, and cradle-to-cradle design. These theoretical frameworks are based on sustainability and environmental stewardship, as they strive to foster sustainability and accountable consumption of resources by examining and refining material and resource flows within the economic system. The fundamental principle underlying CE theory is centered around closed-loop systems, with the core objective of minimizing waste and optimizing resource utilization. This approach is founded on the system thinking principle, which acknowledges the interrelationships and interdependencies between the environmental and economic systems. This method emphasizes the interconnectedness of the different system´s components and the necessity of looking at the entire system rather than just one component. In the context of CE, systems thinking involves examining the whole lifespan of a product, from its inception and development to its usage and eventual disposal. The goal is to identify opportunities for improving the flow of materials and resources throughout this lifecycle.

The concept of Circular Economy emphasizes the importance of creating products and services that can be recycled, reused, or repurposed instead of being discarded after its use. This chapter will delve into the "R Frameworks" and the "Resolve Framework” providing an in-depth comprehension of the various facets and key principles of the circular economy.

3.1.1 Historical Development

While the terminology "Circular Economy" may appear to be a relatively modern concept, the underlying principles have been well-established for a considerable time. In the past, human communities coexisted peacefully with nature, viewing ourselves as a part of it. Sadly, this changed around 40-50 years ago due to industrialization. During that time, many businesses started dumping waste into rivers and lakes. Unfortunately, this practice still occurs in many developing countries today. Additionally, recycling was not widely implemented or embraced by consumers and businesses. Both practitioners and academics are interested in the CE idea since it is considered as an operationalization for enterprises to achieve sustainable development inside their organizations.

Looking at human history demonstrates impressively that we not only harm ourselves (through slavery, colonialism, and armed conflicts) but as well as our environment (through mining, agriculture pollution, landfills, overfishing, and overexploitation of resources in general). Therefore, humanity needs to be changed its energy, industrial, and agricultural systems (…).

According to a recent forecast, the world population will reach 9.7 billion people in 2050 and approximately 11 billion by 2100 (United Nations, 2019) , demonstrating that humans are aware that the planet cannot sustain the current population.

The most recent strategy for a sustainable combination of economic activity and environmental wellness is the CE. Because of its capacity to address the sustainability challenges, this theory has recently gained popularity as an alternative economic theory to the existing Linear Economy, which is known as the "take, manufacture, and dispose" paradigm.

The difficulty of finding the right balance between industrial development, environmental protection, human health, and economic expansion is another factor of importance. Due to valuation of materials in a closed loop system that enable the use of natural resources while also reducing pollution and thwarting resource constraints by continuous economic growth, the development of low carbon and low resource usage that included the CE concept emerged (Winans et al., 2017). Additionally, organizations, governments, and customers are focused on leaving a smaller carbon footprint and respecting and not harming the environment, making accountability and long-term thinking popular/trendy. As a result, it calls businesses to implement new circular economy business models, consumer to generate demand for goods and services that include CE principles, and decision-makers to allow improved governance and policy tools (Antikainen et al., 2018). Consequently, businesses are expanding without depleting the earth´s finite resources, wasting energy, or producing goods that pollute that environment or end up in landfills (Lacy & Rutqvist, 2015).

The CE must be regarded as high relevant because it alters economic logic and replace current manufacturing methods by encouraging "*reuse what u can, recycle what cannot be used, repair what is broken, and remanufacture what cannot be fixed*" (Stahel, 2016, p.435). According to a 2015 study by "The Club of Rome", which includes Finland, France, the Netherlands, Spain and Sweden, each country´s greenhouse-gas emissions could be decreased by up to 70% while the workforce increases by 4% (Wijkman & Skånberg, 2015, p.50)

Furthermore, during the past ten years, research programs have been developed that support circular economies by encouraging remanufacturing and reuse in South Korea, China, and the United States (Stahel, 2016, p.436). As the transition to a CE will have enormous effects on the economy, environment, and society as a whole, it is crucial for researchers and policymakers to understand such impacts when planning future advancements in the field (Rizos et al., 2017).

To fully grasp the circular economy notion, it is important to understand how it was gradually established. John Las and Richard Cantillon introduced the idea in economic literature for the first time in their 1720 works, "Money and Trade Considered", and "Essai sur la nature du commerce en general", respectively. In these works, concepts like "input-output tables, national accounts tables, and general equilibrium approaches" were developed. The flow of expenditure between classes, how their produced output within a given year is consumed, and additionally how it can be ensured that the same circuit will reproduce itself in the following year and all succeeding yeas were all described by Fracois Quesnay in "Tableu économique" in 1759 (Cardoso, 2018). These three historical foundations demonstrate the initial fundamental ideas behind the CE.

The idea first appeared in the work of Boulding (1966), which emphasized that the world is a closed system and that natural resources are finite.

Georgescu-Roegen's seminal work, "The Entropy Law and the Economic Process," served as a pivotal influence in the development of the "Circular Economy" paradigm. The ideas presented in this work were also instrumental in inspiring Pearce and Turner. Central to Georgescu-Roegen's thesis is the proposition of a "fourth law of thermodynamics," which posits that matter, much like energy, becomes increasingly inaccessible over time. Thus, the economic process must prioritize the concept of entropy, with economics itself focusing on the intricate, unpredictable, and human elements that are involved.

The tome entitled "Environmentalism," penned by Timothy O'Riordan in 1981, showcases an extensive and notable contribution to policy analysis, environmental governance, and sustainability. Furthermore, O'Riordan developed the "green ideology of environmentalism," which established a sturdy foundation for policy and decision-makers in the realm of environmental planning, resource management, and pollution control.

The concept proposed by Walter R. Stahel in his 1986 paper titled "Product life as a variable: the notion of utilization" is a sound scientific approach to address the problems of the unsustainable linear economy. By implementing a self-replenishing system that operates on a spiral-loop concept, we can minimize energy and matter flow and reduce environmental degradation without hindering economic growth or social and technological advancement. This approach is based on scientific principles and has the potential to create a sustainable future for our planet.

In 1989, Frosch and Gallopoulos coined the term "industrial ecosystem" in their publication "Strategies for Manufacturing." This concept promotes the idea that waste generated by one industrial process can be used as raw materials for another process, resulting in a reduced impact on the environment. Additionally, this approach optimizes the consumption of energy and materials.

The term "Circular Economy" was first introduced by Pearce and Turner in their book "Economics of Natural Resources and the Environment" in 1990. Scholars have attributed the development of the circular economy system to Pearce and Turner, who based their theoretical framework on the studies of Kenneth Boulding and the laws of thermodynamics of Georgescu-Roegen.

Their work emphasizes the importance of the interdependence between the economy and the environment and outlines measures to protect natural resources while transitioning from a traditional linear economic system to a circular one. The authors provide insights into the interactions between economics and the environment and offer practical solutions for preserving the natural world.

In 1994, John T. Lyle published the book "Regenerative Design for Sustainable Development," which laid the foundation for applying regenerative design concepts to all systems, not just agriculture. The book covers regenerative theories, practices, and strategies for utilizing water, land, energy resources, and waste valorization.

William A. McDonough and Michael Braungart published in 2002 the book "Cradle to Cradle: Remaking the Way We Make Things". They proposed a paradigm shift beyond the concept of eco-efficiency by arguing that eco-efficiency, while reducing petrol consumption and CO_2 emissions in cars, still causes pollution. The proposal put forth by the authors suggests that economic development and thinking should prioritize "eco-effectiveness" over "eco-efficiency". This approach aims to achieve a greater good rather than simply minimizing harm. The cradle-to-cradle concept is a sound scientific approach that goes beyond just materials. It also involves utilizing renewable energy sources, supporting biodiversity, and embracing cultural and social diversity.

The Ellen MacArthur Foundation (EMF) holds an esteemed position in the annals of CE history, despite not being counted among the contemporary pioneers of the circular economy ethos. The Foundation is committed to advancing and popularizing the transition to a circular economy by disseminating reports that cover a broad range of topics, such as expediting the adoption of the concept, identifying prospects for the consumer goods sector, and facilitating the expansion of circular practices throughout global supply chains. The Foundation is a charitable organization established by a consortium of global companies. Its current focus is on four key areas: business-government relations, education, analysis and insights, and communications and publications. The ultimate objective is to expedite the transition towards a circular economy.

By reducing waste and maintaining the value of resources, the CE seeks to convert a system of linear consumption into one that is circular (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). This may be accomplished through a variety of cycles that include recycling, reusing, repairing, redistributing, and reusing. Resources are used and optimized via the invention of new business models, products, and services.

replace the current linear economic model where resources become products and, at the end of their life, will inevitably end as waste polluting the environment. Thus, the idea is to develop a circular economic model where waste can be utilized as input to create new products. This intervention aims to reduce societal material throughput and thus reduce the pressure on finite resources. It is heavily linked to the idea of resource decoupling. That aims to decouple resource use from economic growth.

The substantial growth in research output on the topic demonstrates the Circular Economy (CE) Paradigm´s growing popularity among academics and practitioners. The CE is viewed as a means to approach economic growth while concurrently pursuing the objective of sustainable development, which is the rational for this (Kirchherr et al., 2017). Furthermore, there has been a recent urgency to reduce waste creation combined with a concern to optimize resources and material consumption, as indicated by the 17 Sustainable Development Goals adopted by the United Nations in 2015 (Colglazier, 2015).

In order to transition to more sustainable models that can respect the environment and advance society, there is an urgent need to make a dramatic transformation in both production and consumption patterns. According Phipps et al. (2013 p.1227) sustainable consumption is a "*consumption that simultaneously optimizes the environmental, social, and economic consequences of consumption in order to meet the need of both current and future generations*".

In fact, consumer choices have the potential to affect demand, which in turn forces a shift in production paradigms to satisfy consumer requirements.

Although research indicates that consumers have been increasingly concerned with environmental concerns over the past ten years are still hesitant to drastically alter their routines and forgo convenience in favor of the environment (Zabkar & Hosta, 2013).The consumer is crucial to the market because he or she might develop a strong attachment to a particular product, brand, or business and change his or her purchasing behavior as a result. So, in the context of sustainable development, the role of the consumer and the way of life is even more important.

3.1.2 From a linear to a circular economy

While there are some indications of progress, our economy remains largely rooted in a linear approach to resource utilization known as the "take-make-dispose" model, as labeled by the Ellen MacArthur Foundation in 2013. This refers to the business practice in which companies gather resources to manufacture a product for sale to consumers, who ultimately dispose it after use. This method of production was made possible by the first industrial revolution following World War I. At that time, there was a significant surge in the global population, leading to various adverse effects including climate change, environmental contamination, and a decline in biodiversity (Cui, 2021). However, as the global population continues to increase, its impact on the environment has become problematic and unsustainable. Consumption of natural resources exceeds the capacity of ecosystems, leading to a depletion of the earth's natural resources. The "Earth Overshoot Day" initiative by the Global Footprint Network aims to highlight the critical point in a year when our demand for renewable resources exceeds the earth's capacity to replenish them. Earth Overshoot Day is a date calculated by analyzing the global demand for biological resources within a given year and comparing it to the total global biocapacity for the same year. This calculation provides an estimate of how many Earths would be required to sustain that level of resource use annually. The campaign's primary objective is to increase people's awareness of the limited nature of our planet's resources and encourage actions that can postpone Earth Overshoot Day.

It is imperative to acknowledge that a linear approach to production will result in significant wastage. To demonstrate this, the chart below showcases the upward trajectory of worldwide resource consumption, GDP, and population over time. The number of resources used worldwide is measured in billions of metric tons (on the left scale), while population and GDP growth are measured on the right scale using 1900 as the baseline (equal to 1). GDP is calculated in constant 1990 Geary-Khamis Dollars.

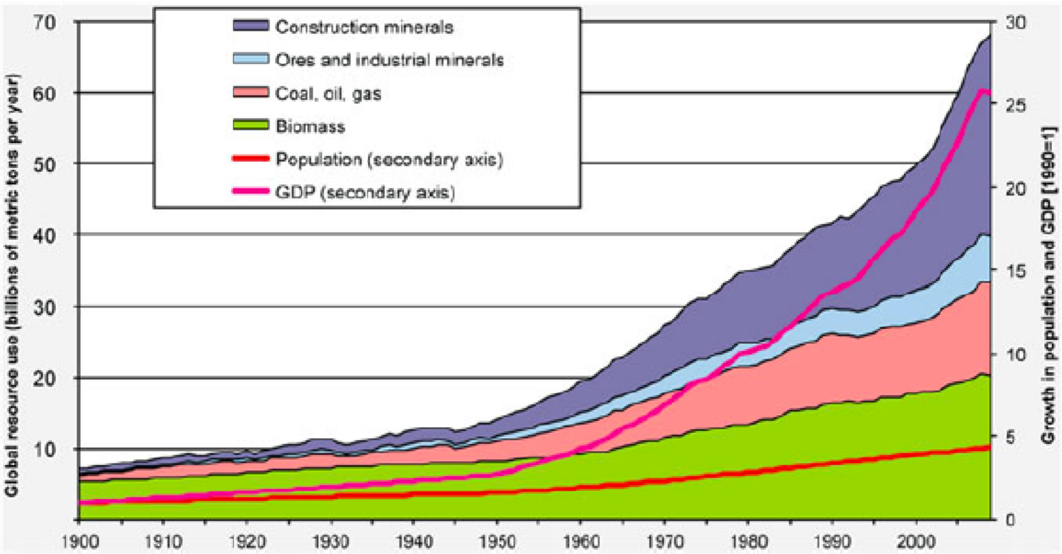


Figure 3 Global Resource Consumption, population, and GDP
Source: adopted from Cui 2021

It becomes apparent that the significant increase in GDP has been accompanied by a corresponding rise in resource consumption. While the current linear model has certainly contributed to the prosperity of humanity, it has also resulted in an uptick in resource utilization and consequently, greater pressure on the planet's boundaries.

Additionally, the linear approach to production, as stated by the Ellen MacArthur Foundation in 2013, results in significant resource losses. Building upon that, the OECD reports that around 21 billion tons of resources are lost annually throughout the production chain, from mining to final production. Examples of these lost materials include agricultural harvesting losses and materials separated during mining (Ellen MacArthur Foundation, 2013).

Another issue to consider is the waste produced at the end of a product's life cycle, which results in an additional significant loss of materials in the linear economy according to Ellen MacArthur (2013). In Europe, recycling, reuse, composting, and digestion accounted for only 40% of the total waste generated in 2010. Moreover, recycling rates are only sufficient for waste streams that occur in significant, uniform volumes (Ellen MacArthur, 2013).

According to the Ellen MacArthur Foundation in 2013, energy consumption is highest during the extraction and conversion of materials into a form that can be commercially used in linear models. To reduce energy usage, it's crucial to avoid using new materials each time a product is manufactured. This is especially important since the current economic system relies heavily on fossil fuels.

Lastly, the linear model led to the erosion of ecosystems services[2] (Ellen MacArthur Foundation, 201.

In the face of the various challenges discussed above, the concept of resource decoupling has emerged as a promising tool. This concept is also closely linked to the principles of the circular economy. Resource decoupling refers to the process of separating economic growth from resource consumption, thereby breaking the traditional correlation between economic development and environmental degradation as represented in Figure 4. It challenges the notion that economic growth must be accompanied by a proportional increase in resource consumption, arguing that advancements in technology, innovation, and efficiency can enable economies to achieve growth while minimizing resource inputs and environmental impact. The theoretical foundations of resource decoupling draw upon concepts such as dematerialization, circular economy, industrial ecology, and eco-innovation.

Absolute decoupling is the term used when resource consumption decreases in actual terms while economic growth continues. On the other hand, relative decoupling occurs when resource consumption decreases in relation to economic growth, but total resource consumption still increases. Both types of decoupling are crucial for sustainability, but absolute decoupling is essential for achieving long-term sustainability by reducing overall resource consumption and environmental impact. Nonetheless, it should be noted that abosolut decoupling has not yet been discovered from scientists, so it might be a myth.

[2] According to Costanza et al (1997, p. 253), “*Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human population derive, directly, from ecosystem functions.”*

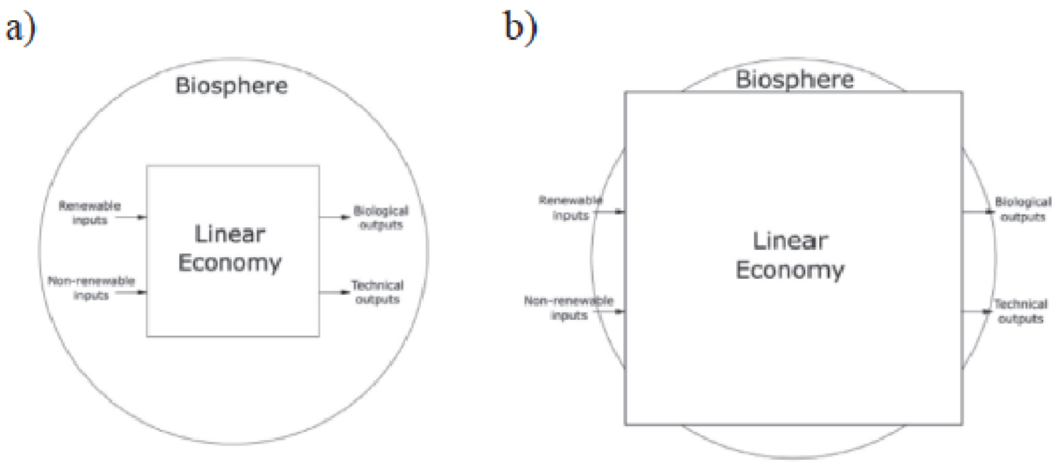


Figure 4 The Linear´s economy impact on the biosphere
(adopted from Suárez-Eiroa et al., 2019, p 956)

In 2019, Suarez-Eiroa et al., proposed a paper on the Linear economy and its impact on the Biosphere. Their findings indicate that while the size of the linear economy system was once in balance with the biosphere, the current state of our economy has surpassed the limits of the biosphere's capacity. This has resulted in a depletion of resources, as well as an increase in emissions and waste that exceeds the biosphere's ability to manage. These observations are illustrated in Figure 4.

Given the stressing of planetary boundaries mentioned by Cui, (2021) and the described resource losses, a transformation of the linear model on which todaýs affluence is based, towards a model, which can help in maintaining the integrity of the system earth, is necessary.

The concept of a circular economy presents a viable and practical alternative to the current economic system. According to a study by (Suárez-Eiroa et al., 2019), the ultimate objective of a circular economy should be to reduce the size of the economy to a level that is sustainable for the biosphere. This is illustrated in a figure 5 below.

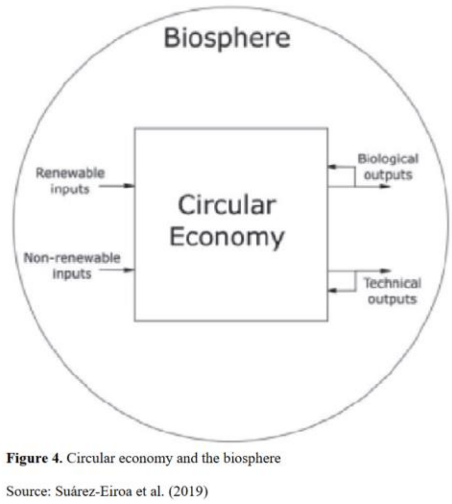


Figure 5 Circular economy and the Biosphere
(adopted from Suárez-Eiroa et al., 2019, p 956)

In other words, the goal of a circular economy should be to decrease the size of the economy below the planetary boundaries and the carrying capacity of the biosphere, by providing a different approach from the linear economy, which results in significant resource losses.

There are numerous definitions of the circular economy concept, with the Ellen MacArthur Foundation's definition (2013) being one of the most well-known:

> *"A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models."* (Ellen Mac Arthur Foundation, 2013, p.7)

Another popular definition:

> *" A circular economy aims to maintain the value of products materials and resources for as long as possible by returning them into the product cycle at the end of their uses, while minimizing the generation of waste."*
> (Eurostat, nd.)

A third example of defining circular economy is presented by (Sauvé et al., 2016), which is also worth considering:

> *"Production and consumption of goods through closed loop material flows that internalize environmental externalities linked to virgin resource extraction and the generation of waste (including pollution)".*
> (Sauvé et al., 2016, p.49)

It is beyond the scope of this thesis to provide an in-depth analysis of various circular economy definitions. Instead, reference will be made to the comprehensive study conducted by Rizos et al. (2017), which explores the different potential definitions of the circular economy.

Additionally, the R framework is commonly used to define a circular economy. This framework involves a range of strategies that are ranked from high circularity, represented by a low R number, to low circularity, represented by a high R number (Potting et al., 2017).

3.1.3 Key Principles of CE

By reducing waste and maintaining the value of resources, the CE seeks to convert a system of linear consumption into one that is circular (Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2017). This may be accomplished through a variety of cycles that include recycling, reusing, repairing, redistributing, and reusing. Resources are used and optimized via the invention of new business models, products, and services. In other words, the idea is to develop a circular economic model where waste can be utilized as input to create new products. This intervention aims to reduce societal material throughput and thus reduce the pressure on finite resources. It is heavily linked to the idea of resource decoupling. That aims to decouple resource use from economic growth.

The substantial growth in research output on the topic demonstrates the Circular Economy (CE) Paradigm´s growing popularity among academics and practitioners. The CE is viewed as a means to approach economic growth while concurrently pursuing the objective of sustainable development, which is the rational for this (Kirchherr et al., 2017). Furthermore, there has been a recent urgency to reduce waste creation combined with a concern to optimize resources and material consumption, as indicated by the 17 Sustainable Development Goals adopted by the United Nations in 2015 (Colglazier, 2015).

In order to transition to more sustainable models that can respect the environment and advance society, there is an urgent need to make a dramatic transformation in both production and consumption patterns. Phipps et al. (2013 p.1227) sustainable consumption a "*consumption that simultaneously optimizes the environmental, social, and economic consequences of consumption in order to meet the need of both current and future generations*". In fact, consumer choices have the potential to affect demand, which in turn forces a shift in production paradigms to satisfy consumer requirements. However, although research indicates that consumers have been increasingly concerned with environmental concerns over the past ten years are still hesitant to drastically alter their routines and forgo convenience in favor of the environment (Zabkar & Hosta, 2013).The consumer is crucial to the market because he or she might develop a strong attachment to a particular product, brand, or business and change his or her purchasing behavior as a result. So, in the context of sustainable development, the role of the consumer and the way of life is even more important.

However, there are several key principles that aim to guide the economic transformation and are found in all of the CE Frameworks.

Generally, the key principles are:

1. **Design Circular System**: Products, services, and systems should be designed with the intention of enabling long-lasting use, efficient resource utilization, and ease of repair, remanufacturing, or recycling. Designing for circularity involves considering the entire lifecycle of a product, from sourcing materials to end-of-life disposal.
2. **Preserve and Enhance Nature:** The circular economy recognizes the finite nature of resources and aims to preserve and enhance natural systems. This principle promotes practices that minimize resource extraction, pollution, and environmental degradation while prioritizing the regeneration and restoration of ecosystems.
3. **Waste prevention and resource efficiency**: The concept of a circular economy, as explained by the Ellen MacArthur Foundation in 2013, involves an intentional focus on restoration and reliance on renewable energy. This approach also seeks to minimize or remove toxic chemicals and waste through thoughtful design. Effective management of material flows is a key component of this system, with two distinct types of nutrients, biological and technical, being crucial for success.
4. **Closing the loop:** The circular economy aims to create closed-loop systems where materials are continuously cycled back into the production process. This involves implementing strategies such as recycling, composting, and reusing materials to minimize the need for virgin resources and reduce the generation of waste.
5. **Collaboration and Stakeholder engagement:** Achieving a circular economy requires collaboration and engagement among various stakeholders, including businesses, governments, consumers, and civil society organizations. Collaboration enables the sharing of knowledge, expertise, and resources to drive collective action and systemic change.
6. **Value preservation and regeneration**: The circular economy seeks to preserve and regenerate value throughout the product lifecycle. This involves extracting maximum value from resources and products through strategies like product longevity, maintenance, repair, and remanufacturing, as well as exploring innovative business models such as product-as-a-service or sharing economy models.
7. **Consideration of Social Equity:** The circular economy recognizes the importance of social equity and aims to ensure that the benefits and opportunities of the circular

transition are accessible to all. This principle emphasizes fair and inclusive practices that address social inequalities, create decent jobs, and enhance community well-being.

Additionally, The concept of circular economy advocates for a clear differentiation between the usage and consumption of materials. It emphasizes the need for a service-based model in which producers retain ownership of their products and offer them for use instead of selling the actual product.

3.1.4 Circular Economy Frameworks

First let’s elaborate on the importance of framework in regard to sustainability or the circular economy. Frameworks are structured approaches or principles that guide implementation of sustainability practices. They aim to provide conceptual clarity, strategic guidance, and consistency to stakeholders. Frameworks define core principles, set goals, and make informed decisions, fostering collaboration and alignment among divers actors. They facilitate scalability, replication, and policy development by promoting knowledge sharing and effective regulations. Overall frameworks are crucial for advancing the circular economy agenda.

The scientific and cooperate literature contains a variety of different existing framework and concepts associated with CE. By analyzing a wide range of studies and frameworks, this aims to provide a comprehensive understanding of the principles and approaches that underpin the CE concept. The most prominent frameworks are, Cradle to Cradle (C2C), the Ellen MacArthur Foundation´s Framework, Biomimicry, Industrial symbiosis, Blue Economy, and Doughnut Economics. By developing into their respective principles, methodologies, and applications highlights their potential for promoting resource efficiency, waste reduction, and regenerative practices.

A detailed analysis of the different frameworks would be out of the scope of this thesis. However, in order to gain sufficient insights into some of the ideas and concepts, the following chapter will elaborate on the Framework proposed by the Ellen MacArthur Foundation. To be precise, this thesis will focus on the “R Frameworks”, and “Resolve Framework.

3.1.4.1 Resolve Framework

The Ellen MacArthur Foundation, in collaboration with Mc Kinsey and Sun, has released a comprehensive report entitled "Growth Within: a circular economy vision for a competitive Europe." This report introduces the ReSOLVE framework, which is composed of six crucial elements: Regenerate, Share, Optimize, Loop, Virtualize, and Exchange. These elements serve as a practical guide for businesses and governments seeking to achieve circularity, offering unique perspectives different from those presented in a linear economy growth framework. Notably, each element contributes to the increased utilization of physical goods, extends their lifespans, and shifts resource use towards renewable sources. This report serves as a valuable resource for global leaders who are interested in exploring circular business opportunities and achieving sustainable economic growth.

Regenerate:

There exists a multitude of measures that can be undertaken to conserve and enhance the Earth's biocapacity. These measures may include the transition from non-renewable fossil fuels to sustainable energy sources, as well as efforts to restore and safeguard ecosystems and recover land. Additionally, the responsible and ecological disposal of organic resources via composting build the foundation for natural regeneration (Ellen MacArthur Foundation, 2015c)

Share:

The sharing economy concept closely aligns with the principles of the circular economy, which prioritize resource efficiency and waste reduction. Sharing goods and services maximizes utilization while minimizing unnecessary waste and duplication. For example, the average European car is utilized for only 5% of its lifetime, leaving it parked and idle for most of the time. Sharing schemes such as car-sharing, tool rental, and libraries all contribute to enhanced value by promoting resource sharing. Additionally, the second-hand market and repair industry also align with these principles by extending the lifecycle of products and reducing the frequency of recycling or reprocessing, thereby improving the overall efficiency of the economy.

Optimize:

The matter at hand concerns the reduction of surplus energy and resources in the production and consumption of goods, entailing the utilization of technology to optimize resource management. One noteworthy illustration is the destabilization of the nitrogen cycle resulting from excessive use of fertilizers. The phenomenon has been subject of extensive research due to its importance on crop productivity. It has been observed that a significant proportion of fertilizer applied to crops, up to 70%, goes unused by the plant, either washed away or remaining in the soil (Rashid et al., 2021). Precision farming methods enable the precise delivery of required amounts of fertilizer directly to the roots, minimizing waste to the greatest extent possible.

Loop:

In the sphere of circular economy, the term "loop" pertains to the practice of retaining products, components, and materials within closed loops. Furthermore, the establishment of "inner loops" that involve remanufacturing is also crucial economy (Iyer-Raniga, 2019). Moreover, it is imperative to emphasize the significance of material recycling by incorporating material choices in the preliminary design phase. Such practices can potentially mitigate the detrimental impact of waste materials on the environment. Additionally, the segregation of organic and inorganic or 'technical' materials is a pivotal step towards resource optimization (Ellen MacArthur Foundation, 2015a). Organic materials are subjected to composting, while inorganic or technical materials undergo recycling or remanufacturing of goods or parts. This process ensures that resources are efficiently utilized, rather than being wasted in landfills, thereby contributing to sustainable economic development.

Virtualize:

Moving from physical to virtual resources by using e-books instead of physical books is a growing concern. The utilization of e-readers and subscription services like Netflix has played a role in the virtualization of the economy. The widespread adoption of mobile phone applications has also led to the replacement of physical gadgets such as alarm clocks, maps, and daily newspapers. Moreover, virtualization encompasses a wide range of technological advancements including teleworking, smart appliances, and virtual products . These examples serve as tangible manifestations of the concept of virtualization, which has become a key area of research in the field of technology and innovation.

Exchange:

The final category pertains to the implementation of new technologies and the upgrading or replacing of outdated methods. An example of this would be replacing internal combustion engines with electric motors. It is also possible to consider alternative approaches such as shifting from private motoring, whether electric or not, to public transportation and autonomous carsharing. This could result in a significant reduction in carbon emissions and a more environmentally sustainable future.

In addition, the Ellen Macarthur Foundation has created the Circular Economy System Diagram, commonly referred to as the Butterfly Diagram, which can be effectively utilized in conjunction with the ReSOLVE framework.

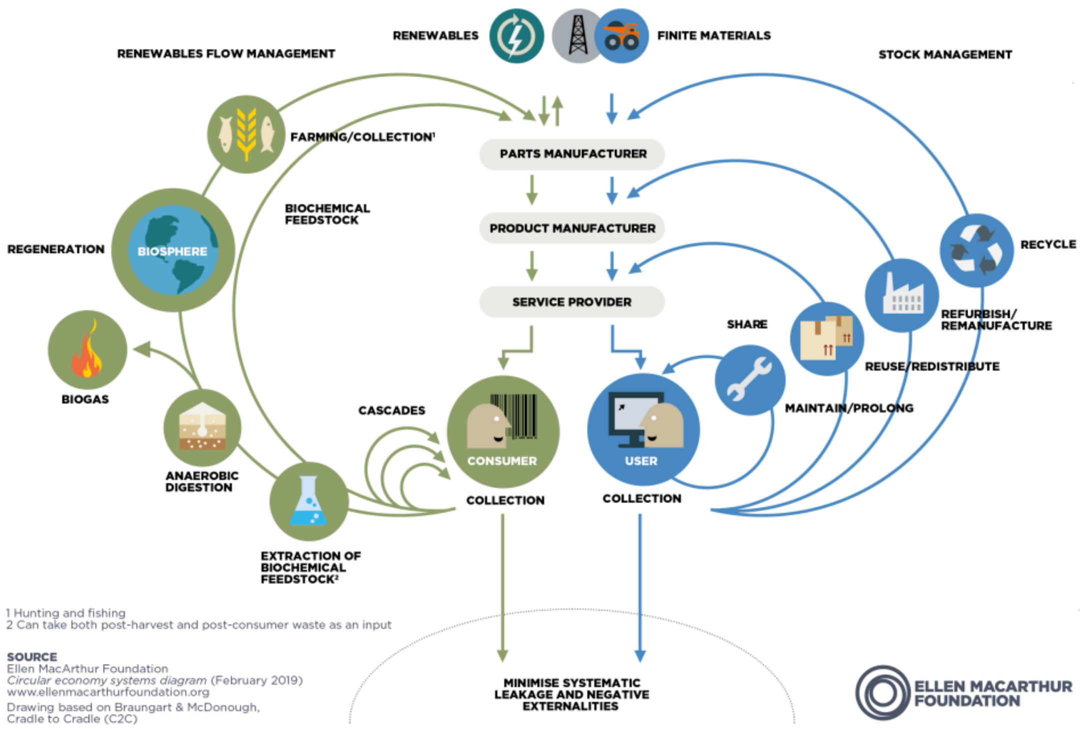


Figure 6 "Butterfly diagram"
(adopted from Ellen MacArthur Foundation, 2015, p.)

The diagram illustrates how biological and technical components circulate through the economic system in cycles. It becomes apparent that there are significant differences in the circulation of these two types of components, which must be considered. It is worth noting that smaller circles generally indicate more efficient circulation.

This means, that the smaller the circles are, the higher should be the savings regarding material, labour, energy, capital, and the reduction of externalities like for instance GHG emissions or toxic substances.

Furthermore, it is crucial to extend the lifespan of products and materials by keeping them in use for a longer period, as suggested by the Ellen MacArthur Foundation in 2013. This can be achieved by either passing them through more cycles or utilizing them within a single cycle for a longer duration. By doing so, materials and products are kept within the system for a longer time and the demand for new, virgin materials is reduced. Moreover, the cascading approach allows for the utilization of the same product or material in different categories, further minimizing the need for virgin materials.

Additionally, there are advantages to utilizing non-toxic, pure, or easily separable materials, as stated by the Ellen MacArthur Foundation in 2013. To reap the benefits outlined in Figure ??, it is essential to have a certain level of material purity and quality, which is currently not being achieved. This is due to the mixing of different materials during both the production and waste collection processes.

By implementing design changes to enhance the ease of material separation and collection during disposal, the circular economy can achieve economies of scale and enhanced efficiency. This can lead to higher quality technical components and longer-lasting materials. Furthermore, the circular economy has the potential to reduce the demand for virgin materials, decrease landfill waste, and minimize material stockpiling, as highlighted in the Ellen MacArthur Foundation's 2013 report.

3.1.4.2 R Frameworks

For years, both academics and businesses have utilized numerous R frameworks, proving that the CE is based on well-established principles. Many authors have referred to these frameworks as the embodiment of the fundamental ideas behind the circular economy. The concept revolves around the ability to disassemble and reuse products, which is its core principle. It is believed that the device's circularity design, especially its ability to disassemble, is necessary for the successful implementation of this principle. Within the realm of R, there exist various frameworks that are commonly referred to as the 3Rs, 4Rs, 6Rs, and 9Rs frameworks. Each of these models encompasses the fundamental principles of reducing, reusing, and recycling. However, the 4R framework distinguishes itself by incorporating an additional aspect known as "recover," which encompasses repurposing and remanufacturing.

The 9R framework developed by (Potting et al., 2017) was later enhanced by Kirchher et al. (2017) and is presented in figure 7 below.

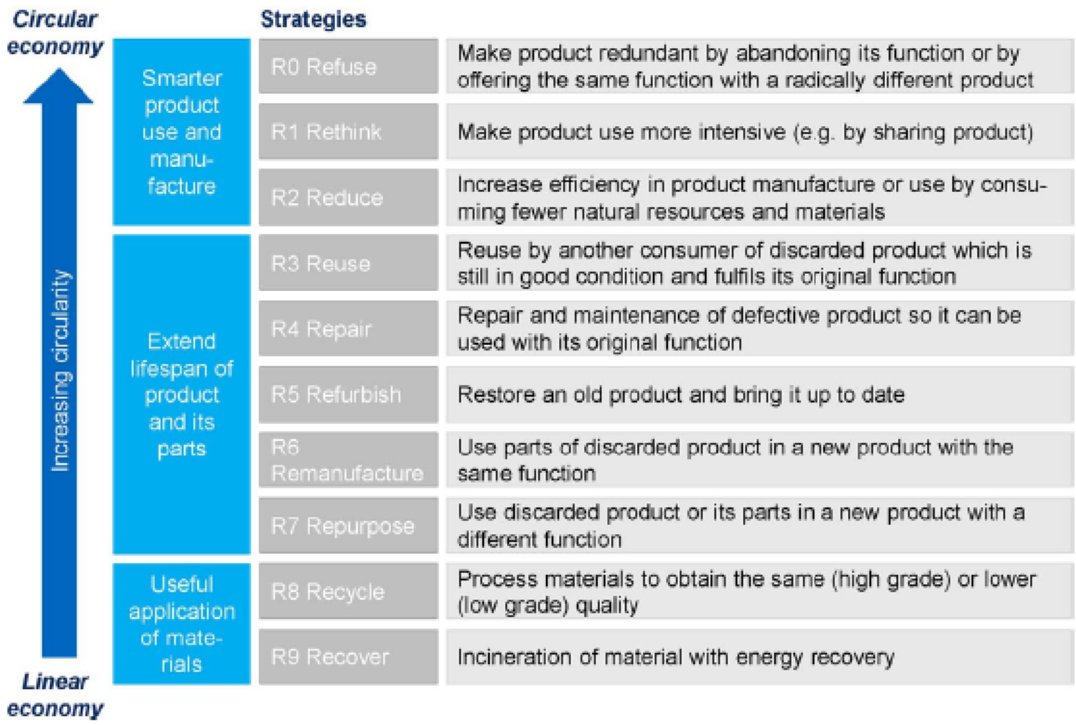


Figure 7 The R framework of circular economy
Source: Adapted from (Kirchherr et al., 2017)

According to the chart, there exist three distinct principles that guide the R strategies. The initial principle “smarter product use and manufacture”, R0 to R2, is centered around the minimization of raw material inputs during product. These strategies are “Refuse”, “Rethink”, and “Reduce”. To **Refuse (R0)** a product implies that its benefits can be met through alternative means, indicating that the product is not essential for the customer and can be foregone. For example, a bicycle does not necessarily have to be used for short distances; the distance can also be covered on foot. **Rethink (R1)** emphasis that it's important to consider that a product's usage can be maximized. For instance, multiple individuals can utilize a single product without necessarily buying it. This trend is currently evident in urban areas where bike or car sharing is becoming increasingly popular. Improving efficiency can result in using less material to achieve the same benefits. One approach to attain this goal is to **Reduce (R2)** the material requirements of the final product through design measures or by optimizing the manufacturing process.

The second principle, which is to "extend the lifespan of the product and its parts" (R3 to R7), focus on the design stage, aiming to enhance the product's durability and longevity, and to foster recycling.

When implementing the **Reuse (R3)** strategy, a product is sold as-is to a third party for them to reuse. An example of this in the private bicycle sales industry is flea markets, which have been around for a while. Additionally, the eBay platform is a digital version of these flea markets. In cases where a product is no longer functioning properly due to defects, the **Repair (R4)** strategy can be applied to restore it to its original state. This allows the product to perform its intended function and provides the benefit it was designed for. For example, public bicycle repair shops are a great option for guided bicycle repair, including patching inner tubes. The process of refurbishment (**Refurbish, R5)** involves enhancing and updating products, not just repairing them. In the case of a bicycle lamp, one way to improve its light quality is to switch to an LED lamp. The **Remanufacture (R6)** methodology represents a recent approach that aims to optimize product reuse and minimize waste. This approach involves utilizing fully operational parts of a product and integrating them into newly finished products. As an example, a cyclist may keep their existing saddle and use it on a new bike, thereby reducing unnecessary waste and promoting resource efficiency. The **Repurpose (R7)** strategy involves utilizing product components in a new way to create a different benefit. This approach is often inspired by private individuals, such as "do-it-yourself" enthusiasts who repurpose handlebars as bicycle racks.

The third and last principles are named “useful application of materials”, R8 and R9.

Recycle R8: When a product or its components reach the end of their useful life, it is essential to consider the recovery of the raw materials used by recycling them. The design of a product plays a significant role in determining its recycling possibilities. In instances where recycling is not feasible, the recycled materials cannot replace the original raw material input for the respective product. This is known as "downcycling," whereby the materials can no longer be recycled to the same high quality. To maximize material recycling, the priority should be to achieve a high recycled content in products rather than high recyclability at the end of the service life. The recycling strategy of relining, or the recovery of valuable materials from products or production residues that were previously discarded in landfills, represents an effective means of implementing this priority. It is worth noting that the recycling of inner tubes from bicycles can yield butyl rubber, which can be utilized in the creation of new inner tubes. Similarly, recycling aluminum bicycle frames can facilitate the production of new frames. However, it should be noted that materials reinforced with fiber can only be "downcycled." Those seeking further information on proper end-of-life management of these types of plastics may wish to review the research conducted by (Oliveux et al., 2015).

The **Recover (R9)** strategy is not considered a primary strategy for circular value creation, as it does not involve recycling materials and is therefore ranked last in priority. However, it is still used in situations where recycling is not yet economically or technically feasible, with the aim of producing useful energy from waste. To reduce the need for this non-circular strategy, it is important to establish supportive government policies, encourage improved product design, and advance recycling technology. For example, Bicycle parts made of plastic can be burned to generate energy in waste incineration plants.

As the supply chain plays a crucial role in this thesis, Figure 8 presents a comprehensive overview of the potential implementation areas for various R strategies within the supply chain. The figure also underscores the key stakeholders who take part in implementing these strategies.

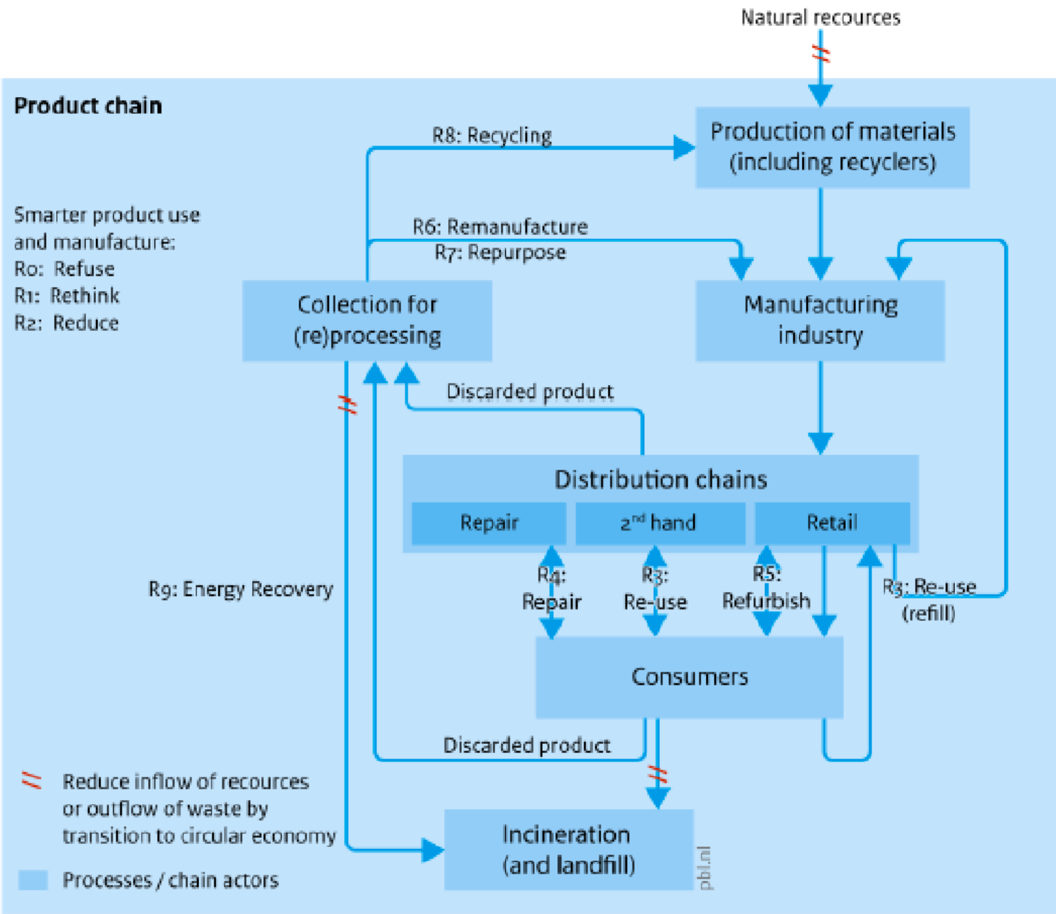


Figure 8 Circularity Strategies and the supply chain

Source: Adopted from Potting et al., 2017, p.5

3.1.5 Circular Economy benefits

The current linear economic model has been found to cause significant harm to the environment and exhaust limited resources. However, there is a promising solution in transitioning to a circular economy. By functioning as a regenerative system, a circular economy aims to reduce waste, optimize resource utilization, and stimulate economic growth. In this chapter, we will explore the numerous benefits of implementing a circular economy approach.

As per Sariatli´s (2017) research, the implementation of a circular economy strategy offers businesses a competitive edge by efficiently managing the reverse material flow cycle, resulting in reduced material expenses and decreased dependence on resources. Moreover, incorporating circular economy principles into the research and development phase results in the production of superior quality and longer-lasting products. Additionally, is assumed to be less vulnerable by price fluctuations. The concept of circular economy, as posited by Sariatli (2017), offers a promising solution to mitigate the risks associated with externalities in material flow and consumption, by adopting closed-loop processes and a reduced material consumption.

The European Parliament has identified several advantages associated with transitioning towards a circular economic model. Chief among these is the potential to alleviate pressure on the environment and its ecosystems, while also reducing demand for scarce resources and increasing their availability for future generations. Furthermore, such measures are intended to incentivize innovation, which can help to boost competitiveness and GDP. Additionally, it is anticipated that the transition to a circular economy will create approximately 700,000 jobs within the EU by 2030. For consumers, the benefits are primarily in the form of more durable and innovative products, which can improve overall quality of life and lead to monetary savings.

- Resource Conservation:
  As previously discussed, the circular economy model aims to reduce resource consumption through the promotion of recycling, reuse, and responsible manufacturing practices. This model advocates for products that are designed in a way that allows for easy disassembly, with their components being reused or recycled whenever possible, thereby reducing the demand for raw materials. The adoption of such an approach can help to safeguard our natural resources, mitigate the negative impact of extraction on the environment, and encourage the preservation of biodiversity. According to the Ellen MacArthur Foundation, the implementation of a circular economy could potentially result in a 28% reduction in global resource extraction by the year 2050 (World Economic Forum, 2016).

  In the case of smartphones, the aim is to produce devices that are durable, modular, and easily repairable to extend their lifespan. By following these principles, manufacturers can lower the need for raw materials, reduce energy consumption, and decrease electronic waste production. Research conducted by Circle Economy indicates that implementing a circular economy in the European electronics industry by 2030 could lead to a 30% decrease in raw material inputs and a 70% reduction in greenhouse gas emissions(Circle Economy, 2019).

- Waste Reduction:
  In a traditional economic system, products are often disposed of after their initial use, leading to a significant amount of waste that ultimately ends up in landfills or incinerators. However, the circular economy model aims to reduce waste by promoting the recovery and reuse of materials. This approach involves employing various strategies, such as waste prevention, recycling, and "industrial symbiosis," where waste from one

industry is repurposed as valuable input for another. The circular economy model has the potential to significantly reduce the burden on landfills and minimize pollution. The European Commission estimates that by 2030, this shift could potentially lead to a 70% reduction in waste generation in the European Union (European Comission, 2020).

The topic of Electronic Waste, including discarded smartphones, has evolved into a pressing environmental concern. However, the smartphone industry can significantly impact this issue by adopting a circular economy model. By implementing take-back programs and improving recycling infrastructure, they can retrieve and reuse valuable materials from old devices. According to a report from the Global e-Sustainability Initiative, the implementation of circular economy practices within the electronics industry could reduce e-waste generation by 50% by 2030 .

- Economic Opportunities:
  A transition to a circular economy not only benefits the environment but also creates economic opportunities. By promoting activities such as repair, refurbishment, and recycling, new jobs and industries can emerge. This encourages innovation and the development of more sustainable business models. According to a study by Accenture, a circular economy could create $4.5 trillion of additional economic output by 2030 and generate over 160,000 jobs in the European Union alone (Accenture, 2017).

  In the realm of the smartphone industry, a shift from the traditional "take-make-dispose" approach to one that prioritizes repair, refurbishment, and recycling has the potential to generate fresh employment opportunities in repair services, remanufacturing, and recycling infrastructure development. According to the Ellen MacArthur Foundation, the implementation of a circular economy could introduce over 100,000 new job openings in the mobile device sector in Europe (Ellen MacArthur Foundation, 2015b).

- Climate Change Mitigation:
  The adoption of circular economy practices, which entail reducing resource consumption, minimizing waste, and promoting renewable energy, is a promising strategy in the battle against climate change. Research published in the journal Nature Climate Change suggests that this approach could have a significant impact on reducing greenhouse gas emissions. Specifically, by 2050, the implementation of circular economy practices could lead to a 39% reduction in global emissions compared to the current trajectory of the linear economy. These findings underscore the importance of adopting a circular economy framework in mitigating the effects of climate change and highlight the potential benefits for companies and society at large.

- Resilient and Regenerative System:

> The circular economy is a transformative concept that involves the creation of closed loops where materials are continually reused, resulting in resilient and regenerative systems. This approach promotes stable and long-lasting supply chains while reducing reliance on scarce resources, as well as mitigating risks associated with price volatility and supply disruptions. By designing durable products and integrating sustainable practices throughout their value chain, companies can enhance their resilience to future challenges and contribute to a more sustainable future.

The advantages of a circular economy go beyond any specific industry or sector. A circular economy prioritizes resource conservation, waste reduction, economic opportunities, climate change mitigation, and the development of resilient systems, leading to a more sustainable future. The benefits of a circular economy for sustainable smartphones are evident. By prioritizing resource efficiency, extending product lifespans, reducing electronic waste, and unlocking economic opportunities, a circular economy approach can contribute to a more sustainable and environmentally friendly smartphone industry. To embrace these principles, manufacturers, policymakers, and consumers must collaborate, but the potential benefits make it a worthwhile endeavour for a sustainable future.

3.1.6 Disadvantages and criticism of the CE

Although the idea of a circular economy offers potential for a more eco-friendly and efficient future, it's crucial to recognize that no system is perfect. The intricate process of implementation, technological restrictions, possible negative effects, and social equality issues require thorough examination. Acknowledging and resolving these drawbacks and criticisms can promote a comprehensive and successful adoption of circular economy principles, resulting in a more sustainable and all-encompassing future. This chapter delves into some of the drawbacks and criticisms associated with the circular economy concept. It's vital to have a comprehensive understanding of these viewpoints to ensure that the implementation of circular economy principles is both informed and equitable.

The circular economy concept has received criticism due to the complexity and challenges involved in its implementation. Moving from a linear to a circular system demands significant changes in business models, supply chains, and consumer behaviours. It requires collaboration among various stakeholders, including government bodies, businesses, and individuals. The transformation can be resource-intensive and may call for substantial investments, research, and development efforts. According to a study published in the Journal of Industrial Ecology, it is crucial to carefully consider the socio-technical aspects and systemic challenges when implementing circular economy strategies (Blomsma & Brennan, 2017).

Technology and innovation are crucial for the circular economy. However, some materials cannot be recycled due to cost or technological constraints. Advanced recycling may have trade-offs, so sustainability must be assessed. According to Korhonen et al. (2018), the circular economy has thermodynamic limitations. Therefore, complete recycling is not feasible, and waste creation and resource consumption are inevitable in circular systems. This idea builds upon Georgescu Roegne's "The Entropy Law and the Economic System."

It is crucial to consider the overall impact on the environment and the system when implementing circular economy strategies, as highlighted by these concerns. A recent publication in the Journal of Cleaner Production raises the issue of possible rebound effects and emphasizes the need for thorough evaluations of circular economy initiatives (Castro et al., 2022).

The idea of the circular economy highlights the importance of using resources efficiently, reducing waste, and creating economic opportunities. However, some people argue that it doesn't do enough to tackle social equity issues. If we focus only on environmental aspects, we might overlook the need to redistribute economic benefits, provide fair working conditions, and promote social inclusion. It's crucial to think about the social impact of implementing circular economy strategies, making sure that the most vulnerable communities, marginalized groups, and workers are not unfairly affected. A recent report in Sustainability Science stresses the importance of including social equity considerations in circular economy plans.

3.1.6.1 Rebound Effect

In the past, attempts to improve resource efficiency have often fallen short of their intended goal. This is due to the fact that gains in efficiency are often offset by increased consumption or demand for the product. This phenomenon is known as Jeavon's Paradox and has persisted for over 150 years (Bauwens, 2021). CE principles, unfortunately, do not effectively prevent or mitigate the rebound effect. CE principles, unfortunately, do not effectively prevent or mitigate the rebound effect (Corvellec et al., 2022). For instance, sharing or pooling a product to save money may lead to the redirection of funds to other activities that cause more harm to the environment. Additionally, as the circular economy enables the prolongation of product lifecycles, it may also slow down the adoption of more sustainable alternatives or technological advancements.

It was proven through a panel data analysis of CE in 28 European countries that the economic growth in these nations contributed four times more to the rise in resource extraction than the efforts made through CE practices to reduce it (Bianchi & Cordella, 2023).

According to Bianchi and Cordella (2023), it is important to acknowledge that as long as the building infrastructure continues to expand, primary resources will still be required, as the supply of recycled materials will not suffice. Additionally, despite achieving a state of balance where all fresh building material requirements are fulfilled by reused materials, the retrieval of non-renewable resources like fossil fuels and biomass would still be indispensable. This is especially crucial when transitioning to renewable energy, as it involves an increased need for metals and other materials that must be extracted beforehand. Additionally, it is impossible to achieve 100% recycling or completely closed material loops due to the laws of thermodynamics. This means that we will always need virgin raw materials, even just to maintain the current state, let alone for economic growth (Corvellec et al., 2022). Therefore, it is improbable and unfeasible to entirely substitute traditional linear goods. Our attention should shift towards intentionally reducing the linear economy and restructuring the circular economy to prioritize avoiding material usage in the initial stages.

A study conducted by Zink and Geyer in 2017 investigated the potential rebound effects of implementing circular economy practices. The researchers posited that the closing of material loops and other circular economy approaches could lead to an overall rise in production, which could counteract the benefits of a more circular economy. This effect could potentially be attributed to two mechanisms: the inability of circular economy activities to effectively compete with primary production and the decrease in prices resulting from circular economy practices, which could lead to a shift in consumption patterns.

Regarding the inability of secondary goods to compete with primary goods, this is rooted in the party inferior quality or other inferior attributes of these products compared to primary goods.

Zink and Geyer (2017) used smartphones as an example, in which the technology changes so quickly, that a second-hand market is not supported, and hence refurbished phones are an addition to new phones instead of replacing them. Hence in similar cases or industries, the overall consumption and production would increase (Zink & Geyer, 2017).

The figure below shows the mechanism of the circular economy rebound effect die to increased production.

The vertical axis on the graph represents the level of environmental impact, with E0 being the starting point. If the goal is to achieve a reduction to E2 without experiencing any rebound effect, it is necessary to maintain production levels without any increase as seen in figure. This approach will enable maximum potential benefit to be attained, with E2 serving as the ultimate target. In the case of a significant rebound effect, the overall benefit could even be completely erased or even an increased impact could occur, which means E0 – E2 ≤ 0

Given the previous findings, this must be assumed rather unlikely and hence the potential benefit will always be reduced by the rebound effect leading to the overall impact E1. Therefore, the overall reduction in impact is only E0 – E1 instead of the E0 – E2 (Zink & Geyer, 2017).

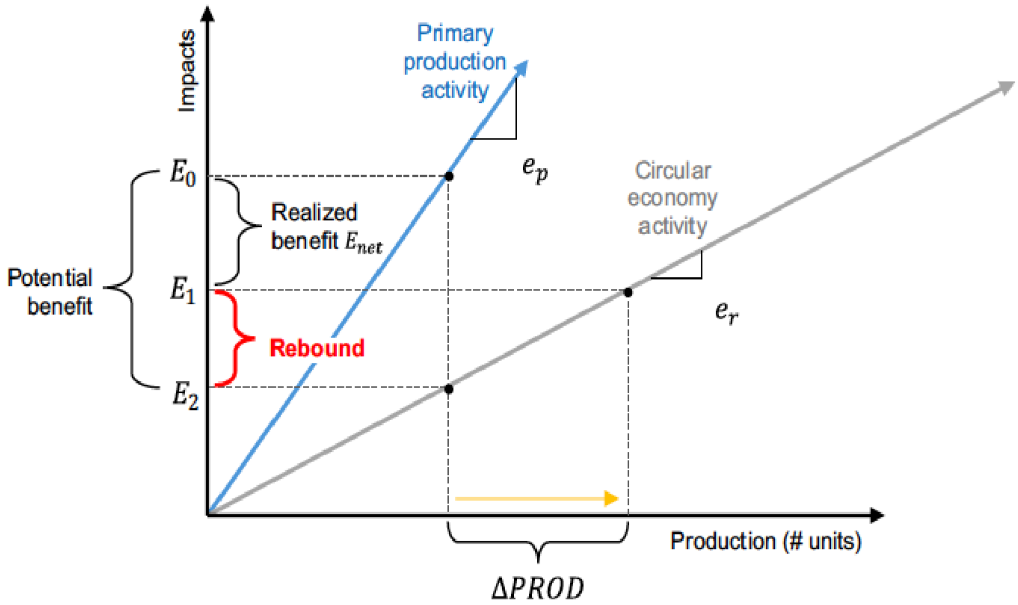


Figure 9 Circular Economy rebound effect

Source: Adopted Zink & Geyer, 2017, p. 598

3.1.6.2 The Paradigm of Economic Growth

Circular business models predominantly focus on continued economic growth, with the goal of absolute decoupling (Hofmann, 2019). This arises concerns among critics, arguing that this emphasis on growth may result in excessive consumption, depletion of resources, and environmental degradation, thus undermining sustainability objectives.

Even when looking at the most ambitious policy initiatives from the EU, it becomes evident that a significant emphasis has been placed on technology-driven growth, as opposed to giving priority to the reduction of the linear economy (Corvellec et al., 2022). As a result, linear business models are still much more prevalent than circular innovations. Unless stricter laws and regulations are put in place, the existing challenges with secondary resources, including issues related to substandard quality, contamination, limited availability, and pricing volatility will remain (Bauwens, 2021).

According to Bauwens (2021), it is important to shift the focus of value and goals from solely maximizing profits for private companies to prioritizing the well-being of society and the planet. In order to design successful circular economies, it is also crucial to consider consumer behavior and consumption patterns (Bianchi & Cordella, 2023). To make this shift, consumers must transform themselves into informed, conscious, and willing users who prioritize a product's life cycle impact over the desire for the latest trend (Corvellec et al., 2022). Addressing issues related to ownership, advertising, and power is essential in bringing about a cultural change among consumers (Corvellec et al., 2022). However, without addressing these fundamental issues, such a change cannot take place.

While the concept of Circular Economy (CE) is laudable, its current implementation as a growth strategy falls short of achieving a significant transformation of our consumerist, extractive, and capitalist economic models. To effectively promote sustainability, we need to witness changes in the corporate, national, and international levels of business, institutions, and governance structures.

3.1.6.3 Missing the Social dimension

The concept of a circular economy has a strong focus on environmental sustainability, but often lacks a comprehensive description of the social sustainability aspect. The principles of a circular economy are primarily derived from a business perspective, with the aim of achieving both environmental and economic benefits. It is important to note, as Stahel emphasizes, that additional manufacturing processes in a circular economy, such as refurbishing or recycling, require more human labour as these processes cannot be standardized. Therefore, for a circular economy to be successful, it must ensure that local employment opportunities are created. While a centralized recycling facility on the other side of the world may be a potential outcome of a circular economy strategy, it may lack the potential for local job creation and most importantly. Moreover, the basic needs of people at a global level can still be compromised by the misuse of authority, unjust working and living conditions, or a disregard for human rights. Therefore, the circular economy model may not encompass all aspects of sustainability.

Despite the numerous challenges faced by businesses today, the principles of the circular economy offer a promising solution. This innovative approach demonstrates that it is still possible to create value while staying within planetary limits, thus fostering both environmental sustainability and economic growth. By taking inspiration from nature, advocates of the circular economy have successfully translated its benefits into tangible business opportunities. This has made it a more appealing alternative to sustainable development, which has been criticized for failing to balance environmental and economic benefits.

3.1.6.4 Technological Optimism

Critics of the circular economy have raised valid concerns regarding its overreliance on technological advancements as the sole solution to sustainability challenges. They argue that this approach may divert attention from the importance of instilling behavioral changes, implementing social innovations, and promoting systemic transformations. Additionally, there are apprehensions that excessive reliance on technology may lead to unintended consequences or rebound effects. It is therefore crucial to consider a holistic approach that balances the role of technology with other interventions to achieve sustainable outcomes.

3.2 The Smartphone Market

The ubiquitous presence of smartphones as a consumer product is emblematic of the widespread adoption of information and communications technology (ICT). According to a in 2019 published research study conducted by the Pew Research Center, mobile phone ownership rates among adults in various EU member states are consistently high, with over 90% of individuals owning a mobile phone. However, the sustainability concerns that surround the smartphone industry, including the sourcing of conflict minerals, the generation of electronic waste, and the limited availability of resources, have garnered significant attention in the public discourse. This chapter will start with a market analysis of the current smartphone industry landscape, covering key aspects such as market size, growth drivers, competitive landscape, and emerging trends especially regarding sustainability.

3.2.1 Market Characteristics and developments

Since the introduction of the first iPhone in 2007, the global smartphone market has witnessed remarkable growth. Between 2009 and 2013, smartphone manufacturers were able to increase their annual sales from around 174 million devices in 2009 to more than one billion smartphones in 2013 within just four years. However, after reaching a peak of 1.47 billion sales in 2016, sales figures have been decreasing in the subsequent four years. According to IDC worldwide smartphone shipmen dropped by 11,3% in 2022 with 1.21 billion unit representing the lowest annual shipment since 2013 (IDC, 2023b). Nevertheless, the total smartphone shipment is expected to reach 3 billion in 2030 (Andrae & Edler, 2015).

The smartphone industry must be considered as a highly competitive market, with numerous manufacturers vying for market share. Key players include Apple, Samsung, Oppo, Huawei, Vivo, and Xiaomi. It is a significant industry, only in iPhones sales, Apple´s most recent quarterly revenues increased by $12 billion from 2021 to close to $40 billion. These companies compete on factors such as product features, design, brand reputation, market strategies, and pricing. Additionally, emerging brands from China and India have gained prominence, offering highly competitively priced smartphones with compelling features. Flagship phones now commonly cost up to 1.000 EURO.

Currently, approximately 3.9 billion individuals worldwide own a smartphone. The number of mobile phone subscriptions also surpassed the total population of the European Union in 2013 (Wernink & Strahl, 2015). According to Deloitte Global, it is predicted that smartphones, the most widely used consumer electronics device, will have an estimated 4.5 billion installed base by 2022 (Gartner Forecasts Global Devices Installed Base to Reach 6.2 billion Units in 2021, n.d.). It is estimated that around 40% of the world's population owned a smartphone in 2018, and this number is rapidly increasing. This surge in popularity can be attributed to consistent sales of over 1 billion devices annually. Additionally, numerous factors and developments contribute to the industry's unprecedented growth. The **rapid pace of technological innovation,** particularly in the last decade, including the development of 5G networks, artificial intelligence, and enhanced camera capabilities, is a significant driver for consumers to upgrade their phones. Moreover, the **increasing accessibility and affordability of internet connectivity** has made smartphones the primary mode of accessing various digital platforms, including social media, e-commerce, and entertainment. The growing **digitalization** of various industries, including healthcare, education, finance and retail fuels the need for smartphones with advanced functions to support these digital services. The availability of smartphones at various **price (Rising Affordability**) points, including budget and mid-range devices, has expanded the consumer base, particularly in emerging markets, contributing to sustained growth.

Notably, the industry exhibits regional variations in terms of market dynamics and consumer preferences. While North America and Europe represent mature markets with high penetration, Asia-Pacific, particularly China and India, is a significant growth driver due to its large population and increasing smartphone adoption rates. Africa and Latin America also offer untapped potential, driven by expanding middle-class population and improving internet connectivity.

According to the International Monetary Fund's 2018 report, the mobile phone market in Europe and other regions may have reached its maximum capacity and is now saturated, with little room for further expansion or sales growth. This conclusion is further corroborated by recent consumer behavior, with individuals holding onto their devices for longer periods of time. In fact, in the five most populous EU countries, the average duration of first ownership or use has increased from approximately 18 months in 2013 to 21.6 months in 2016, as per the data provided by Kantar Worldpanel in 2017. In a market that has reached saturation, the primary factors that influence sales are replacement rates and competition among manufacturers.

Although the demand for new mobile phones in the developed countries seems to have plateaued, the market for sustainable and refurbished smartphones is experiencing an upswing. According to market analysis, the industry of refurbished smartphones is projected to witness a steady annual growth rate of 10.3% from 2021 to 2026, resulting in a collective market value of US$ 99.9 billion, encompassing a total of 415 million units (IDC, 2023a) . Due to consumers increasing awareness about environmental issues, manufacturers are adopting eco-friendly practices, incorporating recycled material, and promoting device recycling programs to address sustainability concerns. This market has been prevalent in developing nations since the early 2000s, but it is now gaining traction in developed nations due to the emergence of high-end smartphones. In mature markets, a smartphone that is four years old may not be as desirable, but it can still hold significant value in emerging markets.

In Europe, the recycling, refurbishing, and remanufacturing rates for smartphones are only around 15%, and the secondary smartphone market only makes up 6% of the primary market (Ellen MacArthur Foundation, 2012) . Refurbishing (or refurbishment) is the process of putting a used products back in good working order by cleaning, replacing, and/or repairing major components (like the battery or screen) that are defective, damaged, or on the verge of failure as well as making aesthetic changes to update the products appearance (Ellen MacArthur Foundation, 2012).

Smartphones are becoming central hubs for Internet of Things devices, enabling seamless control, and monitoring of connected devices in homes, automobiles, and wearable technology. Additionally, the integration of Augmented Reality and Virtual Reality technologies in smartphones is revolutionizing gaming, entertainment, and immersive user experiences.

The influence of smartphones on human behavior cannot be emphasized enough. Smartphones have played a crucial role in the digital revolution that has transformed communication, financial inclusion, and agricultural productivity, to name just a few examples (Chatterji, 2021). However, with the exponential increase in smartphone production, there has also been a corresponding surge in waste streams and carbon emissions resulting from these devices.

Concluding, the smartphone industry continues to evolve, driven by technological advancements, rising internet penetration, and increasing consumer demand for enhanced features and functionality, the competitive landscape remains intense, with key players competing on innovation, design, and pricing strategies. As the market expands into emerging regions and new technologies gain prominence, sustained growth and evolving consumer preferences will shape the future trajectory of the smartphone industry.

3.2.2 The Issue with Sustainability

To lessen our reliance on fossil fuels, car producers are currently switching to electric vehicles. However, looking at smartphones, they appear much more subdued in comparison. However, although the overall contribution compared to the major contributors of global warming, like the energy sector and transportation, Smartphones emit more greenhouse gases than any other consumer electronic device (Belkhir & Elmeligi, 2018). In this chapter, we will explore the major sustainability concerns surrounding the production of smartphones. With the significant increase in sales over the past few decades, these devices have also contributed significantly to the waste stream and carbon emissions. According to The World Bank (2016), mobile phone subscriptions were widespread in 2014, with a rate of 97 out of every 100 individuals. Furthermore, it is estimated that the total number of smartphone shipments will reach 3 billion by the year 2030. (Andrae & Edler, 2015). In addition, the current value chains and business practices have resulted in various negative social and environmental impacts. We will delve into these issues in the following chapter. In several manufacturing nations, laborers are exposed to inhumane work environments while mining minerals or working in production facilities to guarantee that those who are fortunate have access to cutting-edge technologies. However, for now, let's focus on the two most significant challenges: waste and emission generation.

Although phones don´t emit as many pollutants as automobiles and similar vehicles, the Tech industry is a major contributor to climate change. In terms of carbon emissions and climate change, the tech sector accounts for two to three percent of global emissions. Greenpeace reports that approximately 968 TWh of energy has been consumed since the commercial availability of smartphones, equivalent to the yearly energy consumption of India. This will result in 146 million tons of CO2 emissions in the same year. According to Chatterji (2021), The manufacture of mobile phones generates a substantial carbon footprint annually, equivalent to the carbon emissions of a small country per year, according to Chatterji's 2021 study. That amounts to around 0.5 percent of the estimated 34 gigatons of CO2 that will be emitted globally in 2021. The vast majority of smartphone emissions (83%) come from manufacturing, shipping, and first-year usage. On average, a new smartphone emits an average of 85 kilograms of emissions in the first year of life (Lee et al., 2021). The remaining emissions are caused by usage, refurbishment, or end-of-life processes. However, there are rising environmental worries about data storage and usage. The term "Digital Pollution" encompasses the adverse environmental effects associated with the production, consumption, and utilization of digital products and services. It acknowledges that the manufacturing process of digital equipment, as well as its subsequent energy consumption and network usage, are significant contributors to environmental pollution.

The next main issue comes in regard to E-waste. It is a matter of concern that the daily waste generated by smartphones and similar devices is equivalent to the waste streams produced by over 300,000 double decker buses. Total 50 million metric tons of e-waste in 2019 (Kryvinska et al., 2023). The streams of electronic waste are both extremely harmful to the environment and extremely inefficient. This highlights the need for responsible and sustainable practices in the production and disposal of electronic devices.

It is one of the most resource-intensive goods by weight on the globe, with rare earth minerals like gold, silver, platinum, cobalt, or lithium, to mention a few. Studies show that the raw materials in e-waste hold a potential value of USD 57 million, but in 2019, only 17% of electronics were recycled, resulting in the loss of most of this value. Due to the significant surge in smartphone sales, the availability of precious metals and materials needed to manufacture them has dwindled. According to the Royal Society of Chemistry, in the next 100 years, the world is expected to run out of six essential elements for mobile phones, all of which are precious metals.(Chatterji, 2021).

Additionally, since most of smartphone components are produced in China, where coal is still a dominant source of energy, emitting even more emission. Social effects, particularly those related to human rights, are another issue that is frequently raised in this process.

Thankfully, there are encouraging solutions in sight for breaking the harmful cycle of consumption, waste, and social inequality. To effectively address the issue at hand, it is imperative that we thoroughly analyze our individual and market behaviors. Furthermore, it is crucial to acknowledge the detrimental effects that a certain recently launched tech product is having on both the environment and human well-being. A notable trend is that stakeholders are now placing greater importance on prolonging the lifespan of smartphones to mitigate the issue of e-waste.

3.2.2.1 Sustainability Issues along the Value Chain

The production, consumption, and disposal of smartphones have various adverse negative impacts on both society and the environment. According to (Moberg et al., 2014), addressing these issues requires consideration of all phases of the product's life cycle. The value chain of a smartphone encompasses various stages, from extraction of raw materials to disposal and recycling of the device. In a recent publication authored by Zufall et al. (2020), the issue of sustainability surrounding smartphones was examined throughout five distinct phases of the product lifecycle. These phases were identified as *resource extraction and processing, design and manufacturing, distribution and network providers, usage, and end-of-life*. The approach taken by the author was deemed highly effective in terms of clarity and therefore has been adopted into our own written work.

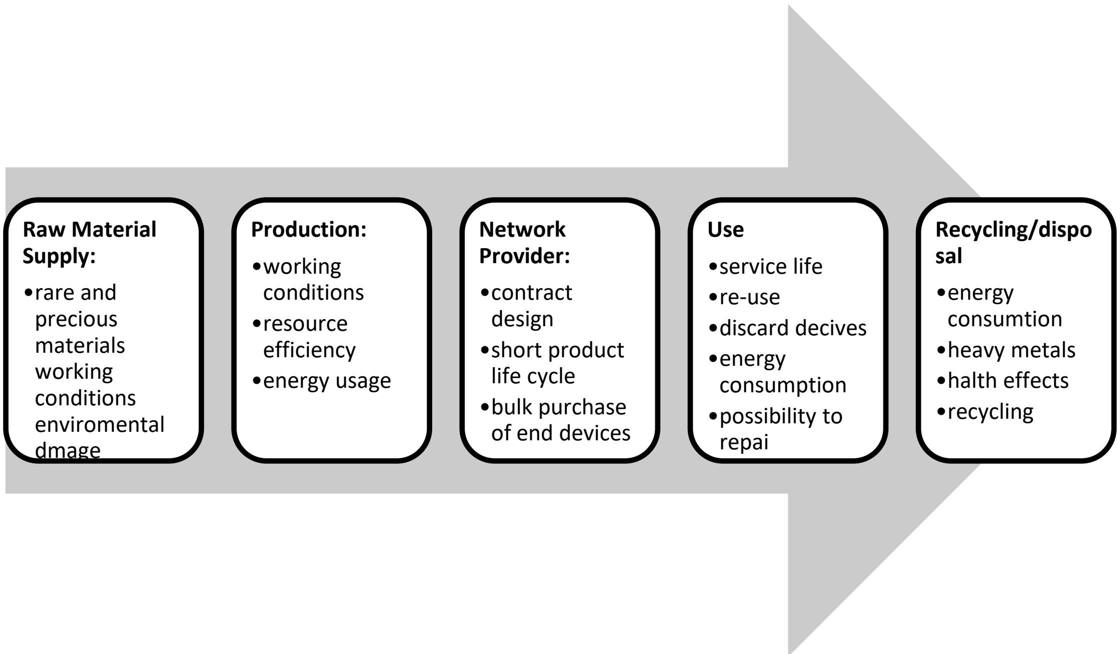


Figure 10 Sustainability issues along the smartphone value chain

3.2.2.1.1 Raw Material Supply

The extraction of minerals and rare earths used in smartphone components can have significant environmental and social impacts. Mining operations can contribute to deforestation, habitat destruction, water pollution, and displacement of local communities.

The typical production journey of smartphones typically begins in a distant mine in South American, Asian, and African countries. often situated in the Democratic Republic of Congo. In a country plagued by conflict minerals, over 50% of mines are run by violent, autonomous militias or armed organizations. Explanation conflict minerals[3].

There are several major sustainability issues that need to be addressed. Illicit operations and harmful sourcing of hazardous or conflict minerals, as well as poor working conditions such as child and forced labor, excessive working hours, and environmental degradation due to mining and processing are among the issues to be tackled (Zufall et al., 2020)**.**

To achieve greater sustainability, it is essential to address the challenges associated with mining through improved global tracking, legislation, and investment in high-risk areas to ensure safe and fair pay for workers (Wernink & Strahl, 2015). In addition, businesses can follow sustainability guidelines provided by global certification systems, such as the ISO standards, including ISO 26000 for social responsibility and ISO 14000 for sustainable development (Van Der Velden, 2016). The European Union has also introduced similar legislation on Eco-design and Energy labeling to promote sustainable practices (Van Der Velden, 2016, pp. 34).

3.2.2.1.2 Design and Manufacturing

The manufacturing phase involves the assembly of smartphone components, which often takes place in countries with lower labor and environmental standards. Poor working conditions, low wages, long working hours, and inadequate health and safety measures are major concerns. The use of toxic chemicals and energy-intensive production processes also adds to the environmental impact.

It is important to acknowledge that many smartphones and their components are manufactured in Asian nations with lower social and ecological standards, as documented by Welfens et al. (2013). Regrettably, this often leads to the disregard of labor rights, resulting in low wages for workers in production facilities (Josephs, 2014). Moreover, corporations have a long-lasting track record of exploiting countries with weaker human rights protections, particularly those in the global south, to cut down on costs. To curb this longstanding pattern of resource, power, and monetary abuse, it is essential to enforce strict global laws (Yang, 2017).

[3] Conflict mineral refers to raw materials or minerals (tin, tantalum, tungsten, and gold) that originate from a particular part of the world where there is conflict affecting the extraction and trade of these materials. These minerals are usually mined in eastern Congo and are found in most consumer electronics products. They are a major source of funding for the warlords in the Democratic Republic of Congo, fueling the violence that has plagued the region for decades.

An issue of considerable concern in the manufacturing industry is the extended work hours that employees are subjected to. Companies such as Apple have taken steps to address this issue by implementing a code of conduct for their suppliers, which limits work hours to a maximum of 60 hours per week and mandates at least one day off (apple.com, 2016, p.20). They introduced real time-tracking systems to track the working hours their 1,3 million workers. According to Apple in 2015 they reached 97% concordance with the proposed code of conduct. However, through investigations of the China Labor Watch, it has been discovered that a mere 1.1% of employees work less than 36 hours of paid overtime (Hagemann, 2017, p. 45). Tragically, in 2014, there were reports of 14 suicides linked to poor working conditions at Foxconn, which is the primary assembler for Apple products in China (Josephs, 2014; Höfner & Frick, 2019). Furthermore, back in 2017, Apple had to confess to the use of child labor in the production of the iPhone X. As a result, the company pledged to enhance labor conditions and implement measures to tackle social concerns (Yang, 2017).

It is evident that there is a pressing need to improve working conditions and ensure employer accountability for the welfare of their employees. To address these critical social concerns, we propose incorporating robust code of conduct monitoring systems, legally binding voluntary contracts, flexible work hours, and accessible channels for reporting instances of employee abuse. By implementing these measures, we can establish a safe and equitable work environment that prioritizes the well-being of all employees.

The decisions made during the design phase have a major impact on all other stages of a product's lifespan, thereby playing a crucial role in shaping social and environmental concerns (Van Der Velden, 2016). According to Van der Velden's (2016) analysis, this can be traced back to two simple decisions made during the initial design phase. Firstly, the selection of material components is a crucial aspect in determining the resources required. Secondly, the design of a product can greatly affect how it will be utilized and eventually recycled at the end of its lifespan. Some design choices, such as non-modular or non-repairable designs, limited upgrade options, and built-in obsolescence, can lead to shorter product lifespans and increased electronic waste generation. Additionally, the use of materials that are difficult to recycle or hazardous to the environment poses challenges for end-of-life management. Additionally, the use of materials that are difficult to recycle or hazardous to the environment poses challenges for end-of-life management.

Regrettably, many current smartphone designs do not seem to place a significant emphasis on eco-design principles. In the past, a significant number of smartphones were designed with rear covers that could be removed, allowing for straightforward repair and maintenance. This feature provided users with the convenience of being able to replace batteries, SIM cards, and other components themselves, without the need to take their device to a repair shop. In modern times, components are commonly secured using strong adhesives instead of screws, to minimize the overall size (Cook and Jardin, 2017 - Guide to Greener Electronics. 2017 Company Report Card).

Such design choices made by manufactures, combined with this closed and proprietary product strategy, make it challenging for users to upgrade, maintain, or recycle their device Furthermore, many companies frequently introduce new generations of devices, often multiple times a year. While these devices may have new features, they often lack significant innovation and contribute to the rapid obsolescence of older smartphones.

Most smartphones and their components are manufactured in Asian countries that have low social and ecological standards (Welfens et al., 2013). This corresponds to a lack of labor rights as well as low wage labor within the production facilities (Josephs, 2014).

Many consumers are always on the lookout for the newest and slimmest smartphones with cutting-edge features, causing our electronic devices to become obsolete at a faster rate. On the one hand, operational phones are being disposed of, while on the other hand manufacturers in the mobile phone industry are failing to deliver products that are both durable and easily reparable. Additionally, it's a common trend that despite smartphones having a lifespan of up to 5-10 years, users tend to replace their devices within 12-24 months on average. It's easy to comprehend the phenomenon of smartphone advertising when observing the promotion of yearly updated models that emphasize minor innovations and conveniences. This trend has resulted in a surge in sales, making Europe the largest market for smartphones. It is commonly understood that these manufacturers offer more than just tangible goods; they provide experience. Over sixty percent of mobile phones sales are replacements for existing phones experience of which are still functioning. So, it is difficult to discuss smartphones without bringing up "planned obsolescence, which is the idea that something is designed to get unnecessarily unfunctional after a certain period. Although manufactures have improved the durability of digital devices, their lifespans ae still relatively short.

Throughout this phase, there exist several noteworthy obstacles to sustainability that require careful consideration. These obstacles include manufacturing processes that require significant resources and energy, insufficient working conditions, potential risks to human and environmental health stemming from the use of toxic substances, and suboptimal product design decisions. Addressing these challenges will be essential in promoting a more sustainable approach to our work (Zufall et al., 2020).

The packaging of smartphones often involves excessive use of plastic and non-recyclable materials, contributing to waste generation. Moreover, long-distance transportation of components and finished products contributes to carbon emissions and air pollution.

3.2.2.1.3 Network provider

Network or Telephone service providers are another blameworthy party. To fully utilize a smartphone's features, users need both a device and a network contract.

Network providers often incentivize customers to upgrade their devices. For example, smartphone upgrade programs or contract renewal options that encourage customers to replace their devices frequently. This can contribute to electronic waste generation when older devices are not properly recycled. Network providers can promote device recycling programs, educate customers on e-waste management, and incentivize responsible disposal or trade-in options for older smartphones.

Network infrastructure, including cell towers and data centres, requires substantial energy to operate. The increasing demand for data services and the expansion of networks contribute to significant energy consumption and associated greenhouse gas emissions. Network providers can work towards minimizing energy use through energy-efficient technologies, renewable energy sourcing, and optimizing network operations.

Expanding network coverage involves installing new infrastructure, such as cell towers and antennas. The construction and installation processes can have environmental impacts, including land use changes, habitat disruption, and visual pollution. Network providers can adopt sustainable practices during infrastructure deployment, such as selecting appropriate locations, minimizing land disturbance, and engaging in community consultations to address concerns. Data centres are crucial for storing and processing the vast amounts of data generated by smartphones. Energy consumption in data centres can be substantial, and inefficient cooling systems can further contribute to environmental impact. Network providers can improve data centre efficiency through advanced cooling technologies, virtualization, and the use of renewable energy sources.

3.2.2.1.4 Initial Use-phase

The degree to which sustainability is achieved during this phase is greatly influenced by both user behavior and network infrastructure. It has been observed that a considerable number of individuals tend to replace their smartphones before they have reached their full lifespan. Consumers frequently upgrade to new smartphones, leading to a high turnover rate and significant electronic waste generation. Improper disposal of electronic waste can result in the release of hazardous substances into the environment, endangering human health and ecosystems. Recycling and proper e-waste management are crucial to minimize these impacts. Consequently, these devices are kept in their homes for extended periods, leading to a decrease in their market value. This phenomenon has implications for the secondary market and may warrant further analysis.

In 2016, a total of 1.47 billion smartphones were sold worldwide, what has been the record year so far (Smartphones - Statistiken und Studien | Statista). which an average operating lifetime of 18 months. A survey of university students from South-East England found that the majority replace their smartphone annually. A survey of university students from South-East England found that the majority of students replace their smartphone annually (Ongondo & Wiliams, 2011). Moreover, smartphones often get replaced even if they still function. Those to number alone highlights the importance that systematical changes are needed not only in product-, and business design but also in the behavior of the costumers. Furthermore, smartphones have become a lifestyle and status symbol which promote short product innovation- and life cycles. To improve sustainability, manufactures must improve awareness.

In order to establish long-term sustainability within the industry, a social shift must occur to transform current product-service practices and alter the mindset of consumers. This can be achieved by making sustainability a core component of one's identity, known scientifically as a "sustainable lifestyle". To successfully transition towards a more sustainable or circular economy, it is imperative for individual consumers to seek alternative forms of consumption and demonstrate social responsibility. Pioneering companies such as Fairphone and Shiftphone, who utilize modular designs, are leading the way in promoting this transformation in both product design and consumer behavior. Chapter 3.3.1 will provide a deeper exploration of Fairphone as an exemplary model in this regard.

However, it is important to note that this is not just in the realm of smartphone manufactures to increase product lifetime as contract lengths by service provider play an important role. For example, instead of offering incentives to upgrade smartphones which are still usable, the industry could shift to incentivize long-term contracts (Velmurugan, 2017).

3.2.2.1.5 End-of-life

The end-of-life phase of a smartphone is a critical aspect of sustainability. Addressing issues like electronic waste management, recycling infrastructure, design for recyclability, material recovery, and consumer education can help to improve the overall sustainability of smartphones disposal and recycling.

The biggest problem, E waste. Proper management of electronic waste is essential to minimize its environmental and health impacts. Old smartphones are tiny treasure troves of rare metals that can be recovered and reused. One million phones are thought to be capable of producing up to 16 tons of copper, 350 kg of silver, 34 kg of gold, and 15kg of palladium. The need for mining may be drastically reduced by recycling and recovering these materials, which would wase the burden on the environment and the workers that are engaged in mines.

The quantity of e-waste created in the sector is enormous (less than 16% was legally recycled in 2014), and most of it is disposed of in landfills where dangerous chemicals can leach out into groundwater endangering both people and plant life. The EU was predicted to produce more than 12 million tons of electrical and electronic equipment waste annually by the year 2020. Much of the environmental damage occurs before the phones ever reach the retailers, even though initiatives around the world to raise awareness of safe recycling or reuse techniques. The manufacturing process produces waste that is 200 times the weight of the phone and is still very reliant on fossil fuels.

Furthermore, it is crucial to acknowledge the detrimental effects that a certain recently launched tech product is having on both the environment and human well-being. Despite its initial appeal, it is clear that this product's lack of sustainability must be taken into consideration moving forward. The problems with smartphones mostly arise from their supply chain. It is one of the most resource-intensive goods by weight on the globe, with rare earth minerals like gold, silver, platinum, cobalt, or lithium, to mention a few. Furthermore, considering that a large portion of smartphone parts are manufactured in China, which relies heavily on coal as a primary energy source, this results in even greater emissions being released. Social effects, particularly those related to human rights, are another issue that is frequently raised in this process.

Network providers and producers can collaborate to establish collection points to take back programs to ensure convenience and responsibility of old smartphones. Thes programs can facilitate the proper recycling and treatment of e-waste to recover valuable materials and prevent pollution. Furthermore, Smartphone manufacturers can play a significant role in designing devices with recyclability in mind. This includes using materials that are easily recyclable and promoting modular designs that facilitate the disassembly and separation of different components. By incorporating standardized connectors and reducing the use of adhesives, manufacturers can make it easier to repair, upgrade, and recycle smartphones at the end of their life.

Raising awareness among consumers about the importance of responsible e-waste management is crucial. Network providers and smartphone manufacturers can educate users about the environmental impact of improper disposal and the benefits of recycling. This can be done through informational campaigns, product packaging labels, and providing clear instructions on how to recycle or trade-in old devices.

3.2.3 Sustainable Development and Trends within the Industry

Over the years, the smartphone market has undergone significant changes, influenced by technological advancements and shifts in consumer preferences. Considering the growing importance of sustainability, sustainable produced smartphones have emerged as a new and innovative concept. More and more consumers are becoming mindful of the impact their purchases have on the environment. As a result, there is a surge in demand for sustainable products, such as smartphones that are made with eco-friendly materials, which produce lesser waste, and have longer lifecycles. When searching for a new phone fulfilling these requirements nowadays, it turns out that there are not many eco-friendly options available. Nonetheless, there has been progress in recent years. Several smartphone manufacturers have started implementing sustainable practices in their production processes to keep up with this trend.

3.2.3.1 Greening the smartphone value chain

According to Deloitte, a new smartphone is responsible for an average of 85 kilograms in emissions in its first year of use. So, it is imperative for smartphone manufacturers to streamline their value chain to reduce carbon emissions. Manufacturing activities, including raw material extraction and transportation, account for a staggering 95% of such emissions. The report highlights that the amount of CO_2 emissions is influenced by various factors such as the usage of recycled materials, the energy efficiency of manufacturing facilities, and the extent to which the manufacturing ecosystem depends on renewable energy sources.

One key approach is to reduce the necessity for mining in the first place by reusing resources. Additionally, smartphone manufacturers must improve their facilities energy-efficiency. When analysing emissions, it is crucial to consider the energy consumption across the entire value chain. This factor will likely have a significant impact on the overall emissions output. To illustrate, maintaining a constant temperature and humidity in a semiconductor fabrication plant can account for up to 30% of the total power consumption (Tsao et al., 2008). Subsequently, it is important to promote the use of renewable energy in all aspects of business operations, including owned facilities and third-party manufacturing or assembly outsourced by vendors.

3.2.3.2 Extending the life of the smartphone

As previously mentioned, the carbon footprint of smartphone production is primarily responsible for environmental impact. Therefore, the most effective approach to reducing a smartphone's ecological footprint is to increase its expected lifespan. Smartphones typically have a lifespan of less than 2.5 years. Even though it may not entail decreasing the overall quantity of smartphones in use, each individual device would be utilized for a longer duration, independent of how many owners it has over its lifespan. According to the Re-Start project, extending the lifespan of a smartphone by 33% (e.g., replacing it after 4 years instead of 3) on a global scale could potentially prevent yearly emissions equivalent to those produced by the entire country of Ireland (Restart, n.d.).

Several trends suggest that smartphone lifetimes will likely become longer soon. In general, smartphones are becoming more durable, which reduces the need for unplanned replacements. In the past, broken screens and water damage were common reasons for phones to break. However, modern screens have become more durable and can now withstand multiple brief drops. Furthermore, high-end smartphones are consistently improving in their ability to resist water damage with each passing year.

According to the Re-Start project, extending the lifespan of a smartphone by 33% (e.g., replacing it after 4 years instead of 3) on a global scale could potentially prevent yearly emissions equivalent to those produced by the entire country of Ireland.

To ensure smartphones have a longer lifespan, vendors must do more than just refurbish them physically. Refurbished electronics are becoming more and more well-liked since they promise to give customers a lower-cost phone with additional favorable environmental impact. The EU5 refurbished market is presently valued at 1.5 billion and have enormous expansion potential (Hamlin, 2021). Refurbished devices enjoy a high level of popularity in France, with 9% of customers opting to purchase them (Hamlin, 2021). Across the EU5, Apple dominated the refurbished market accounting for 6 in 10 refurbished devices sold.

They need to address software support and security, modifying the operating system to function with different device ages. This boosts the resale value of the device. Regular security updates are also necessary to patch vulnerabilities. By the start of 2022, the length of support for a smartphone's OS is expected to range from three to five years, varying by device.

From 2023 onwards, smartphone manufacturers operating in the EU may be mandated to provide security updates for a maximum of five years. This proposed legislation aims to promote the prolonged use of smartphones and tablets, resulting in an eco-friendlier environment. Furthermore, the EU Commission plans to implement a range of mandatory eco-design requirements, primarily focused on enhancing durability and repairability. Some key highlights of the regulations include offering free security updates for five years and function updates for three years, ensuring batteries retain 80% of their capacity after 500 charging cycles and can be replaced by users (or manage 1000 charging cycles if not replaceable), and providing spare parts such as batteries, cameras, microphones, etc. for five or six years in the future. Additionally, the legislation will require manufacturers to be transparent about raw material quantities, such as cobalt and neodymium.

3.2.3.3 Changing the business model

According to the 2022 CxO Sustainability Report published by Deloitte, companies seeking to accelerate their climate initiatives must incorporate climate-related considerations into all facets of their operations. This could potentially entail a fundamental transformation reconfigure of their business model. Certainly, if smartphones usage gets longer, it would affect how the smartphone industry earns profits. Nevertheless, this does not necessarily have to be bad news for manufacturers. It is possible to mitigate the impact on the bottom line and even establish new opportunities to interact with individual customers.

One promising concept is to create a feature out of longevity. By convincing customers that their phone will last longer and retain its value, vendors could justify higher prices for their devices. This could make trading in old phones a more attractive option for customers.

To enhance revenue, it may be prudent to expand the scope of revenue sources beyond device sales. You may want to explore media services, application stores, and online storage, which are expected to become more popular as individuals continue to accumulate a growing number of photos and videos over time.

It may be worthwhile to explore the possibility of offering hardware products with lower emissions per unit than smartphones, such as Bluetooth headphones. According to projections, sales of such items are anticipated to experience a growth of 35% in the upcoming year. This could potentially serve as a viable business opportunity to tap into a burgeoning market while also contributing to environmental sustainability efforts.

One of the latest advancements is the emergence of circular smartphones. In the world of circular smartphones, manufacturers strive to prolong the lifespan of devices by offering extended software updates and security patches. This helps minimize the need for consumers to frequently replace their phones, ultimately reducing waste and encouraging sustainable consumption. These phones often feature modular designs that make disassembly and repair effortless. Additionally, they are typically made from sustainable materials like recycled plastics, biodegradable polymers, and responsibly sourced metals, which greatly reduces their carbon footprint. By enabling consumers to replace individual components like batteries, screens, or cameras instead of replacing the entire phone, this approach promotes a circular economy while reducing electronic waste and extending the lifespan of devices. This helps to minimize the environmental impact.

Many of these sustainable developments promotes closed-loop recycling as proposed by the notion of a circular economy. For example, manufacturers increasingly introduce take-back programs that allow consumers to return their old devices for recycling. The extraction of valuable materials from discarded smartphones presents an opportunity to reduce the ecological impact of manufacturing new devices from virgin resources. Additionally, this approach helps to reduce the demand for new materials and their associated environmental costs, thus promoting a more sustainable and responsible approach to electronic production.

The concept of energy efficiency is another key topic within the sustainability discussion. Modern sustainable smartphones are equipped with various features that promote energy efficiency, such as low-power displays, optimized processors, and intelligent power management systems. These technologies work together to extend battery life and minimize energy consumption, in line with the goals of sustainable development.

However, the success of circular smartphones relies heavily on consumer awareness and education. Manufacturers and industry stakeholders are proactively engaging with consumers to promote the advantages of circular smartphones, their sustainable characteristics, and ways to participate in recycling initiatives.

In summary, the circular smartphone market presents a promising avenue for sustainable developments within the smartphone industry. With a focus on eco-friendly design, materials, modular features, closed-loop recycling, energy efficiency, extended lifespans, and consumer education, circular smartphones align with the principles of a circular economy. As sustainability continues to shape consumer preferences, it is crucial for smartphone manufacturers to embrace and innovate within this market segment, thus contributing to a more environmentally friendly and responsible future.

3.2.3.4 Modular Smartphones: The case of Fairphone

Since then, the company has evolved into a "Social Enterprise" that spearheads sustainable and socially responsible smartphone production. The Fairphone case represents a crucial subject for examination, given its pioneering role in the sustainable smartphone market and its commitment to circular economy principles. Our aim is to conduct a thorough analysis of this business and evaluate the sustainable advancements achieved in this sector. Furthermore, we intend to identify product features that align with the circular economy and warrant further investigation.

Currently, there are no regulations that push the phone industry towards decarbonization. However, manufacturers are conscious of the situation. Consumers are increasingly adopting sustainable practices and making ethical purchase decisions. Customers have incredibly high standards when it comes to their iPhones, and anything that doesn't meet those expectations is simply not an option. With efforts to reduce emissions in other areas and the availability of recycled materials, smartphones will also follow the sustainability trend. This means increased efforts to ensure proper end-of-life recyclability for devices, longer battery life to reduce energy consumption, and more recycled or bio-based materials.

“A phone embodies an extraordinary paradox: it facilitates our potential connection with pretty much everybody, yet we have zero connection with its manufacture.”

(Bas van Abel, founder of Fairphone)

When seeking a new smartphone, one may observe a lack of environmentally conscious options.

Fairphone is a social enterprise based in the Netherlands that aims to create sustainable smartphones. They design and produce smartphones with a focus on ethical, sourcing of materials, worker welfare, and environmental responsibility. It´s main objective is to address the negative social and environmental impact associated with the electronics industry. They strive to improve working conditions in the supply chain, reduce the use of conflict minerals, extend the lifespan of smartphones minimizing the need for new smartphone purchases.

One of the key features is its modular design, which allows users to easily repair and upgrade various components of the phones. The newest additions are the Fairphone 4 and Fairphone 4 Plus. Both models feature a total of eight core modules. These modules comprise the front and rear cameras, loudspeaker, earpiece, USB-C port, display, battery, and back cover, all working seamlessly together to create the innovative device (*Spare Parts for Your Fairphone, Discover Them Here*, n.d.). This modularity helps to extend the lifespan of the device, reduce electronic waste, and reduce the need for new smartphones.

Regarding raw materials, Fairphone focuses on the components that are considered to have to most beneficial effects. They enhance material sourcing in two ways: first, by more ethical mining methods, and second, through greater utilization of recycled resources. Fair phone also emphasizes the use of fair-trade and conflict-free minerals in their supply chain. They work closely with suppliers to ensure responsible sourcing of materials like tin, tantalum, tungsten, and gold. Fairphone is the first electronics firm to purchase gold from “Fairtrade-certified” mines, which provides better working conditions and a premium for the employees of the produced gold. Regarding cooper, the company buys from recycled sources, and they collect old phones to strengthen the supply of recycled cooper within the industry. They are working along with several partners to develop an alternative and more responsible supply for cobalt, neodymium, and lithium. Plastic is the last material they concentrate on, and they have successfully achieved that 50% of the modules are made of post-consumer-recycled plastic. In general, 32.75% of Fairphone´s eight focus materials were obtained sustainably. Additionally, the company strives to improve working conditions int their factories where their phones are manufactured, focusing on fair wages, reasonable working hours, and safe working conditions. The company discloses all relevant information from them, such as materials, production sites, and salaries, as well as resource transparency through certifications and tracking systems. However, the company chose to produce in China since setting up an alternative factory would require huge initial investments and the fact that all necessary components are produced in Asia. Through their initiatives and products, Fairphone aims to raise awareness about the social and environmental challenges in the electronic industry. Notably, they launched in 2010 a campaign promoting awareness about conflict minerals.

About recycling, the company implemented a buyback program. At the beginning, if a consumer purchases a new Fairphone she or he will receive a discount of 20 or 40 EURO, depending on the remaining value of the phones. However, this offer is not limited to fairphones only. Furthermore, any other smartphone may be sent to Fairphone for free recycling. The company’s objective was to collect 20,000 recycled smartphones by 2020. According to the website, the company managed to collect 17,000 devices in 2020 which is the equivalent to 18% of sold phones (*Fairphone Impact - Circularity: Why Do Things Need to Change?*, n.d.).

Building on that, 55% of returned phones are given a new life through refurbishment and are sold via a partner. The remaining 45% are recycled and sent to a European recycling plant, where the precious raw materials of the gadgets are reclaimed. To close the loop of the supply chain and carry out the circular economy, the company is using recycled materials to produce future phones.

For packaging, Fairphone are printing with natural soy-based ink on environmentally friendly, easily recyclable paper. Additionally, doing self-repairs and installing new operating systems do not void the warranty. On top of that, they provide four years of software support for the Android Operating System.

3.2.4 Conclusion

To effectively address the issue at hand, it is imperative that consumers thoroughly analyze the individual and market behaviors. Furthermore, it is crucial to acknowledge the detrimental effects that a certain recently launched tech product is having on both the environment and human well-being. Despite its initial appeal, this product's lack of sustainability must be taken into consideration moving forward. The problems with smartphones mostly arise from their supply chain. It is one of the most resource-intensive goods by weight on the globe, with rare earth minerals like gold, silver, platinum, cobalt, or lithium, to mention a few. Additionally, considering that a majority of the components used in smartphones are manufactured in China, which relies heavily on coal as a primary source of energy, the emissions generated by the production process are significantly increased. Social effects, particularly those related to human rights, are another issue that is frequently raised in this process. To address this challenge, it is important to recognize that smartphones retain value beyond their initial use, and refurbishing presents a promising solution for both mitigating the environmental impact of smartphone usage and supporting the circular economy.

Smartphones possess the capability of enhancing economies and enhancing lives in a sustainable manner. However, this can only be achieved if consumers rethink their lifecycles and broaden our perspective beyond mere recycling.

The increasing frequency of smartphone upgrades and limited options for end-of-life disposal have contributed to a rise in electronic waste and the depletion of rare minerals. To address this challenge, it is important to recognize that smartphones retain value beyond their initial use, and refurbishing presents a promising solution for both mitigating the environmental impact of smartphone usage and supporting the circular economy. In addition, refurbishing is an effective alternative to recycling, highlighting its potential to significantly reduce waste and conserve scarce resources.

3.3 Sustainable Consumption

The current state of Earth's resources has brought about a pressing need for sustainable consumption practices. Given the significant and unprecedented pressures that human activities exert on our planet's ecosystems, it has become evident that fundamental changes in our consumption patterns are necessary to create a sustainable future. The conventional linear consumption model, popularly referred to as the "take-make-dispose" paradigm, has led to the depletion of natural resources and accumulation of waste. In response to this, the Circular Economy (CE) model proposed by "Sustainable Consumption" (SC) offers a viable alternative approach that focuses on minimizing resource extraction, reducing waste generation, and promoting the reuse, recycling, and regeneration of materials.

The idea of sustainable consumption first emerged in 1992 at the United Nation´s Rio Summit´s 1992 action plan for sustainable development (Agenda 21). The term lacked a scientific definition until it was defined by the Oslo Symposium two years later. However, this definition faced heavy criticism from academics. Subsequent attempts were made to provide a more accurate and comprehensive explanation, resulting in a lack of clarity within academic literature due to the numerous available definitions. It is apparent from these definitions that sustainable consumption conceptualizations must:

- (a) encompass the entire cycle of consumption,
- (b) address both ecological and social concerns,
- (c) prioritize the well-being of the global population, and
- (d) maintain a long-term perspective.

The concept of sustainable consumption involves utilizing products and services that have minimal environmental impact, while meeting the present and future needs of humanity, as defined by the World Commission on Environment and Development in 1987. Essentially, it entails adopting consumption practices that prioritize social well-being and economic development while reducing negative environmental effects. SC is a broad category that is closely related to sustainable production and sustainable lifestyles. *“A sustainable lifestyle minimizes ecological impacts while enabling a flourishing life for individuals, households, communities, and beyond. It is the product of individual and collective decisions about aspirations and about stratifying needs and adopting practices, which are in turn conditioned, facilitated, and constrained by social norms, political institutions, public policies, infrastructures, markets, and culture”* (United Nations Environment Program, 2016, p. 6). While this definition is comprehensive, it's helpful to identify its key principles. Sustainable consumption, at its core, aligns with the principles of sustainable development, recognizing the interconnections between economic, social, and environmental systems. It also acknowledges that achieving long-term sustainability is closely linked to social equity and economic prosperity. Therefore, sustainable consumption aims to optimize these factors.

The role of the consumer is central to the concept of SC. Consumer have the power to influence the demand for products and services, shape market dynamics, and drive changes in production and supply chains. By making conscious choices, demanding sustainable products, advocating for change, and adopting sustainable behaviours, consumers can drive the transformation toward a more sustainable and equitable future. The choices individuals make as consumers can have significant environmental, social, and economic consequences. Consumers could make informed choices about the product they purchase. By considering the environmental and social impacts of their consumption decisions, consumers directly influence the market by demanding sustainable and ethically produced goods. With consumers adopting sustainable behaviors in their daily lives, this can make a significant impact. It can include reducing energy and water consumption, practicing waste reduction and recycling, opting for public transportation, or carpooling, and embracing conscious consumption habits such as repairing and repurposing items instead of always buying new ones. These individual actions, when multiplied across populations, can contribute to substantial environmental benefits. Consequently, businesses are incentivized to adopt more sustainable practices and develop ecofriendly products. This demand can further drive innovations and encourage business to adopt more environmentally friendly practices. For example, by choosing products with lower carbon footprints, reduced packaging, or sustainable certifications, consumers can create market incentives to companies. Additionally, consumers play a crucial role in raising awareness about SC and influencing others through their actions and choices. Consequently, by choosing to buy from companies that prioritize environmental stewardship, fair trade, social responsibility, and ethical labor, consumers can send a strong signal that sustainable and ethical considerations matter.

Also, within the smartphone industry the choices made by consumers greatly impact the demands of the market and the acceptance of sustainable and circular practices. To fully comprehend consumer preferences for eco-friendly and circular smartphones, it is crucial to examine existing literature on consumer behaviour, decision-making, and the factors influencing purchase choices in this context. The demand for sustainable goods and services is mostly driven by consumers, and they also actively engage in CE actions like recycling, sharing, and repurposing. Consumers could shape the market and encourage adaptation of CE principles since they are the final users of goods and services.

Sustainable consumption is one of the most important ways that consumers can support the CE. This entails choosing products and services that are environmentally friendly and sustainable, such as those made of recyclable or renewable materials or those with long lasting constructions. Consumers may engage in CE activities like recycling and reusing in addition to make sustainable purchase decisions. Recyclable materials, such as paper glass, and plastic, are gathered, processed, and then added back into the manufacturing process. Participating in renting, or sharing programs is another option for consumers to contribute to the CE. Sharing or renting goods or services rather than purchasing them outright can help to lower resource demand and promote more environmentally friendly consumption habits. Car sharing programs, tool lending collections, and clothes rental services are a few examples of sharing or renting arrangements. Lastly, consumers can support the circular economy by pushing for laws and policies that promote it. This may entail supporting programs like extended producer responsibility, which holds producers accountable for the entire product lifespan, or regulations that encourage the use of CE with discouraging waste and pollution.

Scientific research plays a crucial role in advancing the understanding and implementation of SC. Scholars and experts from various disciplines, including environmental science, economics, sociology, psychology, and engineering, collaborate to analyze consumption patterns, assess environmental impacts, develop innovative technologies and policies, and explore effective strategies for behavior change. Those scientific exploration aims to delve into the multifaceted aspects of SC, shedding light on is environmental, social, and economic implications. By examining the challenges and opportunities associated with transitioning to SC pattern, we can identify actionable pathways that can drive systematic change and foster a more sustainable and resilient future.

3.3.1 Driver to green consumption

To understand what drives consumers to choose sustainable and circular smartphones, it's important to consider a range of individual, social, and contextual factors. This research thesis aims to identify the most important factors that influence consumer decision-making processes by analysing existing literature on the subject. The findings of this review will be used to design a survey that accurately captures consumer preferences by selecting the most relevant attributes and levels. Additionally, this literature review will highlight areas where further research is needed, providing a foundation for future exploration into sustainable and circular smartphones.

Academic literature has discovered a series of driver that can affect the purchasing behaviour of green products. These factors can generally be aggregated in the following categories: *1. Socia-demographic aspects, 2. Intrapersonal values – environment, 3. Intrapersonal values – non environment, 4. Personal capabilities, 5. Behavioural factors, 6. Product and producer related factors, 7. Factors that relate to the context in which the consumer is at the time of purchase* (Testa et al., 2021).

Additionally, Figure 11 adopted from (Testa et al., 2021), graphically synthesizes the different variables in each category.

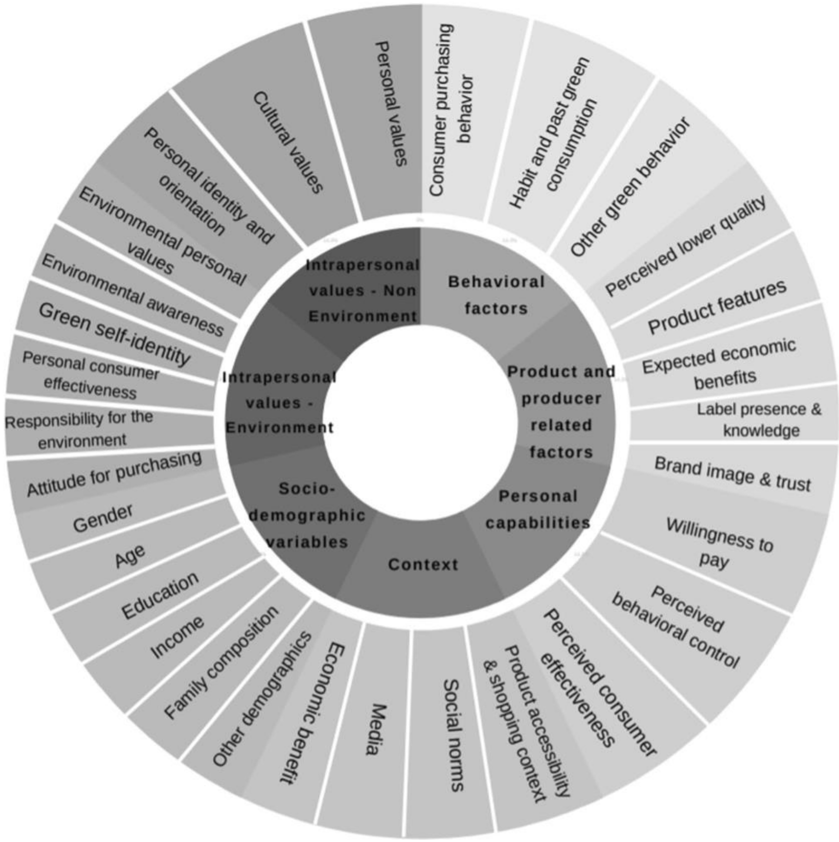


Figure 11 Driver to green consumptions
Source: Adopted from Testa et al., 2021, p.13

Given the complexity and depth of the numerous factors at hand, it is not practical to exhaustively explore all of them within the confines of this thesis. Consequently, this paper will only provide a cursory review of the pertinent findings that bear relevance to this work.

3.3.1.1 Intrapersonal values- environment

A crucial determinant is **environmental consciousness** and care. People who prioritize the environment are more likely to consider sustainability when making purchases, especially regarding smartphones. Studies suggest that individuals with heightened environmental awareness are more inclined to choose eco-friendly products. Education, informational campaigns, and social influences can all contribute to fostering environmental awareness, shaping consumers' attitudes and intentions.

In addition to **environmental awareness**, other individual-level factors impact consumer preferences. Personal values, beliefs, and attitudes towards sustainability and technology can significantly influence the selection of sustainable and circular smartphones. Consumers who prioritize sustainability and possess positive attitudes towards sustainable practices are more likely to choose smartphones that align with their values. Conversely, consumers who prioritize functionality, price, or brand image may prioritize different attributes when making their smartphone choices. Customers are searching for items that are created with sustainable materials, have less packaging waste, and are energy efficient as they become more conscious of the environmental effect of their shopping decisions. According to literature, the value that customers place on various product attributes while making a purchasing choice is greatly influenced by sustainability attitudes. For example, Sherer et al. (2028) discovered that environmentally aware consumers are more likely to choose a a product with a higher share of bio-based synthetics. Similarly, Brand and Rausch (2021) stated that green consumers value sustainable packaging. Material, and country of origin of an outdoor jacket more than less green consumers.

3.3.1.2 Personal capabilities

Consumer preferences can be shaped by various social influences, including peer groups, family, and social norms. The behaviour and opinions of others can significantly impact individuals' decision-making processes. To illustrate, people are more inclined to adopt sustainable smartphone practices when they observe that their peers or social groups prioritize sustainability. Social norms and societal pressures can effectively encourage sustainable consumption behaviours. When it comes to consumer preferences, the availability and presentation of sustainability-related information is crucial. This includes product information such as eco-labels, certifications, and descriptions, which consumers rely on to evaluate the sustainability of smartphones. Providing clear and credible information is key in helping consumers make informed choices and positively influencing their preferences for sustainable and circular smartphones. Effective communication strategies that emphasize the environmental benefits and features of sustainable smartphones can have a significant impact on consumer decision-making. In addition, factors such as cost, accessibility, and convenience play a significant role in shaping consumer preferences for sustainable and circular smartphones. Although people may have a favourable outlook towards sustainable practices, practical concerns can challenge these preferences. The high price, limited availability, and inconvenient repair and recycling options may impede the adoption of environmentally friendly practices. To bridge the gap between attitudes and actions and encourage sustainable smartphone use, it is vital to overcome these obstacles.

Circular Consumption is the study of how consumers make decisions about circular products and business strategies. Understanding how consumers make decisions is essential for boosting their desire to buy refurbished smartphones. The fact that refurbished products might not be accessible in all areas is a significant obstacle. Yet, even if refurbished smartphones are available, there are two orientation phase hurdles that might prevent them from reaching consumers´ final consideration set: Lack of awareness and misconceptions of the concept of refurbishment. Lack of awareness discourages people from contemplating buying a reconditioned smartphone.

Nowadays, many customers are not aware that there are refurbished phones accessible. Potential customers can completely pass up the chance if it is not offered through their preferred retail channels. Yet, there is also a broad misunderstanding of the refurbishment idea, as some customers do not immediately understand the distinction from used smartphones (Hazen et al., 2012; Van Weelden et al., 2016).

3.4 Ethical Consumer

Ethical Consumers are those who base their purchasing decisions on how socially responsible a product is. The definition of ethical consumption is the act of stratifying one´s own wants without impairing the capacity of others to satiate their needs in the presents or future. According to Mohr et al. (2001), consumers have become increasingly concerned about socially responsible product attributes. However, while the notion of social responsibility is popular mong consumers, ethical consumption is still in its infancy. So, a favorable attitude towards environmentally friendly products does not always translate into actual purchasing activity.

There are two major barriers to ethical consumption: the willingness to pay for it, and the information gap between businesses and consumers (Etile & Teyssier, 2011). Since it is assumed that consumers must be fully educated to make the best decisions, having more information must always be considered beneficial (Teisl et al., 2001). As a result, it is challenging to evaluate the social and environmental quality of the production process.

3.5 Willingness to Pay

In this chapter, the different methodologies employed in both scientific and commercial contexts to ascertain consumer willingness to pay (WTP) will be explored. Furthermore, the advantages and disadvantages of these approaches are analyzed.

“Pricing decision can be complex and difficult, but they are some of the most important marketing decision variables a manager faces”
(Monroe and Cox, 2001)

Willingness to pay (WTP) is a concept widely used in economics and marketing to discover consumer preferences. Setting the prices for products in consideration of how much the customers are willing to pay for each of the goods forms the basis of developing a pricing strategy. It is crucial for the marketer to forecast how many products will be sold at a certain price point. The marketer requires a thorough grasp of how customers will respond to various pricing schedules to forecast demand for different items at various prices.

The term "willingness to pay" refers to the highest amount a customer is willing to spend on a product or service. So, it measures the maximum amount of money a person is willing to sacrifice to obtain a particular product or experience. However, Customers will only make a purchase if the price falls below their maximum willingness to pay price. It's worth noting that this limit may change over time based on shifts in customer preferences and circumstances (1.).

In the context of WTP research, there are two related concepts: maximum price and reservation price.

The term "**Maximum Price**" denotes the highest amount of monetary compensation a customer is willing and capable of affording for a specific product or service. This serves as the upper limit of the financial threshold a consumer is willing to surpass to obtain their desired item. The maximum price reflects the consumer's perceived value or estimation of the product, which may vary based on individual perspectives.

In determining the maximum price, several factors come into play such as consumer preferences, income, perceived benefits, and the perceived value of alternatives. Knowing the maximum price, a consumer is willing to pay is vital for businesses and researchers as it influences pricing decisions and profits. Setting the price below the maximum price allows companies and researchers to capture the consumer's perceived value and encourage purchases.

The **“Reservation Price**” refers to the minimal amount that a consumer is willing to accept in exchange for a particular product or service. This figure reflects the individual's personal assessment of the item's minimum value that they would find satisfactory. In essence, the reservation price represents the consumer's threshold for relinquishing the product.

The concept of reservation price comes up frequently in market transactions, negotiations, and auctions. It plays a crucial role in determining the minimum price at which a seller would agree to sell an item or the maximum price at which a buyer would be willing to make the purchase. If the offered price is lower than the reservation price, the transaction is unlikely to proceed. The reservation price can vary based on an individual's unique circumstances, preferences, and perceived value of the product. It is influenced by factors such as the individual's need for the item, the availability of alternatives, and the perceived benefits or utility associated with the product.

As a marketer, it is not usually important to distinguish between a consumer's reservation price and maximum price when determining their willingness to pay. However, accurate predictions of consumer behavior become increasingly crucial when offering multiple items at varying price points.

3.6 The Attitude Behavior Gap

Despite the rising consumer concern for the environment and increased awareness in sustainability, the quantity of sustainable products purchases continues to be modest. According to a study on organic food, whereas 67% of respondents had a favorable attitude toward purchasing organic food items, just 4% made the purchase (Hughner et al., 2007). This discrepancy between consumer´s favorable attitudes and their displayed purchase behavior, is called the “attitude behavior gap” (Brand & Rausch, 2021). Researchers utilized theoretical frameworks from several areas, such as consumer behavior, business ethics, and social psychology, to investigate the attitude-behavior gap of sustainable or ethical consumers.

According to Ajzen (1991), the attitude towards a behavior can be defined as “*the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question*” (p. 188). In 2000, Wilson and colleagues introduced a highly interesting concept referred to as dual attitudes. This theory posits that it is possible for individuals to maintain two attitudes concurrently towards a single entity, one that is implicit and the other that is explicit.

Most models in the field of SC behavior stem from the fundamental cognitive progression outlined: Our beliefs shape our attitudes, which then guide our intentions, ultimately influencing our behavior (Wintschnig, 2021). This framework suggests that there could be a division between the attitudes people hold and their actual intentions, as well as a gap between intention and action. These gaps may be responsible for the difference between what consumers claim they believe and what they actually do. Wintschnig (2021) determined four major reasons for the attitude behavior gap: *Deficiency of research methods, Misleading monistic view of morality and personal goals, Rationalization strategies, and the plethora of influencing factors (p. 326-327).*

To illustrate this, Figure 22 presents a representation of the attitude-behavior-gap in regards to sustainable food. The study was conducted by Statista in cooperation with DHB Heilbronn among German residents in 2022. During the study, participants were asked about their priorities when it comes to purchasing food. The researchers also followed up to determine how often these individuals put those priorities into action. For instance, it was found that a lower C02 footprint was a significant factor in their purchasing decisions, with a score of 36 out of 100. However, the behavior score for this criterion was only 22, indicating a 14-point gap between attitude and behavior.

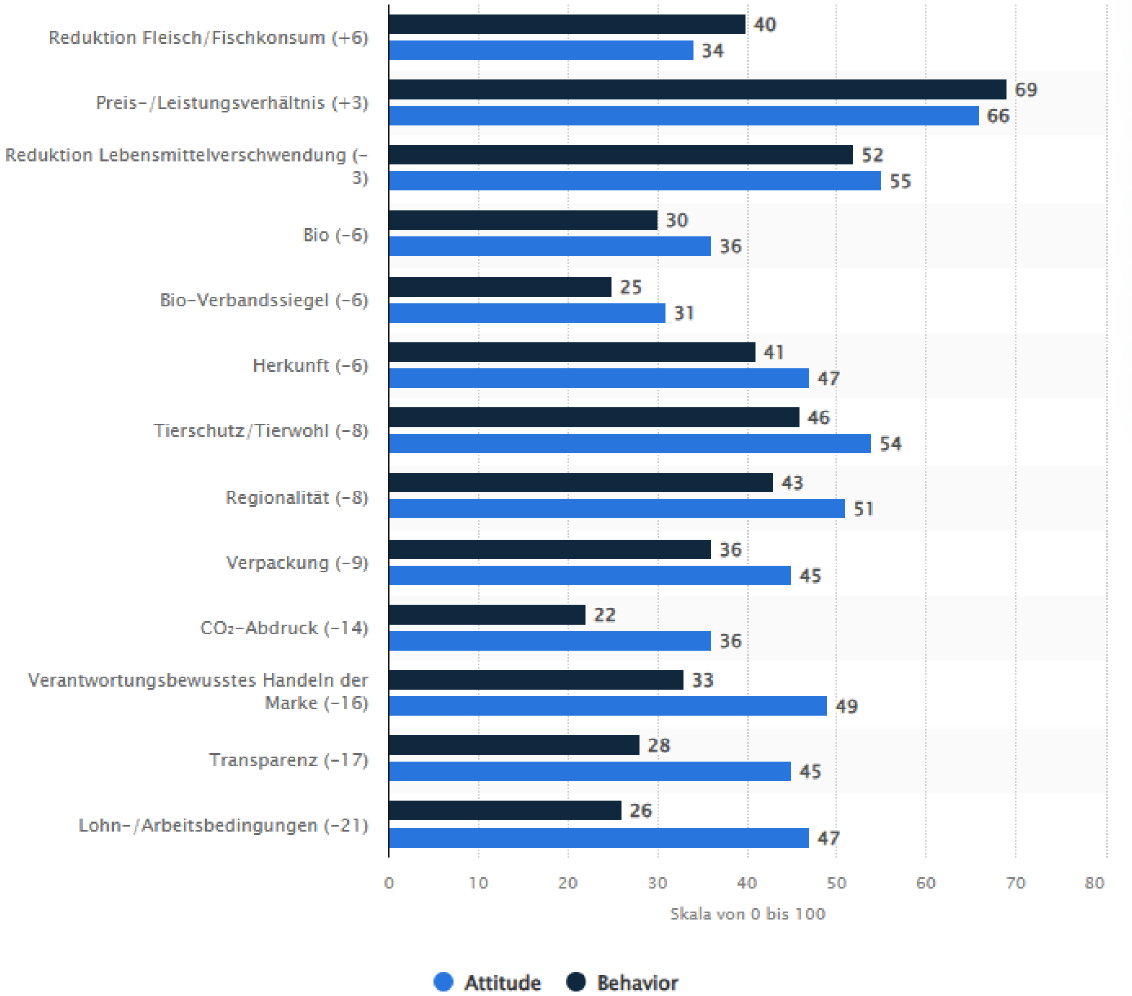


Figure 12 Attitude behavior Gap among German grocery shopping
Source: Statista, 2022

Furthermore, the report has identified significant disparities across categories, including transparency, wages and working conditions, and carbon emissions.

To gain a thorough understanding of sustainable consumption behavior, it is necessary to not only be aware of the reasons behind the gap between attitudes and actions, but also to have knowledge of how behavior is typically shaped. There are three social cognitive frameworks that have dominated the research agenda of SC: “Theory of Reasoned Action”, “Theory of Planned Behavior”, and “Norm Activation Theory”. This thesis will build upon the work of Icek Ajzen to provide explanations for consumer behavior.

3.6.1 Theory of Planned Behavior

The “Theory of planned action”, which is built on the idea of reasoned action, has proven to succeed as a framework for modeling consumer behavior.

The key component of the notion of planned behavior is the person´s intention to carry out a specific action. Additionally, Intentions are thought to reflect motivational drivers that influence behavior, indicating how much effort a person intends to put into engaging in the behavior. Even though some behaviors may in fact fulfill this condition rather well, the performance of the majority is at least somewhat dependent on non-motivating factors like the availability requisite opportunities and resources (Ajzen, 1985).

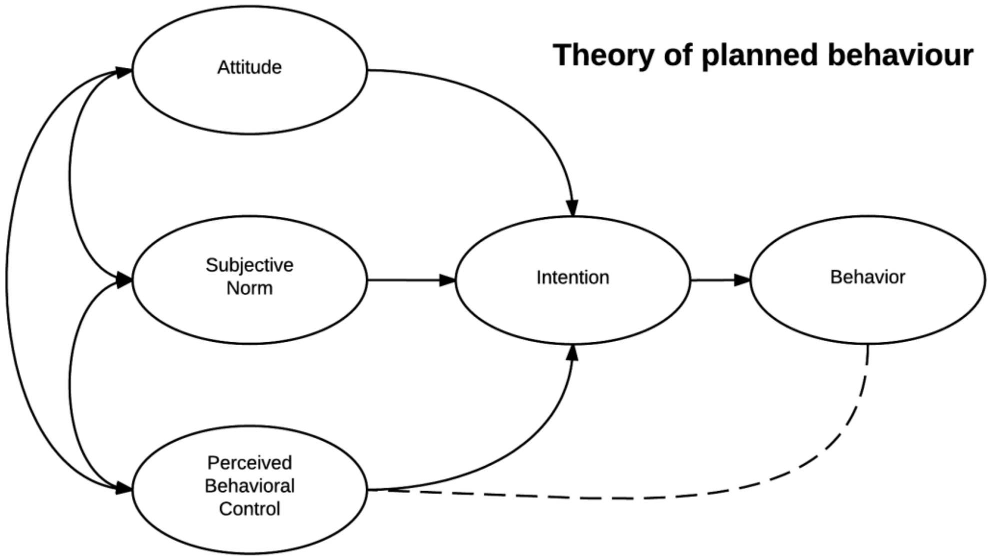


Figure 13 Theory of planned behaviour

The definition of attitude can be broadened to include a cognitive process containing positive negative valences, moods, or emotions when looking more closely at how attitudes are formed. An agitated mood, a favorable or unfavorable emotion, or a motivating factor are all parts of an attitude toward an item. Because attributes are very complex, many researchers used multi attribute attitude models to understand them. This kind of model assumes that a consumer’s attitude of a product is influenced by his or her opinions about several of its attributes. One product is frequently made up of several different attributes or features, and consumer´s preferences or a product is influenced by its composition. Then, by combining these attributes the overall consumer´s attitude is measured. Three basic components are used in basic multi attribute models (Solomon, 2010):

1. Attributes
2. Beliefs
3. Importance Weighs

To conclude this section, the most influential multi attribute model is the Fischbein model and its basic formula is as follows:

$$A_{jk} = \sum \beta_{ijk} \; * I_{ik}$$

i = attribute

j = brand

k = consumer

I = the importance weight given attribute I by consumer k

β = consumer k´s belief regarding the extent to which brand j possesses attribute i

A = a particular consumer´s (k´s) attitude score for brand/product j

According to the TPB conceptual model presented in Figure 12, individual intentions serves as a mediator between behavioural attitude, subjective norms, and perceived behavioural control., which in turn affects actual behaviour. According to Ajzen (1991), intentions are a good predictor of how strong a person is willing to try to engage. A greater intention is typically thought to be able to predict behaviour. If a person has behavioural control over their actions, intention predicted to have an impact on performance (Ajzen, 1991). According to Belk et al., (2005), Shaw and Connolly (2006), there is still a lack of knowledge of the gap, particularly in the area of ethical or sustainable consumption. Because of this gap, it is increasingly difficult for marketers and others to address the issue and promote sustainable consumption. Consumer´s attitudes toward an object are shaped by the opinions they hold about it because of how certain features are linked to it (Ajzen, 1991). Market share is an excellent way to gage the size of the attitude-behaviour gap to put it into perspective.

According to a variety of studies on consumer behaviour, purchasing intentions may not always translate into actual purchasing behaviour. Additionally, there are additional environmental and individual elements that influence how consumers make decisions.

3.6.2 Driver and Barriers

The following chapter summarizes the major findings of the academic literature dealing with barriers and drivers of CS. This should provide more clarity into this complex topic and helps to identify relevant factors for the underlying study.

Previous studies have recognized various situational and individual factors that affect the gap between attitude and behavior (ElHaffar et al., 2020; Vermeir & Verbeke, 2008). It is crucial for companies to be mindful of these factors to lessen the attitude-behavior gap among consumers. An in-depth and well-organized analysis of the current academic literature on the factors that drive and hinder sustainable consumption was presented by Wintschnig in 2021. The article focused on the issue of the attitude-behavior gap, which can be classified into two main categories: factors related to individuals and factors related to the environment.

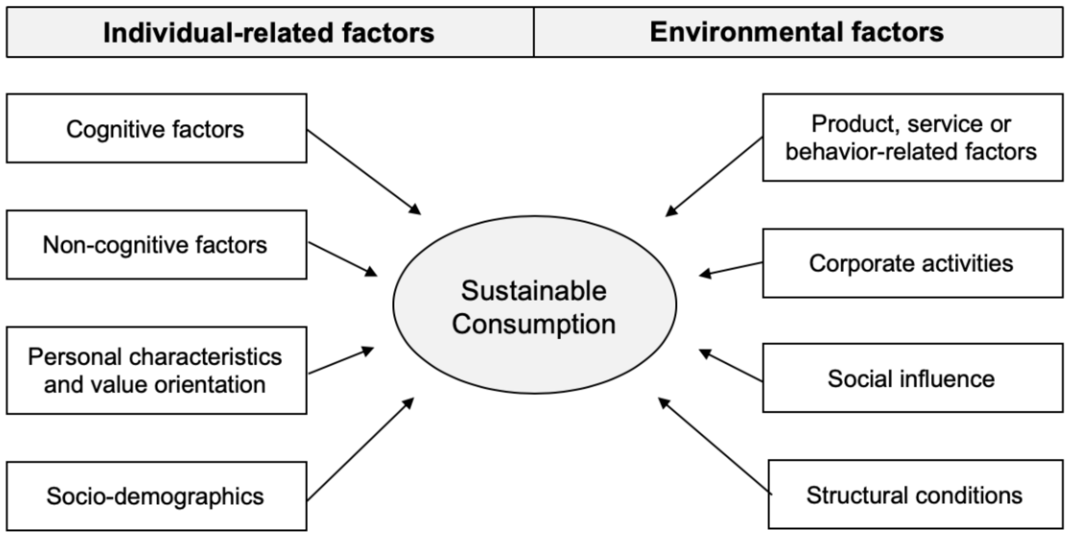


Figure 14 The main factors that have an impact on sustainable consumption
Source: Adopted from Wintschnig, 2021, p.

As shown in Figure 13 the former includes social demographics (age, income level, education level, gender, and religiosity), personal characteristics and value orientation, non-cognitive factors (habits and emotions), and cognitive factors like knowledge. Notably, although demographic variables have been used to understand the adoption of sustainable practices, their inconsistent and inconclusive results limit their usefulness in this regard (Diamantopoulos et al., 2003). For example, when it comes to gender differences, they are usually associated with varying personality traits that are commonly seen in women versus men (Brough et al., 2016). As a result, research has shifted towards analyzing intrapersonal factors since socio-demographic factors cannot be altered through promotional measures.

The personal characteristics and values of consumers are indicative of their inherent disposition and character, which are established during their formative years. While these factors may not have a direct correlation with sustainability, they have been observed to significantly impact individuals' proclivity to engage in sustainable practices. Research has identified certain personal characteristics that may serve as drivers for translating attitudes into action. These include *altruism, commitment to one's beliefs, emotional intelligence, an individual's locus of control, long-term orientation, openness and affinity, and self-discipline* (Wintschnig, 2021, p.330).

Factors that are not cognitive are those that consumers are not consciously aware of, and as a result, they do not possess complete control over the consequences they produce (Wintschnig, 2021). On example is emotions. Positive or negative emotions frequently serve as both a generator and an inhibitor of sustainable action, as well as an effect of such action (Gregory-Smith et al., 2013). Another non-cognitive determinant that proposed to affect behavior are habits. Russell et al., (2017)posit that habits have the potential to significantly influence an individual's perceived behavioral control, which is a critical determinant of behavior in accordance with the Theory of Planned Behavior. Habits, in this context, are characterized as consistent patterns of behavior that operate without conscious thought and are guided by automatic responses (Lanken et al., 1994), requiring minimal cognitive effort in contrast to deliberate reasoning (Welsch & Kühling, 2009). However, automated responses may prevent consumers from choosing a different, more sustainable option because they may forget their initial intention to do so.

Research has shown that in addition to habit, past experiences linked to a sustainable action can also increase the probability of repeating that action (Vassallo et al., 2016). Some research even suggests, engaging in sustainable behavior adopted in one domain can potentially influence and encourage sustainable behavior in other domains of life (Thøgersen & Ölander, 2003).

Unlike the previous factors, cognitive one´s pertains to the consumer's intellectual activity (Wintschnig, 2021). The factors examined in this category include awareness, knowledge, and concern. Research has shown that individuals who are more aware of the consequences of their actions tend to behave more responsibly.

One important cognitive factor that motivates sustainable consumption is the individual's sense of personal responsibility towards environmental and social issues. Studies have shown that denying such responsibility can hinder behavioral change. Another related concept is "consumer effectiveness" which refers to the belief that one's consumption decisions can make a difference in protecting the environment.

Factors influencing choices related to products, services, or behaviors are known as environmental determinants. These factors may include preconceptions about sustainable products, efforts made by companies in their communication, influence of society, and availability of options based on the prevailing structures.

4 HYPOTHESIS

A variety of factors, such as perceived value, the presence of alternatives, manufacturing costs, consumer values, awareness and education, brand loyalty, convenience, and social impact, affect consumers' willingness to pay for circular or sustainable products. Companies may stimulate the adoption of circular products and persuade consumers to adopt more sustainable consumption practices by recognizing these variables and adapting their strategy appropriately.

4.1.1.1 Access to Information

The information-asymmetry between buyer and sellers is one of the major barriers keeping consumers away from ethical consumption. Businesses use a variety of methods nowadays to inform their clients to overcome this barrier. They might give consumer comprehensive information by writing it on the packaging, displaying it in stores, or advertising. However, informing through labels that coney a certain statement is a prominent approach for businesses and NGOs worldwide. “Fairtrade” is a prime example of such a label.

Numerous studies show that choosing more environmentally friendly products is more likely when consumers are interested in learning about the product and are familiar with the notion of sustainability. Potoglou et al., 2020 discovered that across different countries, a reasonable understanding of sustainability-related issues yields moderate importance of sustainability for the purchase decision in the case of cars and phones.

Additionally, as an informed consumer, it is imperative to possess a comprehensive understanding of environmental and social issues. Such knowledge can take two distinct forms: factual and action-related knowledge. The former involves comprehending the definitions, causes, and consequences of these issues, while the latter pertains to knowing how to take meaningful action to address them (Hines et al., 1987; Tanner & Kast, 2003). It is widely acknowledged that action-related knowledge has a more pronounced impact on behavior (Tanner & Kast, 2003). For example, it empowers customers to differentiate between sustainable items and those that are not eco-friendly. Research has indicated that the capacity to engage in responsible purchasing practices is a key factor in driving progress, whereas a deficiency in this ability can be a hindrance (Shaw & Clarke, 1999). Stressing that, the findings of a recent study indicate that a significant majority of respondents, accounting for 70%, refrain from purchasing eco-friendly products due to a lack of understanding of their scope and characteristics (Lin & Chang, 2012). Hence, one of the main obstacles preventing people from adopting green consumption habits is the lack of knowledge on how to carry out sustainable behaviors and identify the most sustainable actions (Thøgersen, 1994).

H: The utility derived from circular product attributes is higher for users that inform themselves about products before the purchase than for users who do not.

4.1.2 Environmental Awareness

Literature describes that the value that customers place on various product attributes while making a purchasing choice is greatly influenced by sustainability attitudes. For example, Sherer et al. (2028) discovered that environmentally aware consumers are more likely to choose a product with a higher share of bio-based synthetics. Similarly, Brand and Rausch (2021) stated that green consumers value sustainable packaging. Material, and country of origin of an outdoor jacket more than less green consumers.

Consensus among experts suggests that although awareness plays a role in promoting sustainable behavior (Buerke et al., 2017), its direct impact is limited (Kollmuss & Agyeman, 2010). Moreover, the idea of environmental knowledge is closely linked to and often hard to differentiate from awareness. There are varying opinions on the correlation between knowledge and sustainable actions. While some studies suggest a positive relationship (Hines et al., 1987; Tanner & Kast, 2003), others argue that knowledge plays a minor role (Grob, 1995; Vainio & Paloniemi, 2014). This discrepancy can be attributed and explained to the distinction between factual and action-related knowledge, which is particularly significant in the context of sustainability.

As an informed consumer, it is imperative to have a comprehensive understanding of environmental and social issues. Such knowledge can take two distinct forms: factual and action-related knowledge. The former involves comprehending the definitions, causes, and consequences of these issues, while the latter pertains to knowing how to take meaningful action to address them (Hines et al., 1987; Tanner & Kast, 2003). It is widely acknowledged that action-related knowledge has a more pronounced impact on behavior (Tanner & Kast, 2003). For example, it empowers customers to differentiate between sustainable items and those that are not eco-friendly. Research has indicated that the capacity to engage in responsible purchasing practices is a key factor in driving progress, whereas a deficiency in this ability can be a hindrance (Shaw & Clarke, 1999). Stressing that, the findings of a recent study indicate that a significant majority of respondents, accounting for 70%, refrain from purchasing eco-friendly products due to a lack of understanding of their scope and characteristics (Lin & Chang, 2012). Hence, one of the main obstacles preventing people from adopting green consumption habits is the lack of knowledge on how to carry out sustainable behaviors and identify the most sustainable actions (Thøgersen, 1994).

H: High Environmental awareness increases the importance consumers give to circular product attributes.

Customers that respect environmental responsibility and sustainability would be more inclined to pay more for circular items. This may be especially true for younger customers who are more conscious of how their purchases affect the environment and are prepared to pay extra for goods that share their ideals.

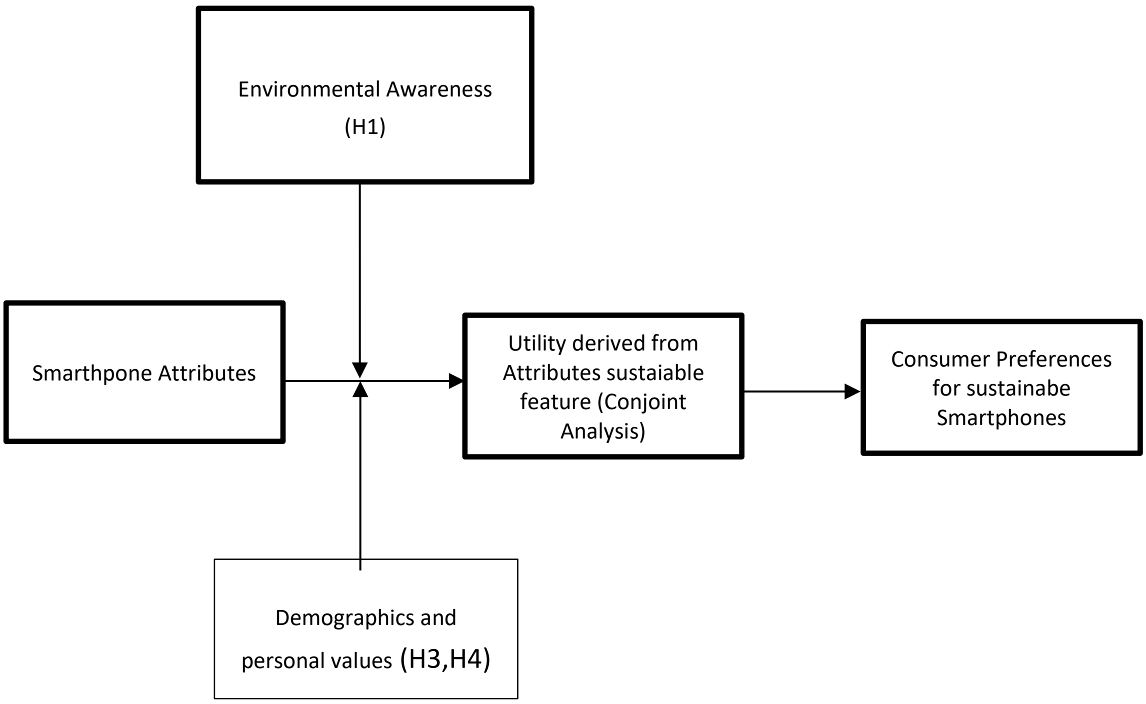
4.1.3 Gender

Most academic argue that women are more likely than males to have favorable attitudes with the green movement. Eagle (1987) argued that women would more carefully evaluate the influence of their acts on others because of social development and sex roles differences, which provides theoretical support for this. However, the literature on gender´s involvement in consumer adoption of green products is less clear, and when found having little or no impact (F. Klein et al., 2019).

H: The utility derived from circular product attributes is higher for woman than for man.

4.2 Conceptual Framework

The conceptual framework outlines the approach that is applied to connect all the relevant aspects as included in the research. It provides a road map that should guide throughout the research.



In summary, buyers are given the opportunity to choose between product profiles that are composed of varying degrees of circular smartphone attributes, starting on the left side. From these choices, the utility for each attribute can be derived. This utility will be used to determine the relative importance of the individual attribute and the WTP. The information effect and the identified segments are expected to affect the utility that customers derive from the separate attribute levels.

5 METHODOLOGY

The methodologies used in this thesis are described in this chapter, as well as an explanation on how the methods of analysis help provide insightful findings.

Choice based conjoint analysis serves as the foundation of this study. Since there are various kinds of conjoint analysis, it will first be discussed why this approach is considered appropriate. The study design is then emphasized while focusing on the implementation of CA. the methodologies employed for the analysis ae then detailed, together with any relevant practical consequences.

5.1 Research Approach and Design

Research papers frequently use the following five main methodologies: mixed methods, quantitative approach, arts-based research, community-based participatory research, and qualitative research (Leavy, 2017). There are several arguments in favor of doing quantitative research, particularly a descriptive online survey. Collecting and analyzing numerical data is referred to as quantitative research. It is frequently used to identify trends, averages, predictions, and cause-and-effect connections between the study's variables (Voxco, 2021). Additionally, it is employed to extrapolate study findings to the target population. Quantitative market research is widely used in the social sciences and natural sciences. Academics can adequately assess the background of a study issue thanks to descriptive statistics.

The author decided to conduct a quantitative research approach with a fixed design. First the participants were confronted with a more classical question-based survey. The choice was made to carry out an Adaptive Conjoint Analysis as the major measurement once the primary research questions and hypotheses were formulated. Conjoint Analysis (CA), are frequently used in literature to quantify the importance that customers attach to certain sustainable product features (Brand and Rausch, 2021). Additionally, many authors have already utilized CA to determine WTP (Hanson and Martin 1990, Eppen et al. 1991, and Vankatesh and Mahajan 1993). The great majority of research use a Choice-Based Conjoint Analysis to determine customer WTP for sustainable products and to decompose the meaning of certain sustainability indicators (such as labels) (Klein et al., 2020). This method measures how much the purchasing decision is influenced by price in relation to other considerations. However, there are a few drawbacks to CBC studies according to literature. First, they can only investigate at a small number of variables without overwhelming the responses (Klein et al., 2020). Second, due to their inability to control extreme response behavior, they compute WTP incorrectly (Gensler et al., 2012). After careful consideration, it has been determined that an adaptive conjoint analysis would be the most appropriate approach to handle the multitude of attributes involved in this study. This methodology has been widely accepted in academic circles as a reliable and effective means of analyzing complex data sets.

In addition to the primary measurement, the author has incorporated two supplementary measurements, along with a classification based on standard socio-demographic characteristics. Keeping in line with the domain of smartphones, the author has also included additional questions that provide valuable insights into usage behavior. A key objective of the thesis is to garner further insights into individuals' attitudes towards sustainability and smartphones. To this end, the author has selected the "New Ecological Paradigm" (NEP) scale as the second supplementary measurement.

5.2 Sampling procedures

The present study employed Sawtooth Software, a commonly utilized tool for conjoint analysis, in the design of an online questionnaire. The survey was distributed during the summer of 2030 to a sample of European residents for the purposes of data collection. The study focuses on adults who own smartphones and are aged between 15 and 65, residing in the European Union. To ensure a balanced sample, the researcher identifies respondents from each representative country within the EU. The EU currently comprises 27 Member States, including Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. In addition, since England has historical roots as part of the EU and shares the same language as this study, the author has included it in the target population.

The author decided to use the convenience sampling method for this study. Convenience sampling is a type of non-probability sampling in which people are chosen because they are a "convenient" source of information. In probability sampling, everyone within the population has a non-zero but known probability of being selected by a random selection mechanism. Additionally, there is no requirement for known selection probabilities larger than zero in non-probability sampling. Convenience sampling is expected to be the least expensive, least time-consuming, and most convenient. However, it is especially susceptible to selection bias which might lead to a nonrepresentative sample.

The primary objective of the study was to employ snowball sampling through social media channels. However, in order to enhance response rates and gather data from regions where personal connections are not available, the "Clickworker" panel was utilized.

As with any research, the goal is to select a representative sample and reduce sampling errors. To determine the sample size needed for the study, the author first looked for existing literature and similar research in the field to draw a first estimate. The usual sample size used for CA in marketing research is 200-300 participants.

5.3 Adaptive Conjoint Analysis

Conjoint analysis was first introduced in the early 70s and has had increasing in various areas of marketing, and science (*The ACA/Web v6.0 Technical Paper ACA System for Adaptive Conjoint Analysis*, 2007). Since than it has become a powerful research method for understanding consumer preferences and decision-making processes. Additionally, recent developments in the technology and statistical modeling have increased its use and flexibility. CA analysis, when use effectively, may offer insightful data that can guide cooperate choices and promote expansion. Using this statistical method, researchers may examine how customers value certain characteristics of aspects of a good or service and make predictions about how they will act in various situations.

In general, CA is predicated on the idea that customers make decisions based in a mixture of traits or qualities rather than on any one aspect alone. Respondents in a conjoint analysis research are shown a variety of fictitious product or service situations, each of which includes a set of attributes or features with varying levels. In order to follow their preferences and determine where they place their values, it provides them with fictitious yet plausible purchase scenarios. Researchers may asses the relative impact of various traits and levels as well as how they interact with one another to influence consumer behavior by studying the decision that respondents make across these situations. It is mostly used to find the best product design, price plan, or market segmentation, among any other research problems. Especially helpful in sectors like technology, healthcare, and automotive where product characteristics are intricate and multifaceted.

There are many different kinds of conjoint analysis, but the two that are the most frequently used in market research are choice-based (CBC) and adaptive (ACA). The great majority of research use a Choice-Based Conjoint Analysis to determine customer WTP for sustainable products and to decompose the meaning of certain sustainability indica-tors (such as labels) (Klein et al., 2020). This method measures how much the purchasing decision is influenced by price in relation to other considerations. However, there are a few drawbacks to CBC studies according to literature. First, they can only investigate at a small number of variables without overwhelming the responses (Klein et al., 2020). Second, due to their inability to control extreme response behavior, they compute WTP incorrectly (Gensler et al., 2012). And third, because they assume that respondents would use compensatory decision heuristics when answering, despite evidence showing that respondents will use none-compensators ones(Ryan et al., 2009; Yee et al., 2007).

Conversely, adaptive conjoint functions somewhat differently. It adjusts, as the name implies, depending on the decision respondents make. ACA was specifically designed to handle scenarios with large numbers of attributes and levels(*ACA Technical Paper (2007)*, n.d.). Thus for large or more complicated research, the technique is a little more effective since it focuses on people´s top traits and levels.

First, let's clarify some important terminology to design the thesis' CA: First, let's clarify some important terminology to design the thesis' CA:

- **Attributes:** They are frequently referred to as the characteristics of the good or service. Those are the facts of the offering that respondents will assess. For instance, a mobile phone´s qualities can include its cost, color, size, camera quality, or battery life.
- **Levels:** Simply said, levels are the alternatives that correspond to each attribute that will be tested. Using the aforementioned case as an example, one may wish to comprehend the importance that consumers place on cellphones color, camera quality, or battery life.
- **Profile or Cards:** The fictitious product (or service) offering created during the experiment is represented by a profile or card. It displays all of the respondents' traits in their whole package at random levels.

5.3.1 ACA Questionnaire

The ACA survey has the capacity to handle up to 30 attributes, with each attribute accommodating up to 15 levels. Nonetheless, the majority of ACA studies concentrate on 8 to 15 attributes, with no more than 5 levels per attribute. As per the ACA Technical Paper (2007), an ACA interview comprises four sections, each targeting a specific area.

The first section of the question pertains to the respondent's preferences regarding the distinct levels of the conjoint design. To elaborate, respondents are asked to rate the levels based on their relative preference. This question is omitted for attributes such as price or quality, as the respondent's preferences should be obvious. For instance, a list of potential smartphone brands (Apple, Samsung, etc.) may be displayed on screen. The respondents is required to check one radio button to rate each brand based on its desirability. The rating scale can range from using two to nine point scales. For this study, a seven-point scale was utilized, in keeping with Sawtooth's recommendation.

The second segment of questions in an ACA serves to gather data on attribute importance. After establishing preferences in part one, this step seeks to determine the relative significance of each attribute for every respondent. The obtained information can be valuable in two ways. Firstly, it may enable researchers to exclude certain attributes from further evaluation if the interview would otherwise be overly extensive. Secondly, it serves as a basis for initial estimates of respondents' utilities.

The questions are based on differences between those levels the participant would like best and least. With the example of smartphone brands, one may be asked: if two smartphones were the same in all other ways, how important would this difference be to you”. This could imply the brand of the most preferred manufacturer, for example Apple instead of the least famous brand LG. Once again respondents selected one radio button on a seven-point scale.

Following the initial two sections of the survey, sufficient data has been collected to determine the most significant attributes for each participant and their preferred levels. Moving forward, the ACA interview focuses on the most crucial attributes and the combinations of levels that indicate the most difficult trade-offs.

In section three, following the initial stages of the interview, where preliminary information was gathered, in section three a set of personalized paired-comparison questions were introduced. The purpose of the Pairs section is to gather insights into the trade-offs respondents are willing to make when comparing two product concepts. In each instance, the respondent is presented with two product ideas and is asked to express their preference between them and the strength of that preference.

The computer initiates the process with rough estimates of the respondent's preferences, which are then refined after each paired comparison question. These initial estimates are derived from the respondent's rankings or ratings of attribute levels and their perceived importance. The computer strategically selects each paired question to maximize the new information it provides, considering what is already known about the respondent's preferences. This process continues until a predefined termination condition, as set by the author, is met.

With every completion of a paired question, the system updates its estimate of the respondent's preferences. This updating enhances the accuracy of future paired questions, leading to more precise results.

In the final step, the computer creates "calibrating concepts" based on key attributes. These concepts cover a range from unattractive to highly attractive. Respondents rate their likelihood of buying each concept. This likelihood can be indicated using a slider scale or by entering a numeric value. The first concept presented is expected to be the one the respondent likes the least among all possibilities, and the second one is expected to be their favorite. These two concepts establish a reference point. The remaining concepts are selected to have varying levels of attractiveness. The purpose is too non-arbitrarily adjust the utility values obtained earlier, making them more comparable to respondents' likelihood ratings. This aids in purchase likelihood simulations during analysis.

5.3.2 Average Importance's of Attributes

By exploring the average importance, the author aims to uncover the features and attributes that matter most to a target audience, thereby contributing to a more consumer-centered approach in product development, marketing strategies, and business decisions.

The output of ACA, average importance's, plays a crucial role in synthesizing and communicating consumer preferences. These values offer valuable insights into the relative significance of various attributes and their levels in influencing consumer choices. They are commonly utilized to determine which attributes hold greater or lesser importance to consumers. Furthermore, average importance provides a clear and straightforward way to compare and rank attributes, enabling the identification of areas of focus for marketing, design, and strategy. Consequently, the author has selected it as the primary measurement for this thesis.

The methodology of this research involved collecting data through an online survey where respondents evaluated various product profiles by weighing trade-offs among attribute levels. Statistical models were utilized to estimate individual-level part-worth utilities which represent the significance of attribute levels for each respondent. These utilities form the basis of our analysis and were aggregated to obtain the average utility scores for each attribute level. The higher the utility score, the more important that attribute level is in the decision-making process. To increase interpretability, the utilities were normalized to a consistent scale (e.g., 0 to 100) allowing for direct comparisons. The attribute level with the highest average importance was scaled to 100, while others were scaled proportionally. The overall preference for each attribute level across the respondent population was quantified by computing the average importance of each level, which is the average of the normalized utilities.

5.3.3 Average Utility of Attribute Levels

Beyond the identification of the average importance of attributes, another critical dimension of ACA analysis is the determination of the average utilities associated with different attribute levels. Average utilities provide a nuanced and profound understanding of consumer preferences, guiding product development, marketing strategies, and strategic decision-making. In this section, we delve into the methods employed to calculate average utilities and explore their interpretation, shedding light on the factors that drive consumer choices.

Data is gathered through structured surveys where respondents evaluate a set of product or service profiles. Advanced statistical models, such as Hierarchical Bayes estimation, are commonly used to estimate individual-level part-worth utilities for each attribute level. These utilities quantitatively represent the value or desirability of a specific attribute level to each respondent. The utility estimation process is crucial, as it allows to understand the unique preferences of individual consumers. The individual-level utilities are aggregated to calculate the average utility for each attribute level. This aggregation provides a population-level view of how consumers, on average, value different attribute levels.

5.3.4 Measuring WTP

In the context of sustainability, determining consumers´ WTP for sustainable products has grown in popularity within literature throughout the past years. The ability to estimate a buyer´s WTP for a product has been done in a variety of ways. Hedonic pricing analysis, conjoint analysis, and experimental auctions are some of the techniques frequently used to determine customer´s WTP (Grenn and Srinivasan, 1990). Numerous studies have explored various factors that influence WTP and its implications across different domains. Research has shown that consumer´s WTP is influenced by the characteristics of the product or service being offered. Attributes such as quality, durability, convenience, and environmental sustainability can significantly impact WTP. Additionally, personal factors including income, age, education, and cultural background can further influence WTP. For example, higher income individuals tend to have a higher WTP, while preferences and values shaped by cultural and social factors also play a role. Lastly, WTP can vary depending on the context and the presence of alternatives. Factors like market competition, availability of substitutes, and scarcity of resources can affect consumer WTP.

Valid WTP estimations are crucial for creating the best price target in marketing, according to Balderjahn (2003). These projections may be used to model demand functions and predict how the market will likely react to price changes. There are numerous methods, which Figure 1, adopted from Breidert et al. (2010) , presents a categorization of the different methods for estimating consumer´s WTP. Techniques like contingent valuation and choice experiments are commonly used to elicit individuals WTP.

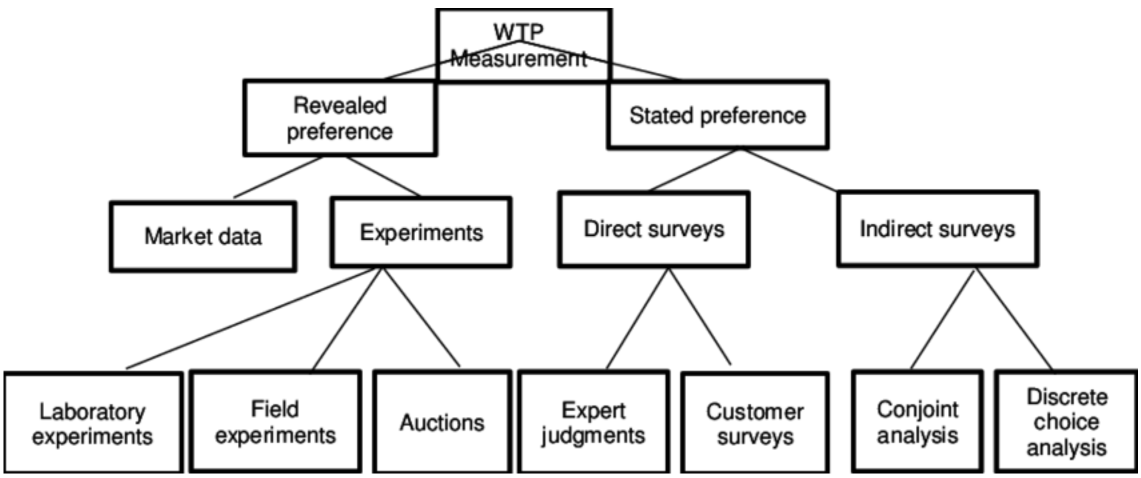


Figure 15 Classification framework for methods to measure willingness-to-pay
Source: Adopted from Breidert et al., 2010, p.

On the top, methods are distinguished whether a method is based on data from observations or surveys. To examine observations more closely actual data, such as real market data, or experiments might be carried out. The other categories for experiments are field experiments and laboratory experiments. Observations are also known at revealed preferences.

Stated preferences methods involve presenting hypothetical scenarios to respondents and asking them to state their WTP for the described good or service. Revealed preferences, this approach examines the actual consumer behavior in real markets. Methods such as hedonic pricing, travel cost analysis, and auction-based experiments analyze observed market prices and consumer choices to infer WTP directly. The comparison of the various approaches shows unequivocally that there is no one strategy that should always be employed. Instead, it relies on the researcher’s goal. Different pricing strategies can be explored through field experiments in actual market situations if costly techniques can be used and immediate results are not the main concern. Applying less time-consuming and more affordable surveying procedures may be more effective if WTP estimates are regularly required.

Many authors have already utilized CA to determine WTP (Hanson and Martin 1990, Eppen et al. 1991, and Vankatesh and Mahajan 1993).

There are direct and indirect surveys available for the purpose of estimating WTP. Declared preferences is another term for preference information gleaned via surveys. Probands are questioned about their willingness to pay for various products in direct polls. A rating or ranking system is further used in indirect surveys to compare various items. An indirect form of surveying is conjoint analysis. However, there are alternatives discussed in the literature that offer an alternative categorization. Marbeau (1987), distinguished on the highest level, whether they are competitive or monadic tests. With monadic tests pricing information is gathered without taking the competitive environment into account. Competitive tests contain a competitive context.

Whether they elicit pricing information at the individual level or the aggregate level, Balderjahn (2003) separates estimate approaches on the highest levels.

Nagle and Holden (2002), distinguish between experimentally controlled and uncontrolled assessment of the variables when classifying strategies for estimating price sensitivity at the highest level. They further categorize the methods depending on the variable measurement, separating them into categories for measuring both buy intention and purchase behavior.

5.3.5 Identification and Categorization of key attributes related to sustainable smartphones.

The major concern of the following literature review is to derive circular product attributes for smartphones. To do so, the Author decided to draw on literature from two categories. First, as part of the literature review, the literature was screened for definitions and frameworks of the circular economy. The second step was to look for papers that have already used conjoint analysis in the context of sustainable products.

Table 1, adopted from Fuchs and Hovemann (2002), provides a representation of the different circular economy categories and provides methods that are in use to tackle those problems.

Table 1 Methods along the circular economy´s categories

Categories	Subcategories
Reduce	Energy and Water Consumption Minimize Waste and Emissions
Circular Products	Durability Repairability Reuse Rental/ Pay-per-use
Circular Materials	Using recycled Materials Recycling of Products Remanufacturing
Regenerate Nature	Shift to renewable Materials and Energy to support conservation and restauration projects

Through extensive research, we have uncovered several crucial findings. Our results indicate that both price and brand reputation significantly impact consumers' decision-making process. This underscores the significance of affordability as well as maintaining a sustainable and favorable brand image.

There is a noticeable trend among consumers towards smartphones with robust durability, easy repairability, efficient recyclability, and upgradability. This highlights a growing demand for sustainable product features.

The extent of warranty coverage for a given product significantly impacts the consumer's perception of its reliability and overall satisfaction. The availability of extended warranty options is highly regarded by customers.

Consumer preferences were impacted differently based on the condition of the smartphone. Some individuals showed a preference for new devices, while others expressed interest in preowned or refurbished options due to their sustainability benefits.

There has been notable interest from consumers who prioritize ethical production practices and social responsibility in obtaining social sustainability certificates. This trend highlights the importance of social sustainability in today's market and the growing desire for transparency and accountability in supply chains.

Each of the following attributes in the conjoint analysis holds significance in understanding consumer´s preferences for sustainable smartphones.

5.3.6 Definition and operationalization of attribute levels

The most important aspect of a conjoint design is to select the attributes and levels for the study. This chapter discusses this process.

5.3.6.1 Price

When consumers make purchasing decisions, the price is crucial for the buying consideration. This study aims to determine the most suitable price range that combines affordability and sustainability by analyzing their preferences across a range of prices. However, deciding on realistic price points has proven to be difficult due to the significant price differences among devices. For instance, while one can easily purchase a phone for less than 200 Euros, prices for more advanced and stylish devices can exceed 1000 Euros. As a result, the author anticipates that price will strongly influence customer choices. Customers will certainly prefer lower prices over higher prices. Therefore, the following price levels have been established for the online survey:

Level 1 - 300 EURO
Level 2: 500 EURO
Level 3: 700 EURO
Level 4: 900 EURO

5.3.6.2 Phone Type

The preferences of consumers towards the freshness of products, cost-saving alternatives, and ecological impact are manifested in their choices of new, refurbished, or pre-owned smartphones. By analysing these preferences, strategies can be formulated to promote circular economy practices. Consumer preferences for phone type reflect their individual values and priorities. Some consumers are primarily interested in the latest technology and features, while others prioritize sustainability and reducing their environmental footprint. "Phone Type" directly relates to the environmental impact of the product. New phones are often associated with higher carbon footprints due to the manufacturing process, whereas refurbished and sustainable green phones are typically perceived as more environmentally friendly choices. The concept of a circular economy is gaining traction in the smartphone industry. "Phone Type" is closely tied to this concept as it evaluates whether consumers are willing to choose refurbished or sustainable green phones, contributing to the reuse and recycling of electronic devices, which is a key aspect of circular economy principles. Sustainable green phones and refurbished phones are often considered more budget-friendly options compared to brand-new phones. By assessing consumer preferences for phone type, manufacturers can determine the demand for affordable, eco-friendly alternatives and offer products that cater to a broader range of budgets. Sustainable green phones are designed to use fewer resources and reduce e-waste. By understanding how consumers value these attributes in relation to new or refurbished phones, manufacturers can optimize their product offerings to contribute to resource conservation. Analysing consumer preferences for phone type can also serve as a valuable tool for educating consumers about the benefits of choosing refurbished or sustainable green phones. Manufacturers can use the data to create educational campaigns that raise awareness about the environmental and cost-saving advantages of these options.

In a related study conducted by Fuchs & Hovemann (2022), consumer preferences for circular outdoor sporting goods were examined using a CA. One of the key variables examined in the present study was the condition of the product, which was operationalized by providing participants with the option of either a new or pre-owned item. After careful consideration, "Phone Type" was included as an attribute for investigation within the adaptive conjoint analysis. This attribute encompasses various factors such as consumer values, environmental impact, affordability, resource conservation, market segmentation, education, product development, and regulatory considerations. Accordingly, the following levels have been added to the CA design:

Level 1: New Phone
Level 2: Refurbished Phone
Level 3: Sustainable Green Phone

5.3.6.3 Warranty

The reliability of a product and the level of commitment to customer satisfaction demonstrated by the manufacturer are often evaluated by consumers based on the warranty coverage provided. To ascertain the appropriate level of post-purchase support desired, it is essential to gain an understanding of preferences for different warranty options.

In general, A warranty is a crucial element in establishing trust with consumers when it comes to the quality and reliability of a product. In order for smartphones to be deemed sustainable, they must be able to compete in both performance and durability. One effective strategy that manufacturers can employ to showcase their commitment to sustainability and quality is by providing more comprehensive and longer warranties, which serves as a testament to their dedication to creating products that are environmentally friendly and dependable. Research shows that longer warranties can play a crucial role in boosting consumer confidence in their purchases. By offering extended warranties, manufacturers can provide a sense of security and reliability that can go a long way in ensuring customer satisfaction. In fact, by analysing warranty preferences, manufacturers can determine the optimal duration and terms of warranty that will ensure the most confidence in the sustainability and reliability of their products, especially in the case of smartphones. Ultimately, longer warranties can help consumers feel more confident in their purchases, while also benefiting manufacturers by enhancing customer loyalty and trust. Sustainable smartphones are often associated with reduced environmental impact. Additionally, offering a longer warranty can signal that the manufacturer expects the product to have a longer life, reducing replacements and contributing to sustainability. Warranty terms can serve as a powerful communication tool to highlight the sustainability of a product. Manufacturers can, for example, emphasize how a longer warranty helps in reducing e-waste and minimizing the overall environmental impact. Knowing the preferences of customers regarding warranty also helps in creating effective sustainability messages that can persuade them to choose sustainable products.

The warranty is a crucial attribute to consider in adaptive conjoint analysis for sustainable smartphones. It impacts quality assurance, consumer confidence, risk mitigation, and more. A well-designed warranty can enhance the appeal of sustainable smartphones and contribute to their long-term success.

Level 1: No warranty
Level 2: Standard warranty (2 years)
Level 3: Extended warranty (5 years)

5.3.6.4 Repairability

Sustainable consumption is an important topic, and the durability and repairability of smartphones are key factors to consider. Sustainable products aim to reduce their environmental impact over their lifecycle. Repairability aligns with the goals of the CE paradigm by extending the useful life of a device, thereby reducing the need for frequent replacements and the associated production and disposal of electronic waste. Additionally, the issues of E-waste is a significant environmental concern, and smartphones contribute to this problem due on their relatively short lifecycle. The overarching argument is the Repairability encourages the conservation of valuable resources like minerals, metals, and rare earth elements used in smartphone manufacturing. By repairing and reusing components instead of constantly producing new devices, the demand for these resources can be reduced, lessening the environmental impact associated with extraction and processing. However, more importantly repairability gives consumers more control over the lifespan of their devices. This empowers them to make choices that align with their values, which is an important aspect of sustainability. Sustainable products should not only be eco-friendly but also user-friendly and adaptable to individual needs. On the regulatory level repairability has also gained a lot of attention. Some governments, like the European union, are considering or implementing laws to promote repairability, which can significantly impact the smartphone market. Therefore, understanding consumer preferences regarding repairability is critical for smartphone manufacturers to remain compliant with evolving regulations. Additionally, Smartphone brands can differentiate themselves from their competitors by having a better repairability score. This can be a unique selling point, and offering repairable smartphones can lead to long-term brand loyalty. With consumers becoming more conscious about the environmental impact of their purchases, a company's reputation for producing repairable devices can enhance its brand image and market position.

In conclusion, repairability is a vital attribute to consider, due to its significant implications for environmental conservation, resource management, cost-effectiveness, regulatory compliance, competitive advantage, and the overall sustainability of the product. By analysing consumer preferences regarding varying levels of durability and repairability, one can gain valuable insights into their inclination to invest in long-lasting products and their demand for repair options. Such insights can inform business decisions and strategies that align with sustainable consumption practices.

Level 1- limited repairability: This particular category of smartphones is characterized by a complex design, necessitating the services of authorized personnel for repairs. Moreover, the availability of spare parts is notably scarce, thus posing a significant challenge in addressing any repair needs.
Level 2 - Moderate Repairability: At the second level, there exists a provision of repair parts and guides, however, the execution of repairs demands a certain level of intermediate skills.
Level 3 - High Repairability: At the third level of operation, spare parts are affordable and accessible. The process of disassembling and reassembling the components is relatively simple and can be executed by individuals with basic skills. Smartphones that have a modular design, such as the Fairphone, would be considered as falling into this category.

5.3.6.5 Social Sustainability

In the realm of smartphones, social sustainability certifications serve to guarantee that ethical labour practices and social responsibility are being upheld. By evaluating the types of certifications that are preferred by consumers, it is evident that they place a high value on companies that prioritize social impact. Sustainability labels offer transparency on a product's environmental and ethical characteristics. With regards to sustainable smartphones, consumers are becoming more worried about the credibility of sustainability assertions. The use of "Sustainability Labels" can help establish confidence by certifying the eco-friendly and ethical aspects of the product, which can in turn have a positive impact on consumer decisions. Such sustainability labels are an effective way for manufacturers to communicate their commitment to sustainability and highlight specific eco-friendly features, such as recyclability, energy efficiency, and reduced carbon emissions. Consumer preferences for sustainability and ethics have become increasingly important for manufacturers in recent years. Sustainability labels, in particular, can offer valuable information to consumers about a product's ethical aspects, such as fair labor practices and responsible material sourcing. As such, it is crucial for manufacturers to understand and prioritize these preferences in order to meet the demands of socially conscious consumers.

Many sustainability labels involve third-party verification and certification. Consumers may place higher trust in products carrying such labels. By understanding which third-party labels are most influential, manufacturers can seek certification from reputable organizations to enhance the credibility of their sustainability claims. Sustainability labels are not only about the immediate environmental impact but also about the long-term sustainability of a product.

In summary, "Sustainability Labels" is an essential attribute to consider in an adaptive conjoint analysis for sustainable smartphones because it addresses consumer transparency, eco-friendly messaging, ethical considerations, market differentiation, regulatory compliance, education, customization, third-party verification, long-term sustainability, and market trends. In a related study conducted by Fuchs & Hovemann (2022), consumer preferences for circular outdoor sporting goods were examined using a CA. Sustainability labelling was included as a feature in their research, which prompted the author to incorporate it into this study as well. Accordingly, the levels are as follows:

Level 1: No sustainability label on the product.
Level 2: Labeled as eco-friendly with information about specific sustainability features.

5.3.6.6 Place of production

The place of production has a direct impact on the ethical sourcing of materials and fair labor practices. Consumers are increasingly concerned about the conditions in which their electronic devices are produced. Analyzing preferences for the place of production allows manufacturers to highlight their commitment to fair labor and ethical supply chain practices.

Different regions have varying environmental regulations and standards for manufacturing. By assessing consumer preferences for the place of production, manufacturers can showcase their adherence to strict environmental standards, emphasizing the reduced environmental impact of their products. Additionally, the location of production can influence the carbon footprint of a smartphone due to transportation and energy usage. Sustainable smartphones aim to minimize their environmental impact. "Place of Production" preferences provide insights into how consumers value lower carbon footprints achieved through local or energy-efficient manufacturing.

Sustainable smartphones often prioritize local and sustainable sourcing of materials. Preferences for the place of production can inform manufacturers about the importance of these sourcing practices to consumers and guide decisions related to materials procurement. Additionally, "Place of Production" can be a unique selling point. Manufacturers can differentiate their sustainable smartphones by promoting certain regions known for eco-friendly practices or advanced technology in production. Consumer preferences for the place of production also provide insights into market trends and evolving consumer perceptions. Manufacturers can use this information to stay ahead of emerging trends and adapt to shifting consumer values.

In the wake of the Covid-19 pandemic, global corporations have redirected their efforts towards enhancing their supply chain resilience to better handle unexpected exogenous shocks. Additionally, amidst global tensions and an ongoing war in Europe, governments are advocating for more localized production. Accordingly, this research aims to investigate if the same applies to consumers.

In light of the aforementioned considerations, it was deemed appropriate to incorporate the "Place of Production" element as an attribute in the adaptive conjoint analysis. This factor can have a profound impact on ethical sourcing, environmental standards, carbon footprint, transparency, local and sustainable sourcing, customization, risk mitigation, education, differentiation, and market trends. Therefore, designers of sustainable smartphones must take this attribute into account to create products that align with ethical and eco-friendly practices.

Level 1: Imported product
Level 2: Partially locally manufactured
Level 3: Locally manufactured

5.4 Additional Measurements

In addition to the primary measurement, the online survey included two supplementary sections to gather further information. The initial segment of inquiry, positioned before the actual conjoint analysis, requested respondents to share information regarding their behavior concerning the usage of smartphones. Following the conjoint questions respondents were presented with fifteen NEP questions to measure their overall attitudes towards the environment. The data gathered from these two questions will be discussed within the following chapter.

5.4.1 Smartphone Use Behavior

The initial part of the survey included questions about the respondent's smartphone usage habits. To begin with, participants were asked to identify the brand of their current smartphone. Brands were selected according to the companies real market shares in Europe (Statcounter Global Stats, n.d.) The list included eleven options: Apple, Samsung, Xiaomi, Huawei, Oppo, Motorola, Google, Fairphone, and LG. In addition to these brands "unknown" and "other brand” could be chosen.

Afterwards, they were asked about their typical usage duration before replacing their phone. Subsequently respondents were asked to estimate the expected lifespan of their phone's optimal functionality. Respondents were asked to select from five categories when indicating the length of time, they have owned their smartphone: "less than 1 year," "1 to 2 years," "2 to 3 years," "3 to 4 years," and "more than 4 years." The same categories were used to gather data on the expected lifespan of a new smartphone.

Additionally, the survey proceeded to investigate the reasons behind purchasing a new phone and the disposal method for the old one. The options included were Hort, Recycle, Sell, and Throw Away.

Participants were also asked to identify their most preferred durability feature from a list of options, including Drop and Impact Resistance, Scratch Resistance, Corrosion Resistance, Waterproofness, and "None of the Above".

Lastly, they were asked if they are aware of the environmental impact of improper smartphone disposal and if they would be more likely to purchase a smartphone brand that promotes sustainability.

5.4.1.1 Lifetime and Expected Use

To derive conclusive insights pertaining to the longevity of smartphones, respondents were presented with a set of two questions within the survey part regarding smartphone behavior. The initial one sought to elicit the actual duration of usage with respect to the participants' most recent mobile device. This following question prompts respondents to indicate their typical expectation for the flawless functioning of a new device. Any discrepancies between the provided answers may indicate a disparity between anticipated and actual usage, potentially highlighting an attitude-behavior gap as per the literature review. Two inquiries were presented in the form of radio button questions, encompassing a spectrum of five distinct ranges pertaining to the duration of usage. These ranges were classified as follows: less than one year, 1 to 2 years, 2 to 3 years, 3 to 4 years, and more than 4 years. In order to assess the outcomes, frequency tables were utilized to determine the percentages within each respective category, alongside a row denoting the cumulative percentages.

5.4.1.2 Replacement Reason and Dispose

In order to gain deeper insights into consumer behavior, particularly in regards to their smartphone usage habits, the second question of part one delved into the reasons behind smartphone replacements. By understanding why respondents opt to replace their previous phone, one can identify emerging trends, motivations, and priorities within the sample. Additionally, this thesis also gathers data on environmental concerns by exploring the reasons behind smartphone replacements, as electronic waste is a burgeoning issue as has already been discussed in the literature review.

The phenomenon of obsolescence pertaining to smartphones and their internal components, such as battery and circuit board, has been a topic of concern in the context of sustainable waste management. Once these components become obsolete, they no longer hold sufficient economic value for reinvestment towards reprocessing, recycling, or exportation. This obsolescence is in general a result of a combination of physical and psychological factors (Wilson et al., 2017). Mobile devices that operate on an outdated software system and lack the possibility of an upgrade undergo a significant decrease in economic resale value especially within the original geographical location (Green Alliance, 2015). However, they still hold a functional value in regions where a lower specification is the norm.

The conceptual framework proposed by Wilson et al., (2017) encompasses eight distinct categories of obsolescence. Absolute, Functional, Aesthetic, Economic, Technological, Ecological, Psychological, and Societal. Each category is characterized by a unique set of factors that contribute to the obsolescence of an object or a system. Table 3 presents a concise yet comprehensive explanation of these categories, providing a solid foundation for the analysis of obsolescence in the context of this thesis.

Table 3 Eight Categories of obsolecence

Category of obsolescence	Describtion
Absolute	Physical product failure, where through use or missuse a product ceases to function due to wear and tear or as the result pf breakage
Functional	Functional obsolescence refers to the inability of a product to meet the functional needs of the user when compared to newer products. It is determined by objective criteria such as economic depreciation and changes in the user's needs, such as buying a larger car after the birth of children, rather than subjective changes like taste, fashion, or status. In simpler terms, functional obsolescence occurs when a product becomes outdated and is unable to perform its intended function as well as newer alternatives.
Aesthetic	How a product looks in the context of cleanliness, wear and tear, newness and whether this is appropriate to the object (Burns, 2010; van Neset al., 1999), and furthermore, how a product corresponds with relevant image concepts, such as style, fashion, novelty and prestige (Burns,2010; Kostecki, 1998). Jeans, as an example, can be both fashionable and pre-worn whereas there is an expectation for consumer electronics tobe clean and pristine
Economic	The cost of a product, and when it becomes financially advantageous to replace the product. This could be when the existing product has a lowperformance/cost ratio when compared with a potential replacement (Kostecki, 1998; van Nes et al., 1999), or when the cost of repair,maintenance, or upgrade of a product is greater that the purchase price of a replacement (Cooper, 2004)
Technological	When a product becomes relatively inferior to a newer product, which may have more features/functions, such as improved computer processorspeed (van Nes et al., 1999), or has changed completely as a result of advances or revolutionary steps in technology or knowledge, such as thecreation of the smart phone
Ecological	When a new product has a less harmful impact on the environment than the existing one. Ecological Obsolescence in isolation is less likely tooccur when the ecological gain from the replacement device has comparatively little value due to the way resources are priced
Psychological	This occurs when a newer product has greater emotional value, or the current product has acquired negative emotional value. This may followwhen an item has been given as a gift, and therefore is endowed with greater emotional value, thus making the existing product obsolete. This is different to aesthetic obsolescence, which concerns cosmetic or decorative value
Sociatal	When changes in societal norms or changes to legislation or standards (Burns, 2010) makes a product obsolete. One change in societal practicethat illustrates this is the use of snuff, ground tobacco, which has not been in popular use since the 19th century. Equally, branded ashtrays seeninside public houses in the UK no longer serve their purpose now that smoking is illegal in public buildings

Source: Wilson et al., 2017

Building up on that it was decided to include the question related to mobile phone replacement reasons as proposed by Wilson et al., (2017) in the online survey. It is noteworthy that this question allowed for multiple answers, thereby providing respondents with the option to select all applicable reasons. The survey's formulation and its answers are presented in the Table below.

Question	Category of obsolescence
What was the reason for replacing your previous mobile phone withyour current mobile phone? Please select all that apply	
- It was stolen	Absolute
- It broke beyond repair	Absolute
- The technology is wornout	Absolute
- It ditn´t have the functions that wanted	Functional
- I wanted a different contract with better features	Functional
- It was no longer novel, stylish or prestigious	Aesthetic
- It was no longer clean, shiny, or new	Aestetic
- It cost too much money to repair (if broken)	Economic
- I was offered a free/discounted upgrade in mycurrent contract	Economic
- I wanted a different contract with better cost value	Economic
- The technology was outdated	Technological
- It was bad for the environment	Ecological
- I am more emotionally attached to thereplacement	Psychological
- It was no longer socially acceptable to use SocietalOther	Sociatal

Furthermore, participants were obliged to indicate their usual method of smartphone disposal. The alternatives presented for selection were Hort, Recycle, Donate, Sell, or Throw away.

5.4.2 Environmental Awareness

To measure the respondent’s environmental awareness the “New Ecological Paradigm” (NEP) was chosen as many researchers and policymakers commonly use the NEP scale to evaluate public attitudes towards environmental issues and monitor changes in environmental awareness over time. The NEP scale, created by Riley Dunlap and Kent D. Van Liere in the late 1970s, is a prevalent tool for evaluating an individual's or group's environmental consciousness and principles. Its purpose is to assess shifts in attitudes towards the environment by measuring the degree to which an individual adopts an ecocentric or pro-environmental outlook, as opposed to a human-centered perspective.

The NEP scale is composed of a set of statements or questions that individuals are asked to express agreement or disagreement with. These statements encompass various environmental topics and viewpoints, and the answers provided are evaluated to ascertain the person's degree of environmental awareness. A higher score on the scale indicates a more pronounced environmental inclination, whereas a lower score implies a greater focus on human-centered perspectives. This research methodology employed a five-point Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," to measure the participants' responses. The 15 statements were adopted from Dunlap et al. (2000) and are presented in table 2 below.

Table 2 NEP Statements

NEPQ1: We are approaching the limit of number of people the Earth cann support.
NEPQ2: Humans have the right to modify the natural enviroment to suit their needs.
NEPQ3: When humans interfere with nature it often produces disastrous consequences.
NEPQ4: Human ingenuity will insure that we do not make the Earth unlivable.
NEPQ5: Humans are seriously abusing the environment.
NEPQ6: The Earth has plenty of natural resources if we just learn how to develop them.
NEPQ7: Plants and animals have as much right as humans to exist.
NEPQ8: Th e balance of nature is strong enough to cope with the impacts of modern industrial nations.
NEPQ9: Despite our special abilities, humans are still subject to the laws of nature.
NEPQ10: The so-called “ecological crisis” facing humankind has been greatly exaggerated.
NEPQ11: The Earth is like a spaceship with very limited room and resources.
NEPQ12: Humans were meant to rule over the rest of nature.
NEPQ13: The balance of nature is very delicate and easily upset.
NEPQ14: Humans will eventually learn enough about how nature works to be able to control it.
NEPQ15: If things continue on their present course, we will soon experience a major ecological catastrophe.

Source: Dunlap et al. (2000)

Furthermore, the NEP scale comprises five facets that individually address different aspects of an individual's consciousness. Collectively, these facets offer a comprehensive understanding of an individual's environmental values and awareness, including factors such as resource use, attitudes toward non-human species, ecological stability, interconnectedness of the environment, and a global perspective on environmental issues. Given the scale's ability to provide a holistic view of environmental awareness, we have decided to consider and incorporate it into our research. These facets are:

1. **Reality of Limits to Growh:** This particular aspect gauges an individual's belief in the finite nature of Earth's resources, as well as the capacity of human activities to surpass the planet's carrying capacity. A high rating in this area indicates an acknowledgment of ecological limitations and a dedication to the sustainability of resources.
2. **Antihumanexceptionalism (Antiantropocentrism):** The present facet serves as an evaluative measure of an individual's perception of the human species in relation to other forms of life within the ecosystem. A higher score indicates a more ecocentric perspective that recognizes the inherent value of all life forms.
3. **Fragility of nature´s balance:** This facet of inquiry revolves around an individual's perception concerning the natural world's intrinsic equilibrium and stability. Those attaining elevated scores typically uphold the notion of ecosystems as fragile and susceptible to disruption, thereby emphasizing the criticality of safeguarding and conserving this delicate balance.
4. **Rejection of exceptionalism:** This facet pertains to one's comprehension of the interdependence of ecological systems and the significance of coexisting with nature in a harmonious manner. A higher score indicates a heightened recognition of the knowledge that can be obtained from studying and esteeming the natural world.
5. **Possibility of an eco-crisis and Global environmentalism:** This aspect of environmental awareness evaluates the degree to which an individual recognizes the worldwide scope

of environmental concerns and assumes a duty to tackle them on a global level. Individuals who score higher in this category typically advocate for international collaboration and joint initiatives to tackle environmental issues.

5.4.3 Demographics

The impact of demographic factors on the results of a particular study shouldn’t be underestimated. These factors offer valuable insights into the intricate and diverse nature of human populations, enabling researchers to gain a better understanding of the practical implications of their findings. Additionally, analyzing demographics facilitates the identification of disparities and inequalities, which is crucial for addressing the research questions raised in this thesis.

Thus, to gain a more comprehensive understanding of the participants, the survey's final section requested demographic information such as Gender, Age, Education, Income, and Country of Residence. This data collection provides a more in-depth description of the individuals involved in the study.

6 RESULTS

The result section presents the outcomes of the study, which aims to investigate consumer preferences for sustainable and circular smartphones. The section starts with an introduction, followed by a description of the sample and data collection process. The findings are then presented in detail, including the average importance and utility of smartphone attributes, willingness to pay for sustainable features, and key performance indicators of individual smartphone usage. The section concludes with a discussion of the implications of the results for smartphone design and sustainability practices.

6.1 Data Collection and Sample Characteristics

The data for this research was collected through an online survey, which was distributed to participants from 16 European countries. The survey was designed using an adaptive conjoint analysis approach to capture consumer preferences and choices among various product features related to sustainable smartphones. Additionally, environmental awareness and key performance indicators concerning individual smartphone usage were considered.

The statistical analysis was conducted utilizing both Jamovi Software and Excel. Jamovi was selected as the primary tool for data analysis due to its seamless workflow and ease of use in executing the necessary tests. However, given its limitations in producing visually appealing figures, particularly in terms of labeling, Excel proved to be a valuable addition in generating more aesthetically pleasing graphs.

6.1.1 Demographics

In the sample of 284 participants, 52,46% identified as male (149) and 46,83% identified as female (133). Two participants opted not to disclose their gender. These findings indicate a relatively balanced distribution of gender within the sample. The sample population's median age is 30.5 years, ranging from 16 to 70 years. The mean age is 31.9 years, with a standard deviation of 10.2. The mode, or the most frequent age, is 23. It's worth noting that there are multiple modes, but only the first one was reported by Jamovi. Compared to the European Union's median age of 44.4 years, the sample population in this study is relatively young. Upon thorough analysis of the histogram presented in figure 15, it is evident that a significant proportion of the study population comprised individuals below the age of 40. This demographic characteristic needs to be considered in further interpretation.

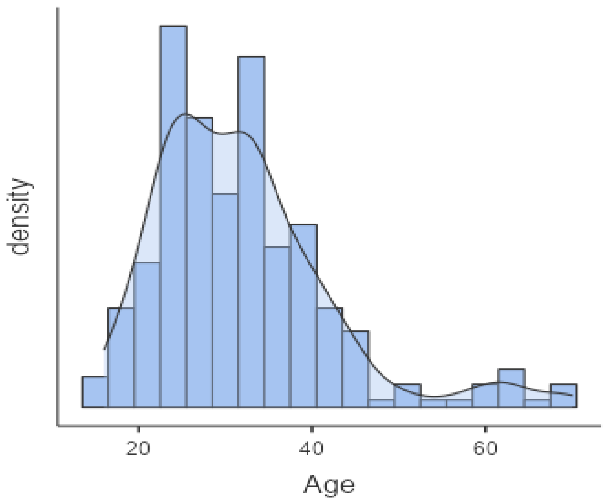


Figure 16 Histogram Age

In terms of educational attainment, 42.2% (117) of respondents hold a bachelor's degree, while 24.3% (69) have earned a master's degree. A total of 54 (19.01%) respondents are currently in high school or pursuing their GED. A small percentage, 6.69%, opted for trade/technical/vocational training, and 6.34% have an associate's degree. Interestingly, seven respondents have achieved the highest academic degree, which is a doctorate.

Regarding Income, respondents were asked to select one of nine groups based on their household's monthly gross income for the Income section of the study. The groups and their corresponding percentages are as follows: Less than 500 EURO (4.58%), 500 to 1,500 EURO (6.69%), 1,000 to 2,000 EURO (14.08%), 2,000 to 3,000 EURO (20.24%), 3,000 to 5,000 EURO (22.89%), 5,000 to 7,500 EURO (13.38%), 7,500 to 10,000 EURO (3.52%), and "prefer not to answer" (11.97%). Table 16 below provides a better visualization of the sample income distribution.

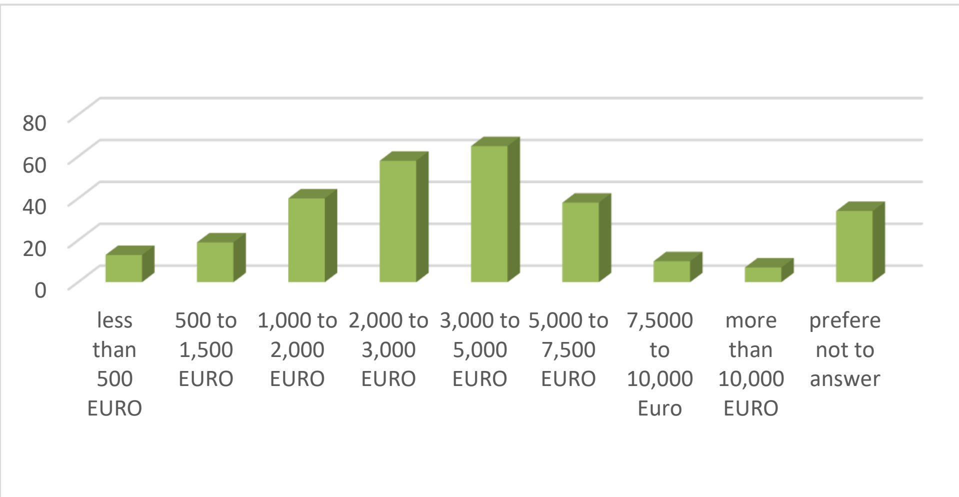


Figure 17 Income distribution

The study gathered data on the respondents' country of residence, with the goal of reaching individuals from all 27 EU member states. England was also included as an additional country, bringing the total to 28. Additionally, a column was provided for individuals who did not fall under the targeted study population. However, out of the 28 possible countries only 17 were represented. That's being Germany (41.2%), England (25.35%), Austria (14.49%), Netherlands (3,87%), Spain (3.17%), Sweden (1,76%) , Finland (1,76%), France (1.76%), Poland (1.41%), Denmark (0,70%), Romania (0,7%), Belarus (0.35%), Belgium (0.35%), Croatia (0,35%), Greece (0.35%), Hungary (0.35%), and Ireland (0.35%). Additionally, two out of the 284 participants were from neither of the countries included in this study. To display the distribution of re-spondents, the author included Figure 1 below. Notably, countries with no participants were denoted by the color red, while countries with a higher-than-average representation were marked by a darker shade of green. The frequency table used for this chapter can be found in appendix 2.

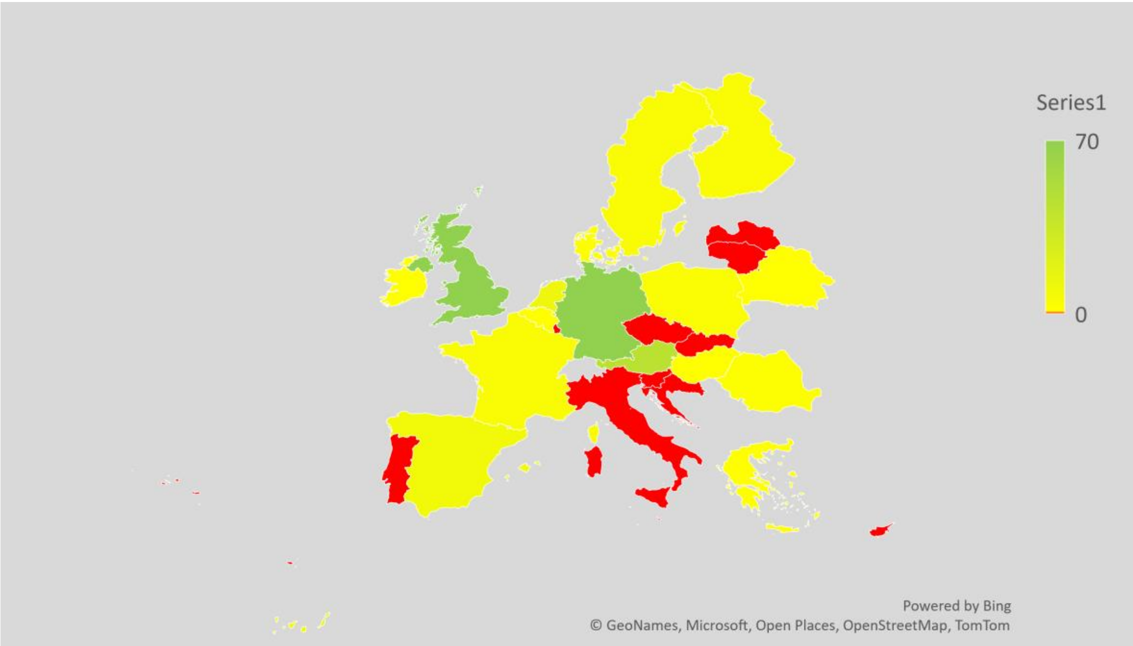


Figure 18 Residence of respondents

6.2 Conjoint Analysis

In this section the empirical findings obtained from the major measurement of the Thesis - the adaptive conjoint analysis (ACA) - are presented. To evaluate the results, the author drew conclusions based on the calculated values representing the average importance of the attributes. Additionally, the average utilities derived from the different feature levels across all respondents are calculated. The complete findings are available in Appendix 3.

6.2.1 Average Importances

In the following, the average importance's obtained from the ACA study will be presented and interpreted. The key features utilized in this research encompassed Price, Phone Type, Warranty, Repairability, Sustainability Label, and Place of Production. The average importance obtained from the sample (N=284) is represented in figure 15 below.

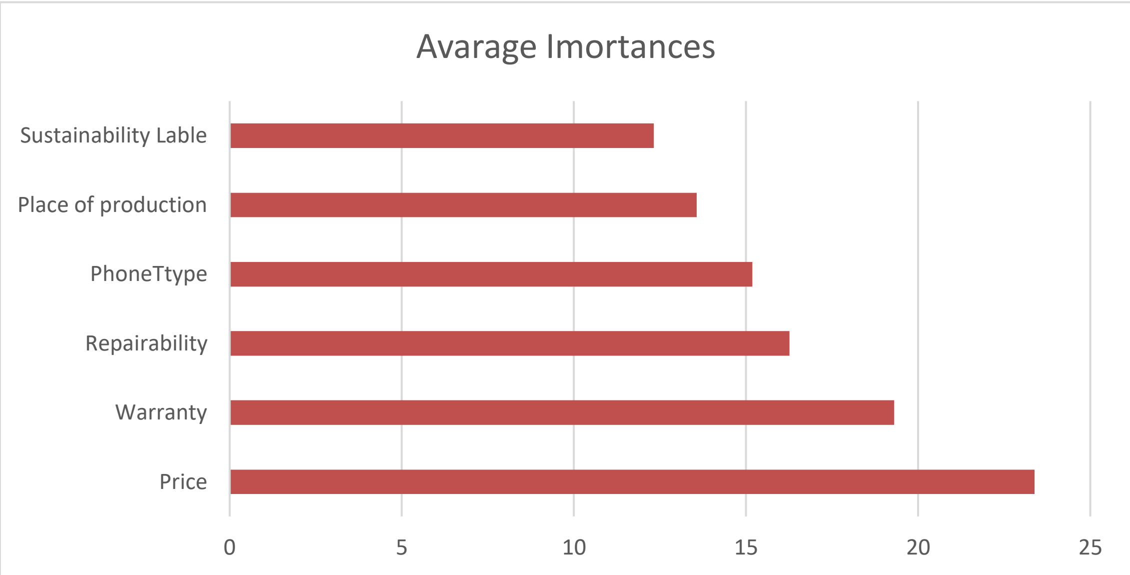


Figure 19 Average Importances

The most straightforward interpretation of average importance's is the ranking of attributes. The attribute with the highest average importance is the one that holds the most sway over consumer decisions. This indicates the feature that is most critical to our target audience.

According to the data generated, the attribute deemed most crucial in influencing consumer choices is "Price," with an average importance rating of 23.38%. The second most important factor for respondents was "Warranty" at 19.30%. Surprisingly, "Repairability" generated a higher rating at 16.26% than "Phone Type" at 15.18%. "Place of Production" was the fifth most favored feature at 13.57%, while "Sustainability Label" came in last at 12.32%.

6.2.2 Average Utilities

Upon analyzing the data, it becomes apparent that the price point of 300 Euro for a new smartphone was the most popular choice among respondents. It yields an average utility of 43,65. However, it's worth noting that a price of up to 500 Euro (average utility = 21,92) still yielded positive utility. Any price above the 500 Euro threshold resulted in negative average utilities, indicating a significant preference for lower price levels.

Regarding phone type, buying a new phone was clearly the most favored option among participants yielding 16,86 average utility. In contrast, refurbished phones received a high level of negative utility (-24,62). It is important to note that, in economics, negative utility is not a valid concept. However, it is often used in the method of CA for comparison and interpretation purposes. Sustainable Green Phones, on the other hand, received only a modest positive average utility (7,76).

Regarding warranties, the absence of a warranty for a newly purchased device resulted in a significantly negative average utility (-51,71) among all survey participants. Providing a standard two-year warranty resulted in a small yet positive average utility (9,18). Nonetheless, the most popular option among respondents was an extended warranty of up to five years. It yields an average utility value of 42,52.

In the realm of phone features, repairability is a highly valued attribute, ranking just behind price and warranty. Upon examining the average usefulness of these three factors, it is evident that most individuals prefer a new phone to be easily repairable (41,32). This entails accessible and affordable spare parts, as well as a design that simplifies disassembly and reassembly. Conversely, limited repairability - where repair guides are available but require intermediate skills - is not as desirable (-2,69). It is not surprising that a phone with limited repairability, one that can only be repaired by authorized service centers, is the least popular option (-38,63).

Regarding the existence of sustainability labels, it became clear that respondents prefer a new phone that is certified with a sustainability label and contains specific information regarding its sustainability features (30,68). Although sustainability labels are ranked last in terms of importance across all attributes, having a label with additional information is still considered the fourth most important utility overall, surpassing the utility derived from a new phone.

Finally, the location of production was scrutinized. Interestingly, the findings suggest that consumers exhibit a preference for products that are locally manufactured (average utility = 28,83) as opposed to those that are only partially produced locally (-0,73) or imported (-28,1). This underscores the significance of the "made in" label on products as a factor that influences consumer behavior and choice.

Figure 16 summarizes these results of the determination of the average utilities.

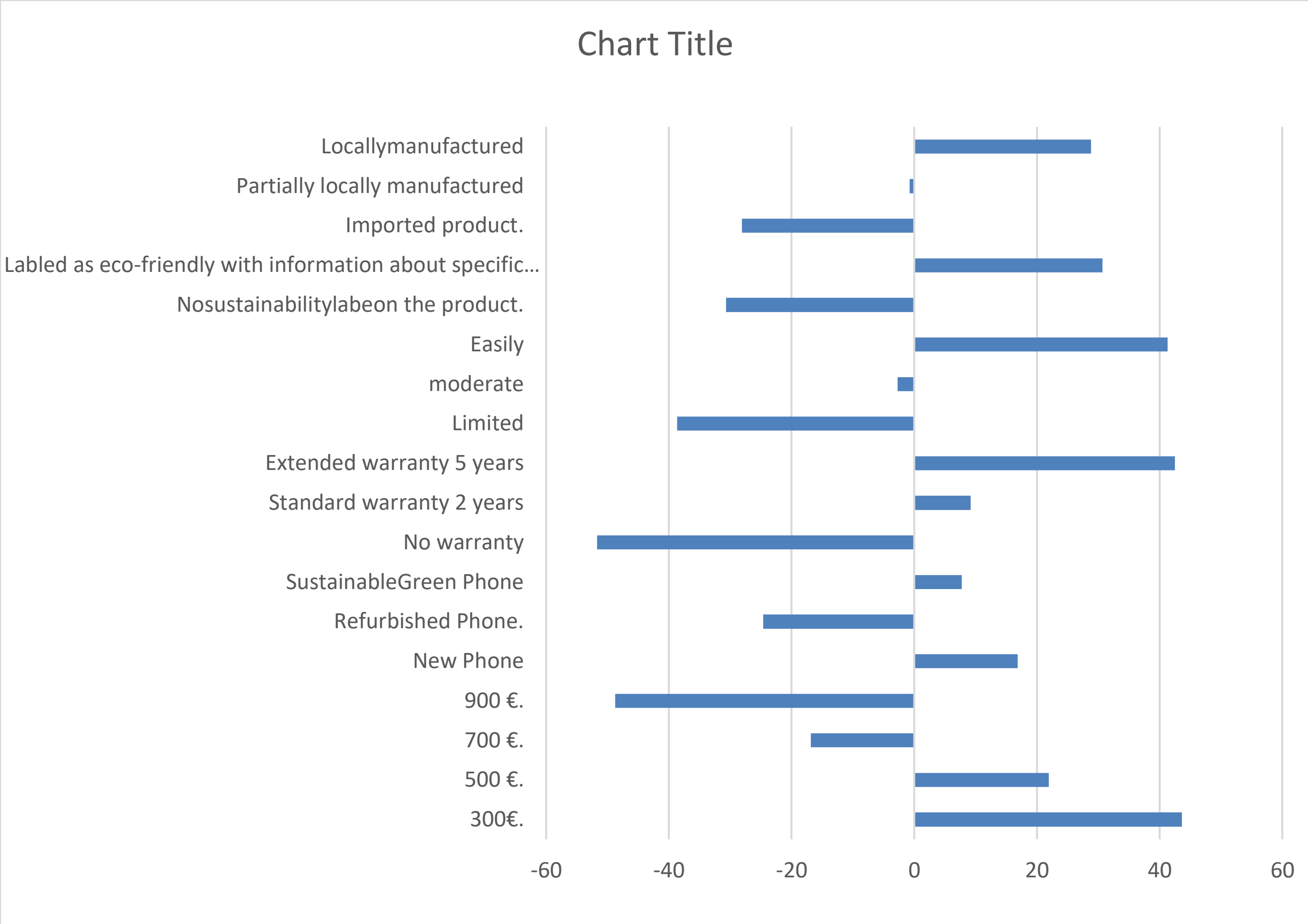


Figure 20 Average utilities among the attribute levels

6.2.3 Gender

Overall, the data suggests that among both gender groups, mainstream indicators such as price and warranty hold greater importance compared to circular or sustainable features. However, upon further analysis, the author identified some gender differences. While the mean importance for phone type and sustainability label is similar across both groups, there are differences for repairability (mean male = 15.3, SD 4.99; mean female = 17.3, SD 5.27) and place of production (male mean = 13.1, SD 5.15; female mean = 14.1, SD = 4.56). It's worth noting that the data pertaining to repairability importance had three statistical outliers which were excluded from further evaluation. A T-Test and Mann-Whitney analysis were conducted to test for significance, yielding a p-value of 0.001 ($p<0.05$) and a reported Cohen's d of -0.426. The negative value of Cohen's d indicates that the importance female respondents placed on repairability was significantly higher than that of male respondents within the sample. Additionally, a Mann-Whitney test was applied to test significant differences across the two genders for the importance of place of production, with nine outliers excluded. The test yielded a significant result of p-value = 0.005, leading to the conclusion that females also place significantly more importance on the place of production.

Upon analyzing attribute levels, it is evident that there are no notable discrepancies concerning price and warranty attributes amongst both genders. However, when considering the type of phone, disparities arise between New Phone and Sustainable Green Phone. Refurbished phones hold a negative utility value and are comparable among both genders.

After analyzing the satisfaction gained from acquiring a new phone, it was found that on average, women (0.027, SD: 0.831) derive less satisfaction than men (0.387, SD: 0.820). However, upon conducting further tests, no significant differences were found between genders when it came to the level of satisfaction obtained from purchasing a new phone. Additionally, the mean satisfaction derived from a Sustainable Green Phone was higher for women (0.231) than for men (0.148). Nevertheless, a T-test revealed no statistically significant difference between genders.

Based on previous findings that repairability is more important to women overall, we compared different attribute levels. After considering the mean value across both genders and all three levels of repairability, no significant difference was found in terms of moderate repairability. However, there were some differences in the mean value for limited and easy repairability. Specifically, the mean utility derived from a phone with limited repairability was higher for males (-0.769) than for females (-0.932). Important to say that both values were negative, indicating that phones with limited repairability were the least preferred for both genders. To test if these differences held statistical significance, we identified and excluded eight outliers and conducted a Shapiro-Wilk test to confirm normal distribution. We then used a Mann-Whitney U test, which yielded a significant p-value of 0.003 ($p<0.05$) and a mean difference of 0.199. Therefore, within the sample, the utility derived from a phone that offers only limited repairability was significantly lower for female than for male. Based on the data, it was found that females have a mean value of 1,057 for preferring easily repairable phones, while male have a mean value of 0.882. The data was further reduced by 16 outliers. A Mann-Whitney U test yielded a significant p-value of 0.003, indicating that there is a significant difference between the two groups. Therefore, it can be concluded that females show a greater preference for phones that are easily repairable compared to males.

When it comes to sustainability labels, both groups expressed a negative perception towards products without them. This indicates that both genders have a clear preference for eco-friendly phones. While the overall mean value suggests a higher preference for females, no significant differences were found between the two groups.

Lastly, it has been observed that the average preference for locally manufactured products is higher among females compared to males. To eliminate any anomalies, the data has been filtered to exclude 43 outlier values. The remaining sample conforms to a normal distribution, and a T-Test performed on this data has yielded a significant p-value of 0.001 ($p<0.05$). The corresponding Cohen's d effect size is -0.429. Based on the study's sample population, it can be concluded that females exhibit a significant preference for locally manufactured smartphones when compared to their male counterparts.

6.3 Additional Measurements

In addition to the primary measurement, the online survey included two supplementary sections to gather further information. The initial segment of inquiry, positioned before the actual conjoint analysis, requested respondents to share information regarding their behaviour concerning the usage of smartphones. Following the conjoint questions respondents were presented with the fifteen NEP questions to measure their overall attitudes towards the environment. The data gathered from these two questions will be discussed within following chapter.

6.3.1 Smartphones related

The initial part of the survey included questions about the respondent's smartphone usage habits. To begin with, participants were asked to identify the brand of their current smartphone. Afterwards, they were asked about their typical usage duration before replacing their phone. Subsequently respondents were asked to estimate the expected lifespan of their phone's optimal functionality. Additionally, the survey proceeded to investigate the reasons behind purchasing a new phone and the disposal method for the old one. Lastly, participants were inquired about their awareness of the environmental consequences of improper smartphone disposal, such as e-waste, and whether they prefer environmentally conscious brands that prioritize repair and recyclability.

In the survey sample, Apple emerged as the most popular smartphone brand with a 44.37% share. Samsung followed with 28.17% of respondents currently owning their phones, while Xiaomi and Huawei had 7.75% and 3.87%, respectively. Among the 284 participants, Google was the preferred choice for ten, Motorola for eight (2,82%), and LG and Oppo for three each (1,06%). Notably, three individuals (1.06%) opted for "Fairphone", putting it on par with LG and Oppo in terms of popularity. The frequency table can be found in appendix 4.

The final two questions of the survey focused on the awareness of the environmental impact of smartphones and whether individuals would be inclined to purchase sustainable smartphone brands. The outcomes, illustrated in figure 20, exhibit that most participants (80,28%) acknowledged the detrimental effects of improper smartphone disposal on the environment. Moreover, the majority (86,62%) expressed their preference for smartphones that endorse eco-friendly practices, such as repair and recycling.

Figure 21 Respondents Environmental Awareness and Attitude towards buying sustainable-phones

6.3.1.1 Lifetime and expected use

The frequency tables used for the following chapter are attached in appendix 4.

According to the survey results, a majority of the participants reported using their smartphones for a period of two to three years (33.45%). However, a significant proportion of respondents (27.11%) stated that they tend to keep their phones for three to four years. In total, 60.6% of the sample reported using a smartphone for a duration of two to four years. The least popular response was a lifetime of less than one year (4.58%). Notably, a considerable portion of participants (20.42%) reported using their smartphones for more than four years. Furthermore, the data reveals that 19.02% of respondents reported a lifespan of less than two years for their current phone, while a significant majority of 47.53% indicated a usage period exceeding three years. In conclusion, the findings suggest that a considerable proportion of participants utilize their current mobile device for more than two years.

Looking at expected use the overall frequency distribution looks similar, however there are some differences. A mere 1.41% of individuals expect their new smartphone to exhibit flawless functionality for less than a year. Conversely, 15.49% of respondents deemed a usage expectancy of one to two years as acceptable. According to the survey results, almost 24% of respondents anticipate a device lifespan of two to three years. In total, 40.58% expect their new device to function for less than three years. Interestingly, the next two ranges are the most commonly pick: 25.70% of respondents hope for flawless operation between three to four years, while 33.34% expect a lifespan exceeding four years. The data reveals that a combined total of nearly 60% (59.15) of the participants had a lifetime frequency of less than one year.

6.3.1.2 Replacement and dispose

Based on the responses of 284 participants, a total of 488 agreements were made across all reasons. This indicates that, on average, each respondent selected 1,7 options.

Based on participant feedback, the primary reasons for replacing their smartphones were either due to worn-out technology (21.31%) or irreparable damage (18.03%), totaling 39.34%. Additionally, 9.02% (73 respondents) reported that repairing their device would have been too costly, 6.76% wanted a different contract with better features, and 6.35% reported that their previous phone did not have the desired functions. Approximately 4% expressed dissatisfaction with their phone's lack of novelty, style, or prestige, while the same number desired a better value contract and accepted a free or discounted upgrade. Unfortunately, 3.48% had their device stolen. Only six participants (1.23%) replaced their previous phone due to environmental concerns. A similar proportion reported replacing the item due to a stronger emotional attachment to the new one or social unacceptability of the old one.

Table 3 Type of Obsolescence

Absolute	42,83%
Functional	13,11%
Aesthetic	8,40%
Economic	16,80%
Technological	14,96%
Ecological	1,23%
Psychological	1,43%
Sociatal	1,23%

After analyzing the categories of obsolescence outlined in chapter 5.4.1.1, Absolute obsolescence (42,83%) is the primary driver for individuals to upgrade their current mobile phone. Economic factors come in as the second most influential category, accounting for 16.80% of all replacements. Technological obsolescence follows at 14.96%, while functional reasons account for 13.11%. Aesthetic obsolescence is responsible for 8.40% of smartphone disposals. Ecological, Psychological, and Societal obsolescence are much less significant, each accounting for less than 2% of all replacements.

In the first section of the survey, participants were asked to specify their preferred method of disposing of a smartphone in question four. It is important to note that only one answer was allowed for this query. The data collected from the sample indicates that a significant percentage of respondents (30.99%) typically sell their old smartphones. The next two most frequently reported methods were Hort (23.34%) and Recycle (22.89%). A smaller percentage of participants (14.44%) reported donating their old phones, with only a minority (8.45%) choosing to discard their devices.

Additionally, respondents were asked about their most preferred durability feature, presenting them with a selection of options including "Drop and Impact resistance", "Scratch resistance", "Corrosion Resistance", "Waterproofness", and "None of the above". The findings revealed that the majority (59.51%) of respondents regarded drop and impact resistance as the most crucial feature. Scratch resistance (14.44%) and waterproofness (12.32%) followed as the next preferred options. A mere 20 out of 284 participants opted for "none of the above", while 19 favored "Corrosion Resistance".

6.3.2 NEP Scale

As already argued in chapter 1.1.2., the study utilizes the "New Ecological Paradigm" scale to evaluate the environmental consciousness of the participants. So, this chapter will present a comprehensive analysis of the degree of consensus among the sample for each NEP aspect and query.

6.3.2.1 Overall Assessment

Table 4 NEP Question according to the five NEP facets

NEP facets	NEP Questions	Mean	SD	Decision
Reality of limit to growth	NEP1: We are approaching the limit of the number of people earth can support	3,57	1,09	Agree
	NEP6: The Earth has plenty of resources if we just learn how to develop them*	2,48	1,03	Agree*
	NEP11: The earth is like a spaceship with very limited room and resources.	3,59	1,00	Agree
Antiantropocentrism	NEP2: Humans have the right to modify the natural environment to suit their needs*	3,11	1,08	Neutral
	NEP12: Humans were meant to rule over the rest of nature*	3,51	1,26	Disagree*
	NEP7: Plants and animals have as much right as humans to exist	3,90	1,02	Agree
Fragility of nature´s balance	NEP3: When humans interfere with nature it often produces disastrous consequences	3,91	0,96	Agree
	NEP8: The balance of nature is strong enough to cope with the impacts of modern industrial nations*	3,38	1,11	Neutral
	NEP13: The balance of nature is very delicate and easily upset	3,73	0,89	Agree
Rejection of exceptionalism	NEP4: Humans ingenuity will ensure that we do not make earth unlivable*	2,92	1,02	Neutral
	NEP9: Despite our special abilities, humans are still subject to the laws of nature	3,99	0,87	Agree
	NEP14: Humans will eventually learn enough about how nature works to be able to control it*	2,98	1,02	Neutral
Possibility of an eco-crisis	NEP5: Humans are seriously abusing the environment	4,03	0,94	Agree
	NEP10: The so called “ecological crisis” facing humankind has been greatly exaggerated*	3,51	1,20	Disagree*
	NEP15: If things continue on their present course, we will soon experience a major ecological catastrophe	3,94	0,93	Agree
Overall Index **Mean total NEP Score**		52,56 3,50	8,22	

* Reverse coded

To assess agreement with a specific statement, the author opted to utilize the means. To support this analytical approach, a range for each feasible response was established. The ranges are as follows: Strongly Disagree (1-1.8), Disagree (1.9-2.6), Neutral (2.7-3.4), Agree (3.5-4.2), and Strongly Agree (4.3-5). We computed these ranges by dividing the total range of the scale (5-1) by the entire number of feasible answers (4/5). Thus, each category of acceptance has a range of 0.8. Additionally, the same procedures were applied to assess the overall acceptance of the five NEP facets. It is important to note that half of the 15 NEP questions are reverse coded. The main objective of this study's NEP is to determine the overall environmental attitudes of the respondents. However, for the specific analysis at hand, the goal is to assess the overall agreement of the respondents based on the 15 questions presented. Thus, a low mean value on a reversed scale in table 3 above indicates that the majority of respondents agree with the statement, and vice versa. However, this does not necessarily imply a high level of environmental consciousness but rather a lack of awareness about environmental issues. To address this concern, the author decided to include figure 21. This figure doesn't reverse the scale and provides a more straightforward interpretation of the respondents' agreement.

The data analysis shows an overall mean value for the first facet, related to the reality of limit to growth, is 3,22. Overall, the respondents appear to be neutral on these items. However, two out of the three questions yielded a mean value of over 3.5, indicating agreement. Respondents agree on “we are approaching the limit of people earth can support” and “the earth is like a spaceship with very limited room and resources”. On the other side, respondents had mixed opinions on the question about earth's resources. The average score for this question was 2.48, with a standard deviation of 1.03.

In addition, most respondents supported the concept of Antiantropocentrism, which challenges the notion that humans are the most significant aspect of existence. The average score for this aspect was 3.5 out of 5. Respondents strongly agreed with the third statement, which asserted that animals and plants have the same right to exist as humans (average score 3.89). For the first question, which inquired whether humans have the right to modify the natural environment as per their requirements, respondents remained neutral. The second question, which posited that humans were meant to rule over the world, was supported by the respondents. However, this item was reverse coded, indicating that most respondents did not believe in the notion that humans were supposed to dominate the planet.

Overall, NEP facet three, which pertains to the fragile balance of nature, received the second highest level of agreement among respondents with a mean score of 3.67. Specifically, participants agreed that human interference with the environment can have disastrous consequences, as reflected in their high level of agreement with item NEPQ3 (mean score of 3.91). Notably, the standard deviation for this facet was below one, indicating a high degree of consensus among respondents. Throughout the survey, participants reached a consensus that the equilibrium of nature is exceedingly fragile and can be disrupted with ease. The data yielded a mean score of

3.73 with a standard deviation of 0.89. Interestingly, question eight, which inquired about nature's capacity to withstand the effects of modern industrialization, produced a neutral response with a mean score of 3.38 - hovering closely to the next threshold. This particular question prompted a range of contrasting opinions, as reflected by a standard deviation of 1.11, the third highest value. Once again, most respondents scored rather low as this item was reverse coded. This suggests that they reject the belief that nature can deal with the effects of modern industries.

According to the survey results, a significant number of participants expressed concerns about an impending environmental crisis. The fifth facet of the NEP questionnaire received the highest average rating of 3.83, indicating a strong belief that humans are severely mistreating the planet. Notably, question five of the NEP garnered the highest mean score out of all fifteen questions. Respondents generally agreed that if current practices persist, a major ecological catastrophe will be inevitable. On NEP question 10 respondents disagree. Once again it is reverse coded, so most respondents eject the idea that the so called “ecological crisis” has been greatly extravagated, as shown in figure 16.

Furthermore, an additional variable was added to the data set being the NEP total score for each respondent across all fifteen questions. The seven even numbered questions have been reversed coded, as a high value in those questions implies less environmental consciousness. This data will be further used to test hypothesis in section 6.4.3.

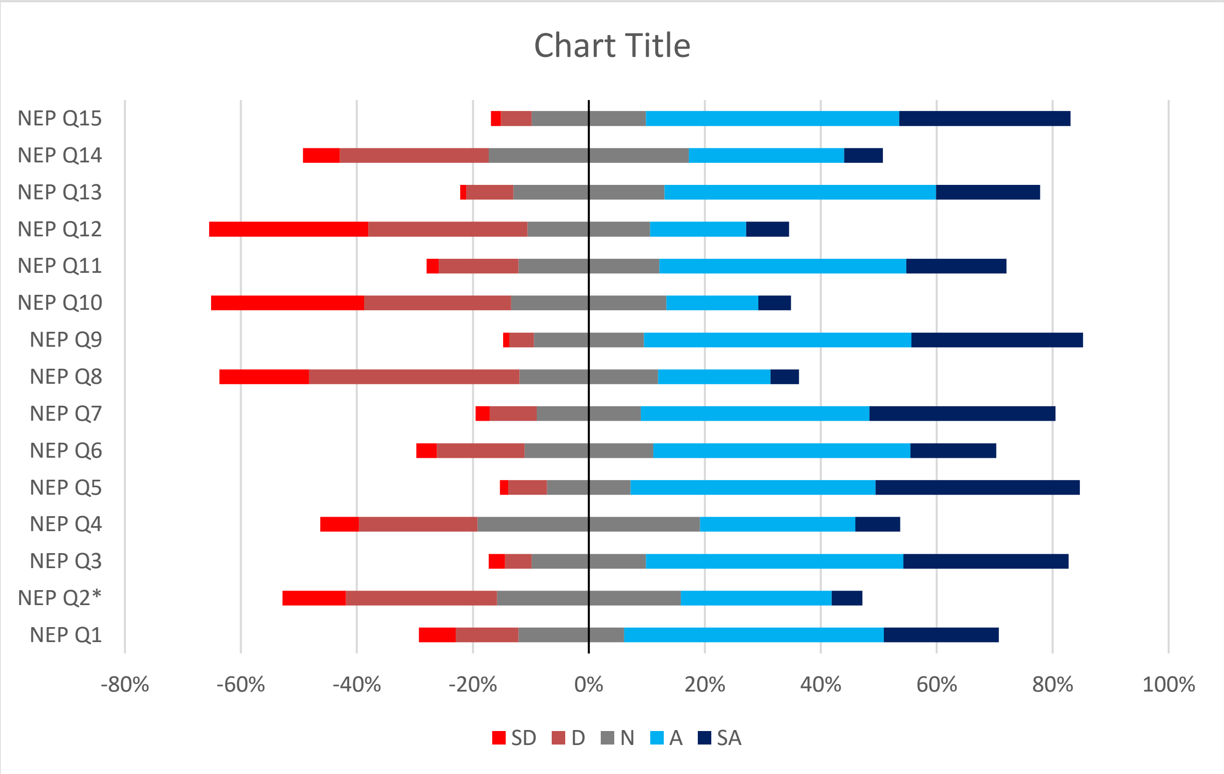


Figure 22 Result from the NEP questions

6.3.3 Hypothesis Testing

The following part contains testing the hypothesis derived from the literature review.

6.3.3.1 H1 Environmental Awareness

The first hypothesis to test aims to explore whether environmental awareness increases consumers importance for sustainable smartphone attributes. Accordingly, the H1 is formulated as follows:

H1: Environmental Awareness increases the importance for repair and sustainability features.

The attributes in question are importance of, phone type, repairability, sustainability label, and place of production which are derived from the conjoint analysis. Additionally, Jamovi's "split by feature" function was utilized to categorize the total NEP scores of each participant into three equal groups. The first group comprised respondents whose NEP score fell below the 33.33rd percentile (i.e., 47 or lower), while the third group included those with scores above the 66.67th percentile (i.e. 56 or higher). The remaining participants were assigned to the second group. The ultimate sample size utilized for subsequent investigation comprised 76 participants in the first cohort, 117 individuals in the second cluster, and 91 respondents in the third group.

Hypotheses H0 and H1 have been formulated accordingly:

H0: There is no difference in mean importance between the groups.

H1: There is a difference in mean importance between the groups.

The first step is to look at the descriptives table to identify any differences among the mean attribute importance among the groups.

Table 5 Mean values and Standard Deviation across groups

	NEP groups	importance phone type	importance repairability	importance sustainability lable	importance place of production
Mean	1	16.3	16.0	11.5	14.1
	2	15.6	15.6	11.8	13.1
	3	13.7	17.4	13.6	13.8
SD	1	7.73	5.55	5.70	6.27
	2	6.27	4.99	5.16	4.04
	3	5.89	5.03	5.46	4.54

After analyzing Table 5, it appears that there are differences among the mean values of all attributes across the three groups. It is noteworthy that the importance participants place on the type of phone diminishes among the groups, while the importance of sustainable labels increases among them. In terms of the significance of sustainability labels, the first and second groups are comparable, while the third group appears to place a high importance on this factor. The importance of local production yields the least meaningful differences among the attributes.

To determine the significance of the observed differences, the author conducted a One-way ANOVA test. However, considering the violation of normality assumption (Shapiro-Wilk p-value < 0,001) within the sample, a non-parametric measurement, namely Kruskal-Wallis ANOVA, was chosen. This test was applied to all attribute importances, and the results are displayed below in table 6.

Table 6 Kruskal-Wallis ANOVA Results

Attribute importance	χ^2	df	p
importance phone type	7.120	2	0.028
importance repairability	6.235	2	0.044
importance sustainability lable	8.070	2	0.018
importance place of production	0.727	2	0.695

Examining the p-values one can conclude, that there are significant differences among the three groups of the importance they give to the type of phone, its repairability, and the existence of a sustainable label. The p-value for place of production yield no statistical significance. Based on the results, we can reject the null hypothesis and accept the alternative hypothesis.

In summary, there are notable variations among the NEP groups in terms of the significance attributed by respondents to phone type, repairability, and sustainability label. Interestingly, heightened environmental consciousness appears to diminish the value placed on acquiring a new phone. Furthermore, greater environmental awareness correlates with increased emphasis on repairability and the presence of a sustainable label. However, no significant correlation was discovered with regards to theplace of production.

6.3.4 H2 and H3 Gender

H2: Women are more environmentally aware than male.

Accordingly, H0 and H1 are as follows:

H0: There are no significant differences among genders in environmental attitudes.

H1: Women have significantly higher environmental attitudes.

To test the hypothesis, the author utilized a variable that calculates the total NEP score for each question. To ensure greater reliability and ease of interpretation, respondents who chose not to answer questions related to gender were excluded from the following analysis. This decision was made as only two respondents had selected this option, which would not have allowed for a meaningful comparison between groups. Moreover, the gathered data´s boxplots indicate the presence of six outliers, which have subsequently been excluded from the analysis. The final sample for analysis consists of 143 male participants and 133 female participants.

To arrive at an initial assessment, the mean values for both gender groups were computed with Jamovi Software. The results used for the following interpretation are attached in appendix 8.6.1. The computed mean value for males was 50.6, while for females it was 54.4. It is worth mentioning that although the minimum values are comparable between both genders, the maximum values exhibit a noticeable difference.

Furthermore, the author judges the data visually. First, to check whether the data is normally distributed a histogram has been created. Additionally, the density was displayed to enhance decision-making. A normal distribution typically appears as a bell-shaped curve. Upon observation of Figure 22, it can be inferred that while the general distribution may not deviate greatly from a normal distribution bell-shape, the data exhibits a notable degree of skewness. Additionally, an effective approach to examine the distribution of data and identify potential anomalies is to create a boxplot. Upon reviewing the visual representation of the boxplots in figure 22 it is apparent that female participants within group two have a greater median and exhibit stronger performance regarding the NEP questions.

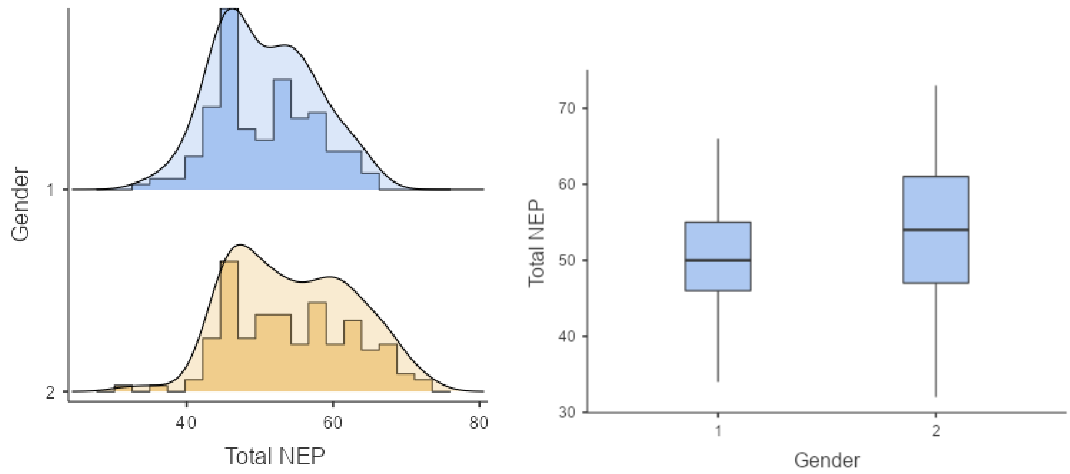


Figure 23 Histogram and Boxplots for Total NEP across Gender

To conduct a more thorough analysis, the Shapiro-Wilk test was utilized to determine normality. This test evaluates the null hypothesis that data follows a normal distribution, and a p-value below 0.05 indicates non-normality. Our results yielded a p-value of 0.038 for males and 0.014 for females, both of which fall below the threshold, leading the author to conclude that the data is not normally distributed. Resulting from rejection of normal distribution Mann-Whitney U test was run to finally test the hypothesis. The test yields a significant p-value of 0,001. Accordingly, the author rejects H0. In addition, the effect size was calculated.

The third research question of this thesis is:

H3: Females importance for sustainable and circular product feature more than for male.

Accordingly, H0 and H1 are formulated as follows:

H0: There is no significant difference across genders regarding the importance of sustainable or circular attributes.

H1: Female rate the important of sustainable or circular product attribute significantly higher than male.

Despite having already been tested in chapter 6.3.3., we have decided to further investigate it. The primary objective of this question is to determine whether women truly incorporate their environmental attitudes into their purchasing decisions. Once it has been established that women are more environmentally conscious than men within the sample, their choices within the conjoint design can be analyzed. To achieve this, the overall response based on gender, as indicated by participants' selections in the second stage of the adaptive conjoint design was examined. As a reminder, the second set of questions in the conjoint design concerns respondents' overall level of importance for the least preferred and most preferred attributes. To analyze the relationship between two categorical variables, we have utilized contingency tables, which are commonly used in statistics to examine the association between variables. As such, table 7 below has been created for the responses regarding repairability. The table is structured in the following manner: the columns denote the responses, the degree of significance assigned to each response ranges from 1, representing an undesired outcome, to 7, signifying a highly desired outcome. The rows correspond to the two gender categories, with 1 indicating male and 2 denoting females. Each cell contains the frequency or count of specific combinations of categories, labeled as "Observed". Furthermore, the expected frequencies for each cell are labeled as "Expected". Differences between these values reveal disparities among respondent groups. For instance, in column seven, the observed count for males is only 20 when 30.1 was expected. Conversely, females have significantly more responses than expected.

Table 7 Contingency Table Importance Repairability for Gender

		ACA_Importance4							
Gender		1	2	3	4	5	6	7	Total
1	Observed	3	6	25	28	51	16	20	149
	Expected	2.11	4.76	18.0	21.7	53.4	19.0	30.1	149
2	Observed	1	3	9	13	50	20	37	133
	Expected	1.89	4.24	16.0	19.3	47.6	17.0	26.9	133
Total	Observed	4	9	34	41	101	36	57	282
	Expected	4.00	9.00	34.0	41.0	101.0	36.0	57.0	282

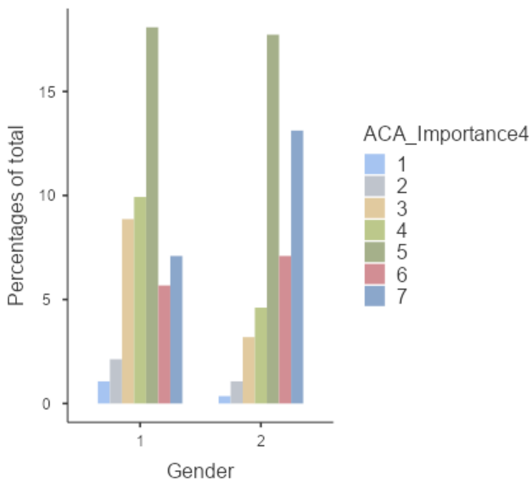


Figure 24 Importance Rating for Repairability

Additionally, the chi-square test of independence was utilized to assess whether the observed frequencies deviated significantly from the expected frequencies. The test yielded a p-value of 0.003 ($p<0.5$), indicating statistical significance. To determine the degree of association between the variables, Cramer's V was computed and yielded a value of 0.254.

Also, contingency tables and chi-square tests were conducted on all other questions related to importance ratings to identify any discrepancies. However, none of them yielded significant results.

6.3.5 Age

The final research question aims to examine whether environmental awareness increases with age. Accordingly, H4 is as follows,

H4: Environmental Awareness increases with age.

H0: There is no significant difference in environmental awareness among age groups.
H1: There is significant difference in environmental awareness among age groups.

The authors created a new variable to test hypothesis four, which represents the mean NEP score across all respondents. Respondents were grouped by age, with initial evaluations of two groups split by the median showing no significant differences. However, when considering overall youthfulness, the two groups differ significantly. To compare differences, many research analyses use more than two groups, and this thesis follows the same procedure. Using Jamovi software, cut points for three equal groups were estimated. Respondents were split using the 33.33 percentile (26 years of age) and the 66.66 percentile (34 years of age). Participants younger than 26 were grouped in group one, those between 26 and 34 in group two, and all respondents above the age of 34 in group three. The final distributions of participants, post the exclusion of one outlier, is presented in Table 8, underneath the corresponding bar- and box-plots in Figure 24.

Table 8 NEP mean differences among age groups

	AGE LH Groups	N	Missing	Mean	Median	SD	Minimum	Maximum
Mean NEP Total	1	84	0	3.40	3.27	0.437	2.40	4.47
	2	112	0	3.48	3.47	0.552	2.07	4.67
	3	85	0	3.64	3.67	0.595	2.27	4.87

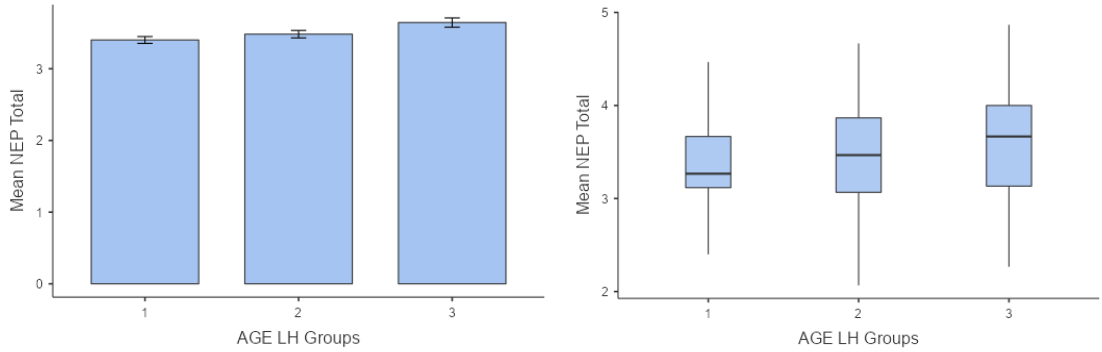


Figure 25: Bar and Boxplots mean NEP total across Age Groups

Upon examination of the images, it appears that the mean NEP score increases across the age groups. Group three exhibits the highest NEP scores, while group one has the lowest scores among all groups. To determine if the differences are statistically significant, One-Way Anova was conducted. However, since the data's overall distribution is not normal (Shapiro-Wilk p= 0,001, p-value < 0,05), a Kruskal-Wallis Anova was utilized instead. The test produced a significant p-value of 0,02 (p-value < 0,05) (see table 9). Subsequently, a post hoc test was performed for pairwise comparisons. The results showed that group one differed significantly from group two (p = 0,014), while groups one and two did not differ significantly (see table 10).

Table 9 Kruskal-Wallis Anova Results

	χ^2	df		p	ε^2
Mean NEP Total	7.83	2		0.020	0.0280

Table 10 Pairwise Comparison Mean NEP

Pairwise comparisons - Mean NEP Total			
		W	p
1	2	1.37	0.595
1	3	3.96	0.014
2	3	2.65	0.147

Based on the statistical analysis performed on the dataset utilized in this study, it is possible to reject the null hypothesis (H0) and accept the alternative hypothesis (H1). Therefore, it can be concluded that there is a positive correlation between age and environmental awareness.

7 DISCUSSION

7.1 Major Research findings

The production and development of electronic devices, particularly smartphones, has seen tremendous growth in the last two decades. The impact of this evolution on society in all aspects of daily life cannot be overestimated (oder shouldn't be underestimated. However, with every single device comes the cost of extensive resource needs that undermine the natural environmental ability to flourish. Moreover, the current production and consumption habits of consumers have various environmental and societal issues along the entire value chain of smartphone production. The topic of E-waste, in particular, has been heavily discussed in science due to its implications on human, animal, and plant life. Similarly, social issues like the topic of conflict minerals are largely due to current global business practices and the linear economy model. The concept of a circular economy aims to replace the classic economic system with one where products and materials are kept in a closed-loop system. The implementation of a circular economy might help to tackle various issues mentioned before. The idea of modular smartphones, first offered by Fairphone, seems to be a promising step towards a more practical circular economy. Products that are initially designed to last longer, with proper repairability and recyclability services, might lead to a decrease in resource use.

Some experts suggest that the smartphone market in Europe may have already reached saturation, which requires even more aggressive innovation in current business practices to increase competitiveness and so gain market sshares. Therefore, focusing on sustainability could become a lucrative business model in the coming years. It is worth noting that the European Union has recently passed a law that grants the general right to repair electronic devices, offering incentives for modular product design.

Moreover, this research has revealed that there is a discrepancy between reported smartphone usage time and the expected lifetime of a newly purchased device. It might indicate that consumers are seeking more durable products. Additionally, the main reason for smartphone replacement was due to absolute obsolescence resulting from either irreparable damage or outdated technology. Such a result further highlights the need for more durable products.

Accordingly, an additional objective of the research was to examine consumers' preferences for sustainable smartphones and provide guidance on how to prioritize sustainability attributes and integrate them into smartphone design. A survey was conducted in 2023 reaching 284 respondents across 17 European countries. The primary measurement used in the survey was an adaptive conjoint analysis. It turned out that the data was largely dominated by respondents from the UK, Germany, and Austria, with a lower median age than the European Union's average. Nevertheless, the findings showed that the price of the product is the most important factor in the purchasing decision, followed closely by the warranty provided. Most importantly, the survey also revealed that repairability was considered a crucial feature among respondents, indicating a growing acknowledgement of modular smartphones. Surprisingly, the type of phone (new or used) ranked fourth in importance. Equally unexpected, the argument for local production was preferred over a sustainability label.

Additionally, the study aimed to explore the relationship between environmental awareness and the importance that consumers give to sustainable product features. To achieve this goal, the “New Environmental Paradigm” scale was utilized, to which the respondents agreed overall. The findings from hypothesis testing suggest that an increase in environmental awareness leads to a stronger preference for sustainability among respondents. Among the sampled individuals, those who demonstrated a heightened sensitivity for environmental issues also placed a significant emphasis on the repairability of mobile devices, the specific type of phone, and the presence of a sustainability label. Notably, women showed higher levels of environmental awareness and attached greater importance to product repairability. Additionally, it was found that environmental awareness increases with age.

7.2 Discussion of findings

The results indicate that sustainable and modular smartphones could be a valid concept for a more circular economy within the smartphone market. It is not only theoretical in line with the ideas of a circular economy but also seems to be in line with the expectations and demand of customers. As revealed by the survey, it comes as no surprise that customers consider price to be the most influential factor when making a purchase decision. The findings indicate that respondents show a strong preference for phones that have a price of 500 € or less. However, it is worth noting that the increased efforts in research and development, the inclusion of new services, and the availability of spare parts may have the drawback of heightened production costs, which in turn, may lead to an increase in prices for the end consumer.

In particular the results show that designing products that are repairable is in consumer interests. Additionally, the implementation of an extensive warranty, coupled with the introduction of repairability and recycling services to encourage product longevity are in demand. This presents an opportunity for phone producers to not only meet consumer and policymaker demands but also cultivate a stronger connection with their customer base. Through the establishment of additional touchpoints, organizations can enhance their overall brand attachment and foster a sense of loyalty among consumers. Moreover, the survey findings indicate that repairability is a feature of particular significance to women. As such, phone companies may benefit from targeting their marketing efforts towards females when promoting sustainable and modular smartphones. Building on the idea of marketing, this study also found that consumers environmental awareness had a considerable impact on consumer preferences. Therefore, companies should focus on raising environmental awareness and promoting sustainable smartphone usage behavior among their customers.

Prior research suggests that the resale value of pre-owned mobile phones, particularly within the European market, is insufficient. However, it is possible that there exist other markets where used phones still retain enough value, particularly if they have been refurbished and are fully functional. It would have been intriguing to investigate whether such markets exist even within the European Union. Unfortunately, although the European Union is one of the most affluent continents on the planet, there are significant disparities in economic strength among its member countries. One commonly held belief is that Eastern Europe continues to lag behind its Western counterparts in various aspects. In light of this, exploring the significance of phone type, particularly with respect to price, across Eastern and Western European countries may prove insightful. However, due to the distribution of the respondents, such a comparison would yield inconclusive results. Therefore, this topic presents an interesting avenue for future research, which will be further examined in the subsequent chapter.

The findings of the study revealed that the sustainable label of a product was deemed the least important factor by the participants. Otherwise, the place of production was found to be of greater significance with consumers preferring products that are locally sourced. This result is particularly intriguing, as it was unexpected. Nonetheless, it can be attributed to the recent drawbacks and public exposure of inefficient corporate sustainable labeling efforts, which may have reduced trust among consumers. Moreover, the Covid-19 pandemic has compelled companies to shift towards more resilient supply chains and local production, and it appears that consumer perceptions have adapted accordingly.

The findings presented bear notable ramifications not solely for manufacturers of smartphones, but for policymakers as well. To address these implications, policymakers must formulate incentives for manufacturers to focus on sustainability in product design and offer backing for domestic production.

Overall, the research provides valuable insights into European consumer preferences for sustainable smartphones and highlights the need for companies to prioritize sustainability in product design. With the right strategies in place, the smartphone industry can move towards a more environmentally responsible future.

7.3 Limitations

It is imperative to acknowledge the limitations inherent in the study despite the valuable insights it offers.

Firstly, the research was conducted using an adaptive conjoint analysis methodology, which may not accurately reflect the complexity of real-world consumer decision-making processes. Therefore, the results may not be entirely generalizable to all consumers.

Secondly, the research was limited to 17 European countries, which may not be representative of global consumer preferences. International differences in consumer behavior and cultural norms may affect the results.

Thirdly, the study only considered a limited set of sustainability attributes in smartphone design, such as repairability, sustainability labels, and the place of production. Other factors, such as material selection, energy efficiency, recyclability, ethical sourcing, disposal and end-of-life considerations, were not included.

Lastly, the study focused on consumer preferences for sustainable smartphones, but it did not investigate the actual behavior of consumers when purchasing smartphones. Therefore, the study could not determine the extent to which consumers' actual behavior aligns with their stated preferences.

Despite these limitations, the findings of this study provide useful insights into consumer preferences for sustainable smartphones and offer valuable guidance for smartphone manufacturers and policymakers in developing more sustainable products and strategies.

7.4 Future research

The data gathered in this study opens a lot more interesting investigation field. Thus, future research in this field could expand on the results of this study to gain a more complete understanding of consumer preferences for sustainable smartphones. It may make sense however, to align with smart phone distributors or even producers to achieve a structured, strategy driven approach. Absent such input, some feasible research paths include:

It is crucial to determine the effectiveness of repairable smartphones in extending the lifespan of these devices. Given their intricate design, it is reasonable to believe that they require more resources than traditional products. Hence, if they fail to extend the lifespan of smartphones, they may not be a sustainable option worth pursuing. It is essential that future research investigates whether repairable smartphones do indeed increase the lifespan of these devices.

Further investigations could focus on analyzing the behavior of consumers when purchasing smartphones to determine the extent to which their preferences align with their actual behavior.

On the marketing level, studying the impact of different strategies on consumer preferences for sustainable smartphones, such as the use of sustainability labels and messaging, could offer valuable insights.

Also, exploring the effects of sustainable smartphone design on consumer satisfaction and loyalty could provide insights into the potential business benefits of sustainable products.

By addressing these additional research questions, continuative studies could contribute to a more comprehensive understanding of consumer preferences for sustainable smartphones. Such insights could be valuable for smartphone manufacturers and policy-makers in developing more sustainable products and strategies.

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8 APPENDICES

8.1 Appendix 1: Sociodemographic Excel sheet

Gender Frequency table:

Gender	Frequency	Percent
Male (1)	149	52,46%
Female (2)	133	46,83%
Prefer not to answer (3)	2	0,70%
Total	284	100,00%

Income frequency Table:

Income	Frequency	Percantage
less than 500 EURO	13	4,58%
500 to 1,500 EURO	19	6,69%
1,000 to 2,000 EURO	40	14,08%
2,000 to 3,000 EURO	58	20,42%
3,000 to 5,000 EURO	65	22,89%
5,000 to 7,500 EURO	38	13,38%
7,5000 to 10,000 Euro	10	3,52%
more than 10,000 EURO	7	2,46%
prefere not to answer	34	11,97%
	284	100,00%

Education Frequency Table:

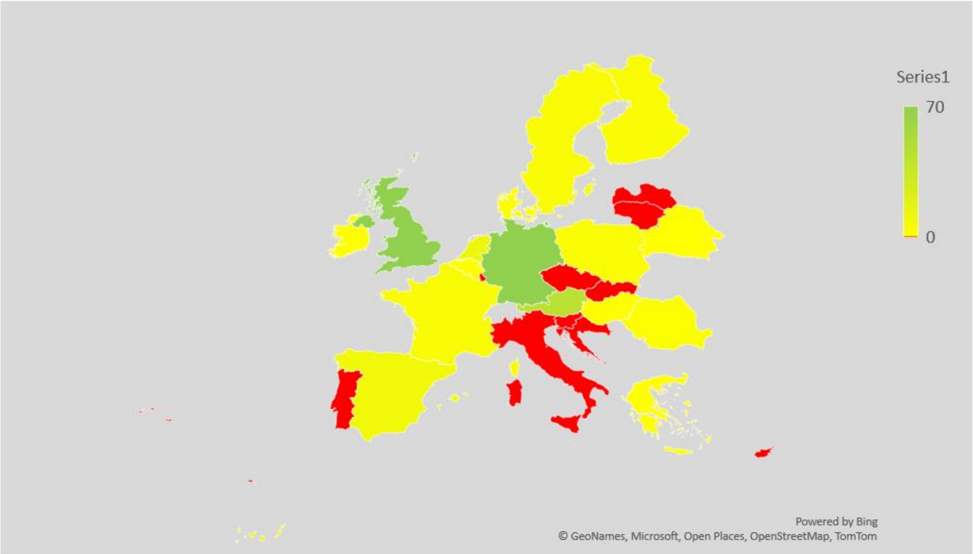
Education	Frequency	Percentage
High School or GED	54	19,01%
Trade/technical/vocational training	19	6,69%
Associate´s Degree	18	6,34%
Bachelors Degree	117	41,20%
Master´s Degree	69	24,30%
Doctorate Degree	7	2,46%

Age Distribution:

Age	
Mean	31,852113
Standard Error	0,6051401
Median	30,5
Mode	23
Standard Deviation	10,198002
Sample Variance	103,99925
Kurtosis	2,4989996
Skewness	1,3680444
Range	54
Minimum	16
Maximum	70
Sum	9046
Count	284
Largest(1)	70
Smallest(1)	16

8.2 Appendix 3: Frequency Tables used for map within Excel

Country			Percentage
1	Austria	44	15,49%
2	Belarus	1	0,35%
3	Belgium	1	0,35%
4	Croatia	0	0,00%
5	Croatia	1	0,35%
6	Cyprus	0	0,00%
7	Czech Republic	0	0,00%
8	Denmark	2	0,70%
9	Finland	5	1,76%
10	France	5	1,76%
11	Germany	117	41,20%
12	Greece	1	0,35%
13	Hungary	1	0,35%
14	Ireland	1	0,35%
15	Italy	0	0,00%
16	Latvia	0	0,00%
17	Lithuania	0	0,00%
18	Luxembourg	0	0,00%
19	Malta	0	0,00%
20	Netherlands	11	3,87%
21	Poland	4	1,41%
22	Portugal	0	0,00%
23	Romania	2	0,70%
24	Slovakia	0	0,00%
25	Slovenia	0	0,00%
26	Spain	9	3,17%
27	Sweden	5	1,76%
28	United Kingdom	72	25,35%
29	Other	2	0,70%
		284	100,00%



8.3 Appendix 3: Results Conjoint Analysis

ACA/HB		
Numbe of Respondents	284	
Avarage Utilities (Zero-Centered Diffs)	Avarage Utility	Standard Deviation
300 €.	43,652	57,74757
500 €.	21,923	25,51995
700 €.	-16,835	29,77528
900 €.	-48,74	50,43467
New Phone.	16,861	45,72214
Refurbished Phone.	-24,619	35,91206
Sustainable Green Phone.	7,757	29,77969
No warranty.	-51,706	37,97831
Standard warranty (2 years).	9,184	23,34041
Extended warranty (5 years).	42,521	32,78724
Limited	-38,628	30,56914
moderate	-2,689	16,99256
Easily	41,316	27,40352
No sustainability label on the product.	-30,678	25,37778
Labled as eco-friendly with information about specific sustainable features.	30,678	25,37778
Imported product.	-28,097	32,52785
Partially locally manufactured.	-0,733	21,88137
Locally manufactured.	28,829	25,50818
Avarage Importances	Avarage Importances	Standard deviation
price	23,3792494	9,833792922
phone type	15,17808873	6,639928829
warranty	19,29557665	7,192482069
repairability	16,26159479	5,194938734
sustainability lable	12,31728862	5,455420939
place of production	13,56820181	4,879388765

Average Importances ranked:

Avarage Importance ranked	
Price	23,3792494
Warranty	19,29557665
Repairability	16,26159479
PhoneTtype	15,17808873
Place of production	13,56820181
Sustainability Lable	12,31728862

8.4 Appendix 4: Smartphone related measurements

Frequency Table Smartphone Brand:

Lable	Brand	Counts	Percentage
1	Apple	126	44,37%
2	Samsung	80	28,17%
3	Xiaomi	22	7,75%
4	Huawei	11	3,87%
5	Oppo	2	0,70%
6	Motorola	8	2,82%
7	Google	10	3,52%
8	Fairphone	3	1,06%
9	LG	3	1,06%
10	Unkown	0	0,00%
11	Other	19	6,69%
	Total	284	100,00%

Frequency Table reported lifetime of smartphones:

Lifetime	Frequency	Percentage	Culm
less than 1 year	13	4,58%	4,58%
1 to 2 years	41	14,44%	19,02%
2 to 3 years	95	33,45%	52,47%
3 to 4 years	77	27,11%	79,58%
more than 4 years	58	20,42%	100,00%
	284	100,00%	

Frequency table expected smartphone use:

Expected Use	Frequency	Percentage	Culm
less than 1 year	4	1,41%	1,41%
1 to 2 years	44	15,49%	16,90%
2 to 3 years	68	23,94%	40,85%
3 to 4 years	73	25,70%	66,55%
more than 4 years	95	33,45%	100,00%
	284	100,00%	

Smartphone Disposing Method:

Smartphone dispose	Frequency	Percentage
Hort	66	23,24%
Recycle	65	22,89%
Donate	41	14,44%
Sell	88	30,99%
Throw away	24	8,45%
	284	100,00%

Frequency Table Smartphone Replacement Reason:

Replacement reason	Frequency	Perentage
It was lost/stolen	17	3,48%
It broke beyond repair	88	18,03%
Technology was worn out	104	21,31%
It didn´t have functions is wanted	31	6,35%
different contract with better features	33	6,76%
Was no longer novel, stylish or prestigious	21	4,30%
It was no longer clean, shiny, or new	20	4,10%
It cost too much money to repair (if broken)	44	9,02%
I was offered a free/discounted upgrade in my contract	18	3,69%
wanted a different contract with better value for money	20	4,10%
The technology was outdated	73	14,96%
It was bad for the enviroment	6	1,23%
I am more emotionally attached to the replacement	7	1,43%
It was no longer socially acceptable to use	6	1,23%
	488	100,00%

Frequency Tabel Type of Obsolescence:

RR Obsolecence		Total %
Absolute		42,83%
Functional		13,11%
Aesthetic		8,40%
Economic		16,80%
Technological		14,96%
Ecological		1,23%
Psychological		1,43%
Sociatal		1,23%
		100,00%

Frequency Table Favored Durability feature:

Durability Features	Frequency	Percentage
Drop and Impact resistance	169	59,51%
Scratch Resistance	41	14,44%
Corrosin Resistance	19	6,69%
Waterproofness	35	12,32%
Non of the above	20	7,04%
	284	100,00%

8.5 Appendix 5: NEP Question results:

NEP Scale items										
		SD	D	N	A	SA	Total	Mean	SD	Interpretation
NEP Q1		17	29	65	120	53	284	3,57	1,09	Agree
%		5,99%	10,21%	22,89%	42,25%	18,66%	100,00%			
NEP Q2*		15	74	90	74	31	284	3,11	1,08	Neutral
%		5,28%	26,06%	31,69%	26,06%	10,92%	100,00%			
NEP Q3		8	13	56	126	81	284	3,91	0,96	Agree
%		2,82%	4,58%	19,72%	44,37%	28,52%	100,00%			
NEP Q4*		22	76	109	58	19	284	2,92	1,02	Neutral
%		7,75%	26,76%	38,38%	20,42%	6,69%				
NEP Q5		4	19	41	120	100	284	4,03	0,94	Agree
%		1,41%	6,69%	14,44%	42,25%	35,21%	100,00%			
NEP Q6*		42	126	63	43	10	284	2,48	1,03	Disagree
%		14,79%	44,37%	22,18%	15,14%	3,52%				
NEP Q7		7	23	51	112	91	284	3,89	1,02	Agree
%		2,46%	8,10%	17,96%	39,44%	32,04%	100,00%			
NEP Q8*		14	55	68	103	44	284	3,38	1,11	Neutral
%		4,93%	19,37%	23,94%	36,27%	15,49%	100,00%			
NEP Q9		3	12	54	131	84	284	3,99	0,87	Agree
%		1,06%	4,23%	19,01%	46,13%	29,58%	100,00%			
NEP Q10*		16	45	76	72	75	284	3,51	1,20	Agree
%		5,63%	15,85%	26,76%	25,35%	26,41%	100,00%			
NEP Q11		6	39	69	121	49	284	3,59	1,00	Agree
%		2,11%	13,73%	24,30%	42,61%	17,25%	100,00%			
NEP Q12*		21	47	60	78	78	284	3,51	1,26	Agree
%		7,39%	16,55%	21,13%	27,46%	27,46%	100,00%			
NEP Q13		3	23	74	133	51	284	3,73	0,89	Agree
%		1,06%	8,10%	26,06%	46,83%	17,96%	100,00%			
NEP Q14*		19	76	98	73	18	284	2,98	1,02	Neutral
		6,69%	26,76%	34,51%	25,70%	6,34%	100,00%			
NEP Q15		5	15	56	124	84	284	3,94	0,93	Agree
%		1,76%	5,28%	19,72%	43,66%	29,58%				
						Overall		52,55	16,44	
								3,50	1,03	
* = Reversed Coded										

	Range
Strongly Dissagree	1 - 1,8
Disagree	1,9 - 2,6
Neutral	2,7 - 3,4
Agree	3.5 - 4,2
Strongly Agree	4,3 - 5

8.6 Appendix 6: Hypothesis 2:

8.6.1. Mean NEP Values according to Gender

Descriptives						
	Gender	N	Mean	SD	Minimum	Maximum
Total NEP	1	143	50.6	6.77	34	66
	2	133	54.4	8.32	32	73