Digital Product Passports in Consumer Electronics: Consumer Engagement and Circular Economy Implications

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Abstract

Title: Digital Product Passports in Consumer Electronics: Consumer Engagement and Circular Economy Implications

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Digital Product Passports (DPPs) are a central policy instrument in the European Union's efforts to advance the circular economy (CE) transition, aiming to improve product transparency. While regulatory, technical, and supply chain dimensions have received much attention, consumer engagement with DPPs and its impact on purchase decisions remains largely unexplored, despite its importance for CE adoption.

This study examines both consumer engagement with DPPs and firm responses in the consumer electronics sector, characterized by high material intensity and environmental impact. A mixed-methods approach combined a survey (n = 167) with eleven expert interviews.

Survey results showed that perceived usefulness and perceived ease of use are the only significant predictors of engagement. Experts additionally highlighted factors such as trust, usability, and design. The survey further revealed a positive effect of DPPs on purchase intention and willingness to pay (WTP) for circular consumer electronics, constrained by high price sensitivity.

Overall, the findings demonstrate that DPPs can contribute to CE adoption by influencing consumer behavior and shaping circular preferences. Simultaneously, the interviews revealed that their strategic value depends on firm-level responses: firms may treat DPPs merely as compliance instruments or leverage them as strategic tools, thereby fostering circular economy business models (CEBMs).

Keywords: Digital Product Passports (DPPs); consumer behavior; purchase intention; willingness to pay (WTP); consumer electronics; circular economy business models (CEBMs); strategic management; circular economy (CE)

Resumo

Título: Passaportes Digitais de Produto em Eletrónica de Consumo: Envolvimento do Consumidor e Implicações para a Economia Circular

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Os Passaportes Digitais de Produto (DPPs) são um instrumento político central nos esforços da União Europeia para avançar na transição para a economia circular (EC), visando melhorar a transparência dos produtos. Embora as dimensões regulatórias, técnicas e da cadeia de abastecimento tenham recebido muita atenção, o envolvimento dos consumidores com os DPPs e o seu impacto nas decisões de compra permanece em grande parte inexplorado, apesar da sua importância para a adoção da EC.

Este estudo analisa tanto o envolvimento dos consumidores com os DPPs como as respostas das empresas no setor da eletrónica de consumo, caracterizado por elevada intensidade material e impacto ambiental. Uma abordagem de métodos mistos combinou um inquérito (n = 167) com onze entrevistas a especialistas.

Os resultados do inquérito mostram que a utilidade percebida e a facilidade de utilização percebida foram os únicos preditores significativos do envolvimento. Os especialistas destacaram adicionalmente fatores como confiança, usabilidade e design. O inquérito revelou ainda um efeito positivo dos DPPs na intenção de compra e na disposição a pagar (WTP) por eletrónica de consumo circular, limitado por uma elevada sensibilidade ao preço.

De forma geral, os resultados demonstram que os DPPs podem contribuir para a adoção da EC ao influenciar o comportamento do consumidor e moldar preferências circulares. Simultaneamente, as entrevistas revelaram que o seu valor estratégico depende das respostas ao nível das empresas: estas podem encarar os DPPs apenas como instrumentos de conformidade ou aproveitá-los como ferramentas estratégicas, fomentando assim modelos de negócio de economia circular (CEBMs).

Palavras-chave: Passaportes Digitais de Produto (DPPs); comportamento do consumidor; intenção de compra; disposição a pagar (WTP); eletrónica de consumo; modelos de negócio de economia circular (CEBMs); gestão estratégica; economia circular (EC)

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List of Abbreviations

AI	Artificial Intelligence
CE	Circular Economy
CEAP	Circular Economy Action Plan
CEBM	Circular Economy Business Model
DPP	Digital Product Passport
DPPE	Digital Product Passport Ecosystem
EEE	Electrical and Electronic Equipment
EoL	End-of-Life
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
Gt	Gigatonnes
ICT	Information and Communication Technology
NFC	Near-Field Communication
PaaS	Product-as-a-Service
QR	Quick Response
RBV	Resource-Based View
RFID	Radio Frequency Identification
SMEs	Small and Medium-Sized Enterprises
TAM	Technology Acceptance Model
TPB	Theory of Planned Behavior
WEEE	Waste Electrical and Electronic Equipment
WTP	Willingness to Pay

1. Introduction

1.1 Background

Global economic growth, population expansion, and rising living standards have caused a rapid increase in the use of material resources (OECD, 2019). Between 1970 and 2020, global material extraction has more than tripled, from 30.9 gigatonnes (Gt) to 95.1 Gt per year, with further growth projected (United Nations Environment Programme, 2024). Contrary to this, the material footprint in the European Union (EU) has stabilized in recent years, but a substantial reduction in the coming decade is still considered unlikely (European Environment Agency, 2024a). A major challenge globally and in the EU is the growing amount of Waste Electrical and Electronic Equipment (WEEE), commonly referred to as e-waste. The total volume of e-waste increased from 7.6 million tonnes in 2012 to 14.4 million tonnes in 2022, making it one of the fastest growing waste streams in the EU (European Parliament, 2024a; Eurostat, 2024). Consumer electronics, such as smartphones, which are an integral part of everyday life, are a major contributor to this growth of e-waste, which is driven by accelerated technological advancements and shorter product lifecycles (PwC, 2023). They pose severe problems, including the use of hazardous substances, high energy demand, and unsafe working conditions, both during production and disposal. This makes the shift from a linear model to a circular economy (CE) crucial (Ellen MacArthur Foundation, 2018).

The EU has been promoting CE practices through different policies and regulations. As part of the European Green Deal, the Circular Economy Action Plan (CEAP) establishes a structured policy framework to foster sustainable growth and competitiveness (European Commission, 2020). However, in spite of continuous efforts, the circularity rate in the EU was just 11.8% in 2023. This indicates the necessity of more robust policies and actions to accelerate the shift to a CE (European Environment Agency, 2024b).

The Digital Product Passport (DPP) is a regulatory initiative under the EU's Ecodesign for Sustainable Products Regulation (ESPR) to address this shift. DPPs will become mandatory for almost all products sold within the EU and aim to enhance product transparency by providing detailed product information on lifecycle, material origin, and environmental impact. While firms will benefit from improved supply chain visibility and better risk management concerning environmental impact, consumers will be empowered to make more informed purchase decisions (European Union, 2024a). Despite these opportunities, DPPs also pose financial and technological challenges, especially in terms of data collection, data security, and transaction

costs incurred by manufacturers (Adisorn et al., 2021). One application of the DPP is the Battery Passport, which will become mandatory for certain battery types by 2027, with other industries expected to follow (Roland Berger, 2024). Among these, the consumer electronics sector can particularly benefit from DPPs. Enhanced transparency and traceability not only allow for tracking products across supply chains and extending product lifecycles, but also enable firms to develop new circular business models and support consumers in making more informed and sustainable purchase decisions (Chaudhuri et al., 2024), highlighting the dual role of DPPs as both regulatory instruments and potential strategic tools.

1.2 Problem Statement

In recent years, as part of the EU's sustainability efforts and its ongoing transition to a CE, DPPs have gained attention as a regulatory tool to enhance information transparency and integrity. Existing research has primarily focused on the technological, regulatory, and supply chain aspects of DPPs (Adisorn et al., 2021).

While DPPs are expected to improve traceability and compliance across product lifecycles, their potential to empower consumers to make more sustainable purchase decisions is also noted (European Union, 2024a). King et al. (2023) emphasize that DPPs are regarded as instruments to shape consumer behavior toward more sustainable purchasing and long-term product use. Yet, Zhang and Seuring (2024) highlight that actual impact of transparency provided through DPPs on consumer behavior and trust remains largely unexplored.

Since Langley et al. (2023) emphasize that, in addition to firms and policymakers, consumers must also change their behavior to facilitate an actual CE transition, it is important to address this research gap. Without consumer engagement, the effectiveness of DPPs as a lever for circularity may be significantly limited.

Although existing research on eco-labels and product transparency suggests that credible sustainability information can both influence purchase intention and willingness to pay (WTP) (European Commission, 2018; Panopoulos et al., 2023), it remains unclear whether these insights can be transferred to DPPs. While DPPs also improve transparency, their scope goes beyond labeling by addressing the entire product lifecycle and relying on more data-driven and technologically embedded systems.

These open questions emphasize the urgency of empirical research into how consumers may engage with DPPs and how such engagement could shape more circular purchase behavior. At the same time, it is equally unclear how firms will respond to this emerging consumer

engagement: whether they will treat DPPs merely as compliance instruments or leverage them strategically to enable circular economy business models (CEBMs). This strategic perspective has so far received little attention, as consumers and business models are rarely discussed as key enablers of CE (Kirchherr et al., 2017).

1.3 Research Objectives, Scope, and Limitations

To address the research gaps introduced in Chapter 1.2, the study seeks to answer the following **Research Question**:

> **How does consumer engagement with Digital Product Passports influence purchase decisions for circular consumer electronics, and what does this imply for circular economy adoption?**

This study investigates how consumers engage with DPPs, how this engagement influences their purchase decisions, and what this implies for CE adoption. Since consumer engagement alone will not automatically translate into circularity, the study also explores how firms can strategically respond to such engagement. In this way, the analysis connects the consumer perspective with the strategic management perspective, examining whether DPPs are treated merely as compliance instruments or leveraged as strategic tools for developing CEBMs.

The geographical scope is restricted to the EU, where DPPs will be obligatory for most products sold (European Union, 2024a). The consumer electronics sector is selected due to its environmental significance and policy priority.

In analyzing consumer behavior, this research conceptualizes DPPs mainly as decision-support tools at the point of sale. Although DPPs may also affect consumer behavior during use and end-of-life (EoL) phases, these fell outside the scope of this part of the research and need to be addressed in future studies.

1.4 Structure of the Thesis

To begin with, **Chapter 1** presents the research background, objectives, and scope. **Chapter 2** follows with the theoretical foundation by outlining the CE and its applicability in the consumer electronics sector. This is followed by an examination of DPPs, including their functionality, regulatory background, and the associated consumer-related opportunities and implementation barriers. Consumer behavior is subsequently examined in terms of adoption, decision-making, and its potential to drive circular business practices, before strategic management perspectives are introduced to contextualize firm-level implications. **Chapter 3** provides details on the

research methodology. **Chapter 4** presents the empirical findings, while **Chapter 5** discusses them. Finally, **Chapter 6** concludes by summarizing the key findings, drawing theoretical and practical implications, reflecting on limitations, and presenting directions for future research.

2. Literature Review

2.1 The Circular Economy in Consumer Electronics

The transition from a linear economy to a CE in the consumer electronics sector is a critical transformation that aims to tackle issues such as the increasing volumes of e-waste, resource scarcity, and the use of hazardous substances (Ellen MacArthur Foundation, 2018). In spite of various efforts within the EU, the linear economy still remains the norm (European Environment Agency, 2024b). Firms can utilize several enablers to facilitate the transition to a CE, including digitalization and active consumer involvement (Bressanelli et al., 2021).

2.1.1 Circular Economy

2.1.1.1 Definition, Principles, Strategies, and Business Models

The linear economy is drawing growing criticism as it embodies a take-make-dispose approach, which results in negative environmental and social consequences (Acquier et al., 2024). CE aims to address these problems by moving away from the linear model and promoting closed-loop systems that extend the lifecycle of products, materials, and resources (Merli et al., 2018). According to Kirchherr et al. (2017), definitions of CE vary widely and often neglect the need for a systemic shift. However, they highlight that the following definition from the Ellen MacArthur Foundation (2013, p. 7) is used particularly frequently:

> *"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."*

The definition underlines the contrast to a linear economy as CE aims for a circular use of resources by optimizing material flows and product lifecycles. This can also be interpreted as advocating for a systemic change, which Kirchherr et al. (2017) emphasize as a requirement for CE.

CE is built on fundamental principles, often referred to in the literature as the 3R framework, which consists of reduce, reuse, and recycle (Ghisellini et al., 2016). Since additional strategies such as redesign, refurbish, and repurpose enhance resource value retention, more refined frameworks have evolved over time (Reike et al., 2018). Potting et al. (2017) suggest the 9R framework and emphasize that these strategies should be prioritized according to their circularity, which is related to their capability to minimize the consumption of resources and waste generation. Under this hierarchy, strategies such as refuse and rethink are prioritized over

comparatively less circular strategies like recycling and recovery, focusing on reprocessing materials rather than reducing the resource consumption.

To promote CE, firms must translate these principles into CEBMs. These models create value by applying CE principles and are characterized by features such as slowing and closing resource loops (Lüdeke-Freund et al., 2018; Bocken et al., 2016). Depending on the chosen typology, different CEBMs can be distinguished, including circular supply, resource recovery, product life extension, sharing, and product service systems. Different industries use these models, which differ in their core value proposition, but all contribute to slowing and closing resource loops (OECD, 2019).

2.1.1.2 Status Quo

In the EU, transitioning to a CE is regarded as a milestone on the path to achieving climate neutrality by 2050. The shift therefore represents a strategic priority under the European Green Deal and CEAP. Fundamental measures include incentivizing circular product design and business models, digitizing product information, and actively involving consumers in the shift. The transition is being made step-by-step, with value chains like electronics being prioritized initially (European Commission, 2020). Despite these initiatives, however, the EU's circularity rate has risen only marginally from 10.7% in 2010 to 11.8% in 2023, still well below the 2030 target of 22.4% (European Environment Agency, 2025a).

Among the prioritized sectors, consumer electronics offer considerable potential to increase circularity since high growth rates and short product lifespans make them an enormous contributor to e-waste and link them to severe environmental and social issues (Ellen MacArthur Foundation, 2018; PwC, 2023). The following chapter therefore explores central challenges, CE opportunities, and above all, the pivotal role of consumers.

2.1.2 Consumer Electronics

2.1.2.1 Definition

Consumer electronics are electronic devices for personal and non-commercial use (Statista, n.d.-a). These products are diverse and comprise smartphones, televisions, laptops, smart home technology, gaming consoles, and digital cameras (Althaf et al., 2019). Among the common characteristics are short product lifecycles, rapid technological progress, shifting consumer preferences, and low emotional attachment of consumers, all of which contribute to increasing e-waste volumes (Ryen et al., 2018). Unlike other scholars, PwC (2023) also includes large

household appliances such as laundry machines and fridges but notes that these differ regarding the lifespan and intended use.

Alongside consumer electronics, the electronics industry entails a number of other segments, including automotive electronics, industrial electronics, and information and communications technology (ICT) (PwC, 2023). While some studies use the term electronics, they often focus primarily on consumer electronics. The CEAP reflects this emphasis by presenting electronics and ICT as a key product value chain, while its specific measures concentrate on mobile phones, tablets, laptops, and printers (European Commission, 2020). This focus underlines the important role of consumer electronics in the CE.

2.1.2.2 Market Dynamics and Challenges

The consumer electronics market in Europe is set to reach USD 199.5 billion in 2025, with further growth anticipated (Statista, n.d.-b), driven by the intensifying penetration of smartphones, smart homes, and 5G (Statista, 2024). However, rising demand also equates to greater material consumption and waste generation, adding further to sustainability challenges (PwC, 2023).

E-waste is a major concern, aggravated by short product lifecycles and the complexity of modern devices, making recycling more difficult. This results in the loss of valuable materials and the accumulation of hazardous waste (Ryen et al., 2018). In addition, the extraction and processing of critical raw materials and rare earth elements used in consumer electronics often involve social and environmental issues, particularly in developing countries (Awasthi et al., 2019). Geopolitical uncertainties and supply shortages further intensify the challenges (Cimprich et al., 2023; Althaf et al., 2019).

The variability of such interconnected matters necessitates the widespread adoption of CEBMs in the consumer electronics sector (PwC, 2023).

2.1.2.3 Circular Economy Approaches

The transition to a CE in the consumer electronics sector is motivated by environmental gains and regulatory pressure (PwC, 2023). This leads to shifts in business models aimed at extending product lifespans and using resources more efficiently. In parallel, customer relationships are evolving through new models (Ellen MacArthur Foundation, 2018).

Refurbishment and take-back programs become more relevant, for example, Apple’s Trade In program providing customers with discounts or vouchers upon returning used devices that are

then resold or recycled (Apple Inc., n.d.). Recycling of valuable materials is accomplished but tends to be ineffective considering complex product compositions, critical raw materials, and constrained sorting technologies in consumer electronics (Althaf et al., 2019; Kasulaitis et al., 2018). This underscores the importance of circular design for disassembly, reuse, and recycling (Ellen MacArthur Foundation, 2018). The viability of these models also relies on active consumer engagement. The European Commission (2023) reports low collection rates of small consumer electronics, with mobile phones recording a return rate of less than 5% in the EU.

Product-as-a-Service (PaaS) has emerged as another promising CEBM, shifting ownership from consumers to firms and thereby incentivizing product longevity. Subscription-based services, pay-per-use, and leasing are the main PaaS types. However, their adoption is limited by consumer data security doubts and ownership preferences (PwC, 2023).

Beyond technical and economic challenges, the lack of accessible and standardized data remains a central barrier to CE strategies such as reuse and recycling (Peiró et al., 2021; PwC, 2023). Ultimately, the effectiveness of CEBMs depends heavily on active consumer participation by choosing circular products, returning used items, and changing personal habits to fit models like PaaS (European Environment Agency, 2024a; European Commission, 2018; Ricardo, 2021). Consumers, therefore, are not just end users but also key enablers of widespread CE adoption. Their role, in addition to prevailing barriers and drivers to their engagement, is therefore explored in the next chapter.

2.1.2.4 Consumer Engagement: Relevance, Barriers, and Drivers

Given the global environmental challenges, the EU's transition to a CE relies on joint efforts of policymakers, firms, and consumers. While policymakers have the responsibility for framing the rules within which CEBMs are to be developed by firms, consumers play a particularly crucial role as their behavior and preferences significantly influence large-scale adoption of such models (European Environment Agency, 2024a).

In contrast to their traditional role as mere buyers in linear business models, consumers in CE are actively involved throughout the entire lifecycle. Their choices made during the purchase, use, and end-of-use phases play a decisive role in driving or hindering CEBMs. Circular decisions comprise the purchase of refurbished or second-hand products and the use of product service systems, adequate treatment and routine maintenance during use, and the extension of product lifetimes through prolonged use, repair, and product return for recycling or reuse. They

not only extend product lifespans and reduce waste but also signal CEBM demand, thereby influencing business strategies (Ricardo, 2021).

A number of studies demonstrate that circular consumer electronics increase purchase intention and WTP, with socio-economic factors playing a significant role (European Commission, 2018; European Commission, 2024; Ricardo, 2021). The Eurobarometer 550 survey in 2024 indicated that 78% of those surveyed view environmental issues as having a direct impact on their everyday life and health, with the promotion of CE being viewed as the most effective measure (European Commission, 2024).

Despite increased purchase intention and WTP for circular products, actual consumer behavior often falls behind. In the European Commission (2018) research on consumer electronics and textiles, 90% of the participants had no experience with renting, leasing, or buying second-hand products. This finding is suggestive of the attitude-behavior gap, where pro-environmental attitudes may not always lead to consistent behavior (Atkinson & Rosenthal, 2014), therefore indicating underlying barriers.

A significant behavioral barrier is the low availability of reliable and standardized product information on sustainability, which results in information asymmetries that hinder consumers from identifying truly sustainable products. The proliferation of misleading claims and greenwashing worsens this situation by deterring consumer trust and thereby reducing the demand for sustainable products (European Commission, 2021). The other barriers include limited awareness and understanding of circular concepts, a strong status quo bias, and skepticism toward collaborative consumption models centered on the loss of ownership, all of which reduce consumer engagement with CE offerings (Grafström & Aasma, 2021; Ghisellini et al., 2016).

Broader interconnected systemic challenges amplify these behavioral barriers. Regulatory fragmentation and weak enforcement contribute to market barriers by failing to create stable market conditions for CEBMs. As a result, firms face additional obstacles like high upfront investment costs or low prices for virgin materials, which weaken the competitiveness of circular alternatives (Grafström & Aasma, 2021; Kirchherr et al., 2018). This reduces demand among consumers who are open to circular products but highly sensitive to price (Boyer et al., 2021).

Digital technologies are increasingly regarded as key enablers of the transition to a CE by increasing consumer adoption of CEBMs. For example, QR (Quick Response) codes on

consumer electronics can improve information availability for consumers, while artificial intelligence (AI) can be used to automatically determine the value of returned products (Bücker et al., 2025). Blockchain enhances consumer trust in circular offerings by providing tamper-proof and decentralized access to reliable product information. This functionality allows consumers to verify sustainability claims as well as ethical standards, thereby supporting more informed purchase decisions (Upadhyay et al., 2021).

Yet, the overall capacity of digital technologies to drive the adoption of CEBMs can only be fully exploited if all actors across the ecosystem adopt and utilize them. Regulatory frameworks are crucial to enabling system-wide adoption (Chauhan et al., 2022). A specific regulatory development in the EU with significant potential is the DPP, which aims to empower consumers in their purchase decisions by providing transparent product information (European Union, 2024a). Therefore, the following chapter examines its role in the CE transition.

2.2 Digital Product Passports in the Circular Economy

DPPs are emerging as both a technological and regulatory instrument to support the transition toward a CE within the EU (Zhang & Seuring, 2024). This chapter first introduces the concept of DPPs and outlines their regulatory background to establish a foundation for determining their potential impact. It then examines the associated opportunities, particularly those concerning consumers, as well as key barriers to their implementation.

2.2.1 Definition and Functionality

A DPP is a product-specific digital tool aimed at enhancing sustainability, circularity, and regulatory compliance (European Commission, n.d.-a). It provides access to real-time product data across the entire lifecycle, encompassing phases from resource extraction to the EoL (Langley et al., 2023). Such data includes origin, materials, environmental impact, substances of concern, and disposal recommendations for each product (European Union, 2024a). Psarommatis and May (2024) further classify product data into seven categories: material, environmental, manufacturing, value network, maintenance, circularity, and end-user data. The authors suggest that circularity data in DPPs should store lifecycle changes after initial product use to enhance CE strategies like reuse, repurposing, and recycling. While they focus on environmental data related to the product's intrinsic characteristics, Jensen et al. (2023) highlight the importance of also capturing external environmental conditions during use – such as exposure to dust – for assessing suitable CE strategies, including the feasibility of product

reuse. This complementary perspective underlines the need for both internal and contextual environmental data for well-informed circularity decisions.

Functionally, DPPs act as a central component within a broader product value ecosystem, as shown in Figure 1 (Giess & Moeller, 2025), which highlights value flows between five main actors: manufacturers, suppliers, consumers, EoL actors, and authorities. The role of DPPs is to enable information exchange and support product lifecycle management within this ecosystem. This allows consumers to access sustainability-related data, which they can take into account when making purchase decisions. Taking this foundation further, King et al. (2023) propose a broader systems thinking perspective and envision the DPP as a Digital Product Passport Ecosystem (DPPE), rather than as a standalone system. The DPPE framework emphasizes the need for interoperability between legal, organizational, semantic, and technical aspects, given its nature as a complex system of systems. Interoperability, along with the systems thinking approach, is essential to unlocking the full potential of CE.

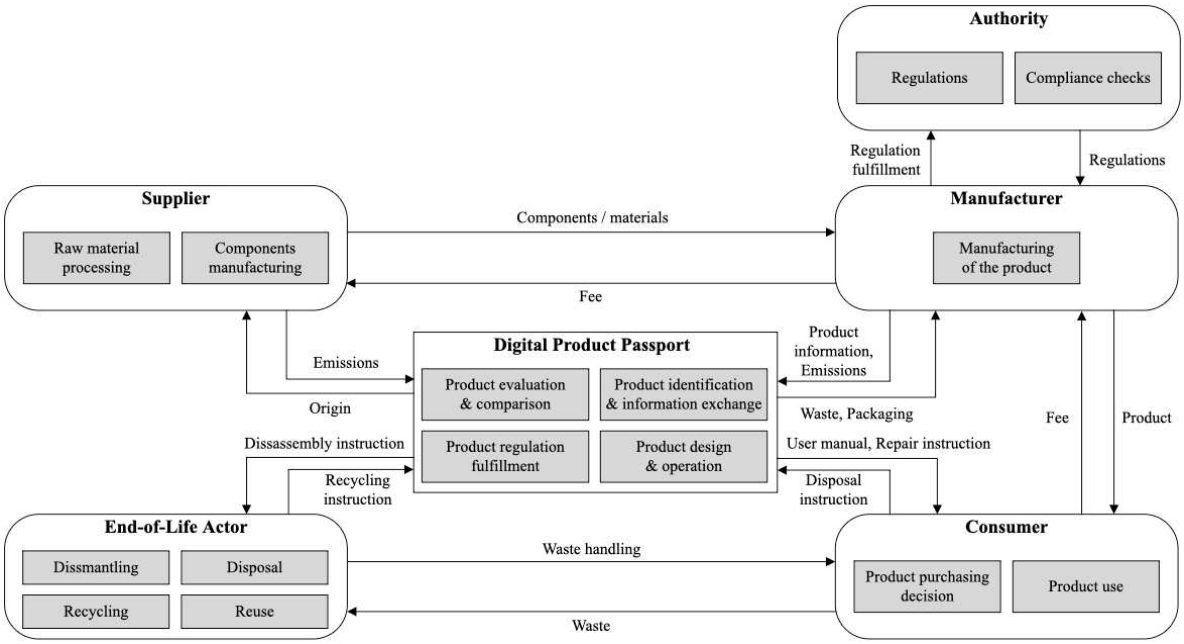

Figure 1. The DPP Value Ecosystem

Note. Adapted from Giess and Moeller (2025, p. 7).

Standardized and comparable data formats, in addition to secure data exchange protocols, are essential in facilitating interoperability along value chains and enhancing collaboration among CE stakeholders (Thunyaluck & Valilai, 2024; Walden et al., 2021). Blockchain technology is another important element to ensure security, integrity, and transparency of data (Psarommatis & May, 2024).

Product data in DPPs is linked to a unique digital product identifier and made accessible through data carriers such as QR codes, NFC (Near-field Communication), or RFID (Radio Frequency Identification) technologies (Chaudhuri et al., 2024; Giess & Moeller, 2025). Scholars broadly agree that low-barrier access to this data is crucial for the effectiveness of DPPs. The data carrier must be physically integrated into the product and access to product data must be free and user-friendly for all stakeholders (University of Cambridge Institute for Sustainability Leadership & Wuppertal Institute, 2022; Walden et al., 2021).

2.2.2 Regulatory Background

Regulation is a major enabler of the CE transition by supporting markets, creating incentives, and promoting circular practices (Geng et al., 2019; Neves & Marques, 2022). Within the EU, this shift is highlighted in the European Green Deal (European Union, 2024b) and operationalized through the CEAP, which promotes sustainable products and waste minimization (European Commission, 2020; Walden et al., 2021). To achieve these goals, the ESPR, which entered into force in 2024, mandates the DPP and details its functionality and requirements (European Commission, n.d.-a; European Union, 2024b). DPPs will become mandatory for most products sold in the EU (European Union, 2024a). The EU is taking the lead in the development of DPPs, which could serve as a blueprint for worldwide adoption (University of Cambridge Institute for Sustainability Leadership & Wuppertal Institute, 2022).

Technical preparations are ongoing (European Commission, n.d.-b), while the first concrete application of the DPP, the Battery Passport, is expected in 2027 (Roland Berger, 2024). DPPs are expected to become legally binding for consumer electronics shortly thereafter (American National Standards Institute, 2024). Given the upcoming requirements, firms should proactively assess how DPPs can generate value (Giess & Moeller, 2025).

Alongside this, further regulatory instruments specifically support the CE transition in the consumer electronics sector. The Right to Repair Directive obliges manufacturers to offer repair services and inform consumers about their rights (European Parliament, 2024b), while the WEEE Directive sets targets for waste collection and treatment (Wautelet & Ayed, 2024).

2.2.3 Consumer-Related Opportunities

DPPs entail considerable progress, such as enhanced transparency, end-to-end traceability along the product value chain, and improved data accessibility (European Union, 2024a; European Union, 2024b). These benefits offer diverse opportunities to accelerate the CE transition in the consumer electronics sector, particularly by strengthening the consumers' role.

More informed purchase decisions could increase consumer demand for sustainable products, encouraging firms to adapt and differentiate themselves from competitors (Thunyaluck & Valilai, 2024). Moreover, DPPs help reduce information asymmetries, making greenwashing more difficult and strengthening consumer trust (Adisorn et al., 2021; Langley, 2023). In addition, DPPs will include information on substances of concern, facilitating the identification and promotion of truly sustainable products (European Union, 2024a; European Union, 2024b).

Apart from shaping individual purchase decisions, DPPs can also enable new and enhance existing CEBMs by providing relevant product information and extending product lifecycles (Chaudhuri et al., 2024; Hakola et al., 2025). An illustrative case is smartphone refurbishment, an emerging CEBM in the consumer electronics sector but held back by information gaps regarding device condition and repair history. DPPs can close these gaps by providing track and trace information across the entire product lifecycle, thereby reducing costs and increasing consumer trust in second-hand products (Adisorn et al., 2021; Wautelet & Ayed, 2024).

Figure 2 shows how circularity strategies can be applied at different stages of the conventional electronics value chain to enable CE (Hakola et al., 2025). DPPs constitute an important enabler by providing relevant data for often complex products in near real time (University of Cambridge Institute for Sustainability Leadership & Wuppertal Institute, 2022).

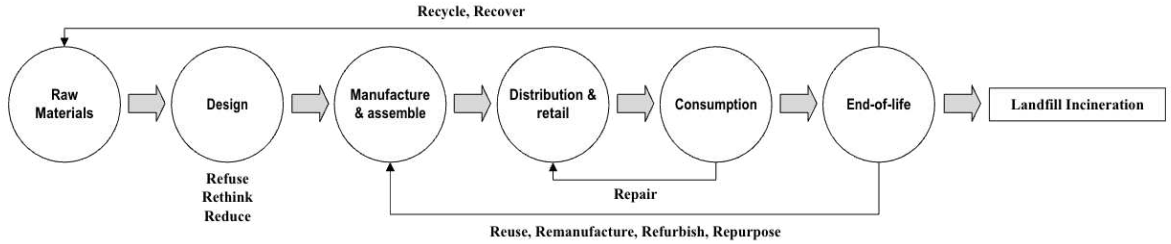

Figure 2. Electronics Value Chain and Circularity Strategies

Note. Adapted from Hakola et al. (2025, p. 2).

2.2.4 Implementation Barriers

While DPPs offer significant opportunities, their successful implementation faces several practical challenges. Many of their benefits rely on the availability and quality of data, yet data collection remains a major difficulty (Adisorn et al., 2021). Technically, collaboration is required to develop common standards that ensure interoperability across systems and industries (University of Cambridge Institute for Sustainability Leadership & Wuppertal Institute, 2022; Psarommatis & May, 2024; Thunyaluck & Valilai, 2024).

Aside from technical issues, DPPs also need to be seamlessly integrated into already existing operational business processes (Psarommatis & May, 2024), with costs of implementation –

particularly for micro, small, and medium-sized enterprises (SMEs) – remaining proportionate (European Union, 2024b). Firms also fear losing competitive advantages through disclosure of sensitive information, underlining the necessity for robust governance structures (University of Cambridge Institute for Sustainability Leadership & Wuppertal Institute, 2022; King et al., 2023).

Early involvement and close cooperation with all relevant stakeholders are therefore crucial to the success of DPPs (Adisorn et al., 2021; Langley et al., 2023). While awareness of these practical hurdles is essential to assessing the full potential impact of DPPs and their role in enabling CE in the consumer electronics sector, a deeper analysis lies beyond the scope of this study.

2.3 Consumer Behavior

This chapter examines factors influencing consumer engagement with DPPs (Chapter 2.3.1), the extent to which DPPs may shape purchase intention and WTP for circular consumer electronics (Chapter 2.3.2), and how consumer demand can drive circular business practices (Chapter 2.3.3). Given the limited empirical research on DPPs in the consumer context, this chapter draws on established theories and related research areas such as eco-labeling, sustainable consumption, and technology acceptance.

2.3.1 Consumer Adoption of Digital Product Passports: Drivers and Barriers

The Technology Acceptance Model (TAM), developed by Davis (1989), provides a foundational framework to explain individual technology acceptance. In accordance with it, perceived usefulness and perceived ease of use jointly determine behavioral intention, with perceived usefulness typically exerting the stronger effect. Perceived usefulness describes the belief that the utilization of a system will enhance one's performance, while perceived ease of use refers to the degree of effort required to use the system (Davis, 1989), which should be minimal in the context of DPPs (Adisorn et al., 2021). In response, the ESPR states that DPP information must be both easily accessible and understandable (European Union, 2024b).

TAM2 extends the original model by incorporating social influence and cognitive instrumental processes, with a focus on perceived usefulness due to its stronger effect on behavioral intention (Venkatesh & Davis, 2000). Social influence factors, such as subjective norm or image, may also play a role in DPP adoption among consumers, as they influence environmental behavior (Griskevicius et al., 2010).

However, a number of barriers can hinder DPP adoption. One fundamental barrier is information overload, which occurs when the information volume surpasses consumers' ability to process it, which leads to confusion and poorer decisions (Malhotra, 1982). Suggested countermeasures include reducing, categorizing, and improving the presentation of information (Eppler & Mengis, 2004). In the context of DPPs, information overload is specifically applicable to the consumer electronics sector, where the presence of both mandatory and voluntary eco-labels for EEE can reduce clarity (Dalhammar et al., 2024).

Moreover, empirical findings by Yu et al. (2017) show that higher digital skills strengthen the positive effect of media experience on ICT adoption, suggesting that digital literacy may also influence DPP adoption. As stated in recent EU statistics, 32% of Europeans lack basic digital skills (EU, 2023).

2.3.2 Consumer Decision-Making and Willingness to Pay for Circular Products

By addressing behavioral barriers such as limited access to sustainability information and trust issues, DPPs could provide conditions that support higher purchase intention and WTP for circular products.

A suitable theoretical lens is the signaling theory, which explains how observable signals reduce information asymmetries, originally in the labor market (Spence, 1973). In the sustainability context, Atkinson and Rosenthal (2014) state that eco-labels function as signals that allow consumers to evaluate environmental claims they are unable to verify on their own, since such claims are credence attributes that rely on extrinsic cues. Their research finds that eco-labels, especially when providing specific information, significantly increase consumer trust in environmental claims, though not purchase intention. In contrast, Panopoulos et al. (2023) identify a positive effect of eco-labels on purchase intention of Gen Z consumers, depending on label awareness and environmental concern.

These varying findings indicate that the effectiveness of eco-labels is situation-dependent and raise the question of the extent to which DPPs can affect consumers' purchase intention. While there appears to be a lack of application of signaling theory to DPPs, scholars stress that DPPs can help reduce information asymmetries and facilitate more sustainable purchase decisions (Thunyaluck & Valilai, 2024). This suggests that signaling theory could provide a suitable framework for assessing the potential impact of DPPs on consumer behavior.

The Theory of Planned Behavior (TPB) also provides a useful lens for understanding the psychological mechanisms behind circular purchasing. According to this theory, behavioral

intention is determined by three independent factors: attitude toward the behavior, subjective norm, and perceived behavioral control. Behavioral intention is a reliable predictor of actual behavior if it is under sufficient volitional control (Ajzen, 1991). This relationship was empirically confirmed by Paul et al. (2016), who validated TPB as a robust predictor of purchase intention for green products. This highlights its relevance for analyzing the potential of DPPs to promote circular consumption.

However, findings on the TPB in circular contexts vary. While Chao and Yu (2024) find subjective norms to be not significant, Kongarchapatara and Hanpanit (2021) report significant effects for all three TPB components. In the case of DPPs, this suggests that their influence on behavioral intention may also depend on external factors beyond the TPB framework – such as credibility as a signal (Atkinson & Rosenthal, 2014) and their ability to support the execution of intended behavior (Ajzen, 2002).

There is also strong evidence that circular product attributes have a beneficial effect on WTP. According to a 2024 EU survey, 59% of Europeans are willing to pay more for repairable, recyclable, and sustainably produced products, primarily driven by environmental concerns (European Environment Agency, 2025b). An EU study in 2018 on consumer behavior toward circular products, covering consumer electronics and apparel, concluded that WTP is considerably greater if product durability and repairability are clearly communicated, for example through labels. Consumers were almost three times more likely to choose the most durable and more than twice as likely to choose the most repairable products. For smartphones, WTP increased by up to 217€ for durability and 98€ for repairability. Nudges highlighting the benefits as well as social norms triggered these preferences (European Commission, 2018).

Boyer et al. (2021) identify three central consumer segments in their experiment with smartphones and vacuum cleaners. While circular enthusiasts show high WTP for circular products, only one of two price-sensitive segments demonstrates purchase intention for such products, conditional on low prices.

In total, this raises the question of to what extent DPPs can influence consumer purchase decisions in circular contexts.

2.3.3 Consumer Demand as External Driver of Circular Economy Business Models

Low consumer demand and limited awareness are frequently cited as key barriers to the adoption of CEBMs (Kirchherr et al., 2018; PwC, 2023). However, as outlined in Chapter 2.3.2, DPPs may have the potential to stimulate demand and increase WTP for circular products by

providing transparent and reliable product information. These economic incentives may, in turn, encourage firms to develop and adopt CEBMs (OECD, 2019a). A 2024 survey by Bain & Company and the World Economic Forum supports this perspective, with 73% of business executives expecting revenue growth from circular business solutions (Bain & Company, 2025). Accordingly, DPPs may represent an important lever in the CE transition by fostering circular purchase behavior among consumers.

Geissdoerfer et al. (2023) identify changing consumer demands as a key driver of circular business model innovation. Such innovation may involve introducing new activities, redefining linkages between existing ones, or changing actors within the value chain (Amit & Zott, 2012). Given sufficient differentiation and difficult imitability, business model innovation can become a source of competitive advantages (Teece, 2010).

CEBMs require a deep understanding of consumer behavior, as they depend on consumers fundamentally adapting their habits, for example by returning products or using service-based offerings. Firms therefore need to analyze consumer behavior, needs, and WTP to derive new circular business model ideas (Bocken & Konietzko, 2022).

Overall, this suggests that evolving consumer preferences, potentially shaped by DPPs, create new market expectations to which firms are likely to respond strategically through CEBMs and circular business model innovation. Throughout the process, consumers are an active stakeholder group whose expectations and behavior must be strategically addressed (Freeman, 1984).

2.4 Strategic Management Perspectives

Beyond their regulatory function, DPPs also offer strategic opportunities, building on the consumer behavior effects discussed in the previous chapter. Although DPPs will become mandatory for most products sold in the EU, firms can either view them as a regulatory burden or leverage them as a strategic tool. To analyze both their role and possible corporate responses, this chapter draws on suitable management theories, including the Resource-Based View (RBV), Dynamic Capabilities, and Diffusion of Innovation Theory.

2.4.1 Strategic Responses to Digital Product Passports

Oliver (1991) identifies five types of strategic responses to institutional pressures such as regulations: acquiesce, compromise, avoid, defy, and manipulate. These depend on factors like perceived legitimacy as well as an organization's willingness and ability to conform. While

many firms consider DPPs as a chance to enhance consumer engagement via transparent supply chain information, difficulties remain in estimating and communicating the expected benefits (Chaudhuri et al., 2024).

The Institutional Theory also fits this context, suggesting that organizational change is driven less by competition and efficiency than by institutional expectations through coercive, mimetic, and normative isomorphism (DiMaggio & Powell, 1983). Sustainability initiatives often respond to regulatory pressure, societal expectations, and cultural norms, ranging from greenwashing to full strategic integration of environmental goals (Galleli & Amaral, 2025). While recent research emphasizes the relevance of the Institutional Theory to explain regulatory and societal drivers for the DPP implementation, it lacks deeper theoretical contextualization (Chaudhuri et al., 2024; Zhang & Seuring, 2024).

In addition to the institutional explanatory approaches, the Diffusion of Innovation Theory by Rogers adds another relevant perspective. Accordingly, innovations spread within social systems via communication channels over time, with adoption speed influenced by perceived attributes such as relative advantage, compatibility, complexity, trialability, and observability. Early adopters can position themselves as pioneers, promote imitation and achieve economic benefits such as windfall profits (Rogers, 2003). In sustainability contexts, early adopters of environmental innovations may gain first-mover advantages by signaling their environmental commitment. This allows them to shape consumer preferences early on and particularly appeal to environmentally oriented consumers, enhancing satisfaction and sales (Su et al., 2024).

According to Orgalim (2024), the European technology industries association including the electronic sector, early DPP adoption and compliance with new regulations allows firms to position themselves as sustainability leaders, foster market differentiation, and increase market share.

2.4.2 Strategic Role of Digital Product Passports

Building on the previous chapter and behavioral consumer insights from Chapter 2.3, this section explores how strategic management perspectives can help to assess the potential role of DPPs in promoting circular business practices and to explain the conditions under which firms may leverage them effectively.

The Resource-Based View (RBV) by Barney (1991) states that firm-specific resources can generate sustained competitive advantages if they are valuable, rare, imperfectly imitable, and non-substitutable. However, the RBV is limited by insufficient consideration of external forces

such as consumer preferences, which are crucial for strategy-making (Priem & Butler, 2001), and by its static nature. Hence, it cannot adequately explain new sources of sustained competitive advantage, particularly in continuously changing environments with new technologies or emerging markets (Kraaijenbrink et al., 2010).

To address these limitations, Teece et al. (1997) introduced the Dynamic Capabilities framework, which explains how firms can maintain competitive advantage in environments of rapid and unpredictable change (Eisenhardt & Martin, 2000). Dynamic Capabilities are defined as ”the firm’s ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments” (Teece et al., 1997, p. 516), shifting the focus from possession of resources to adaptability. Importantly, such capabilities are particularly relevant in dynamic environments shaped by technological change or regulatory restructuring, which often enable new market formation (Teece, 2007). Barreto (2010) understands Dynamic Capabilities as a multidimensional concept consisting of four dimensions that are central to a firm’s adaptability: the propensity to sense opportunities and threats, to make timely decisions, to make market-oriented decisions, and to change the firm’s resource base. This operationalizes Dynamic Capabilities by structuring central characteristics.

While DPPs have not yet been examined in the context of Dynamic Capabilities, adjacent research offers valuable insights. Moon and Lee (2021) assess how Dynamic Capabilities at the micro and macro level enable TV manufacturers to respond to regulatory sustainability demands and shifting consumer expectations. Their framework shows how external stimuli like consumer demands and internal stimuli are transformed into ecopreneurship and eco-innovations, thereby fostering both competitive advantages such as stronger consumers’ loyalty and contributions to CE.

Similarly, Dagilienė et al. (2024) argue that firms require Dynamic Capabilities to successfully implement CE practices. Specifically, so-called zooming-out capabilities, such as adaptability to regulation and consumer acceptance, positively influence product design – a central foundation for CEBMs (Bocken et al., 2016). Consumer acceptance, understood as the willingness to buy circular products, is a prerequisite for firms to invest in circular business practices. To overcome behavioral inertia and cost-related barriers, firms need capabilities to actively engage and empower consumers (Dagilienė et al., 2024).

In sum, the RBV and the Dynamic Capabilities perspective provide complementary lenses to assess the potential strategic role of DPPs and to understand under which conditions firms may transform them into enablers of circular business practices.

2.5 Synthesis and Research Gaps

The preceding chapters highlight that the transition to a CE in the EU is both urgently needed and politically prioritized. The consumer electronics sector is a key area of concern, as short product lifecycles contribute significantly to the rapid e-waste growth, accompanied by severe environmental and social consequences.

To address these challenges, CEBMs need to be adopted on a large scale. However, beyond firms and policymakers, their success heavily depends on active consumer engagement. While environmental concern and social norms have increased interest in circular alternatives, actual engagement remains low. Key barriers include information asymmetries, limited awareness and understanding of circular concepts, and low trust in environmental claims due to greenwashing. DPPs are expected to mitigate many of these barriers by providing standardized, transparent, and verified product information, empowering consumers to make more informed decisions and potentially enhancing their willingness to adopt circular offerings.

Understanding how consumers engage with DPPs, which factors influence this engagement, and how DPPs affect purchase intention and WTP for circular products is essential to assess their potential impact. Related research, for example on eco-labeling, shows that clearly communicated product circularity can positively influence both purchase intention and WTP. These findings support the assumption that DPPs could have similar behavioral effects, although direct empirical studies remain scarce. Resulting shifts in consumer demand may encourage firms to perceive DPPs as strategic resources and innovate through CEBMs.

Chapters 2.3 and 2.4 introduced relevant theoretical perspectives that help explain both consumer engagement with DPPs and firm-level responses. While models such as TAM, TPB, and signaling theory offer valuable conceptual insights, they are largely unexplored in the context of DPPs. At the same time, little empirical research has examined how firms in the consumer electronics sector may respond to DPPs – whether they restrict themselves to compliance or leverage them strategically to foster CEBMs. Frameworks such as Institutional Theory, RBV, and Dynamic Capabilities offer suitable perspectives to study these responses, but have not yet been applied in this context.

This study seeks to fill three important gaps in the existing research. First, there is limited empirical evidence – especially in the consumer electronics sector – on how consumers respond to DPPs, concerning consumers' engagement, purchase intention, and WTP for circular products. Second, individual-level factors such as environmental concern, trust, and digital literacy are underexplored in this context. Third, little is known about how firms respond strategically to DPPs and under what conditions they move beyond compliance to integrate them into CEBMs. By addressing these research gaps, this study also contributes to overcoming the limited recognition of consumers and business models as enablers of circularity, as highlighted by Kirchherr et al. (2017).

3. Methodology

3.1 Research Design

The research design followed a mixed methods approach to address the research question:

> **How does consumer engagement with Digital Product Passports influence purchase decisions for circular consumer electronics, and what does this imply for circular economy adoption?**

The study combined quantitative data from a consumer survey with qualitative insights derived from expert interviews. This mixed methods approach was adopted to enable methodological triangulation. By converging diverse data sources and leveraging their complementary strengths, the design enhanced the robustness, depth, and validity of the findings (Jack & Raturi, 2006).

Both deductive and inductive reasoning were employed to strengthen the explanatory power of this study. While the survey tested behavioral hypotheses on consumer engagement with DPPs and the impact on purchase intention and WTP for circular consumer electronics, the expert interviews followed an inductive approach to explore firm perspectives and provide additional insights, thereby enriching and contextualizing the findings (Creswell & Plano Clark, 2007).

The research design addressed the two dimensions of the research question through distinct but complementary approaches. Consumer engagement with DPPs was examined using both the survey and expert interviews, supported by insights from the behavioral literature. By contrast, firm-level responses were investigated solely through expert interviews, as this dimension could not be covered by the consumer survey, and were contextualized using strategic management perspectives. In both cases, triangulation of empirical data with theoretical frameworks ensured robustness and depth of analysis.

Figure 3 illustrates how quantitative and qualitative data were integrated to answer the research question through a triangulated mixed methods approach.

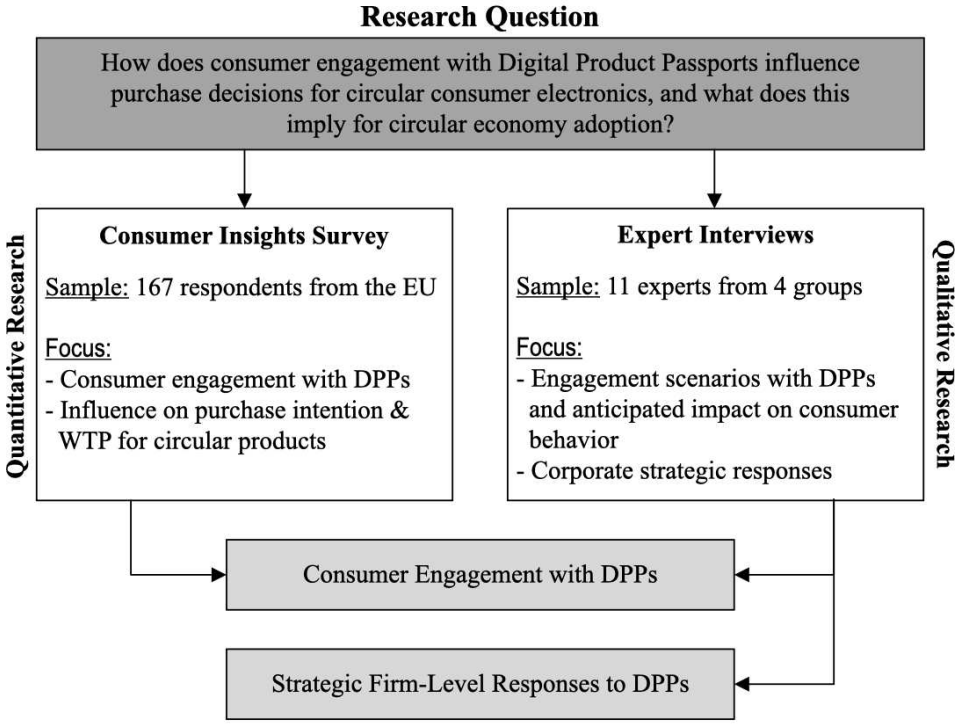

Figure 3. Mixed Methods Approach and Link to Research Question

Note. Own figure.

3.2 Data Collection Methods

3.2.1 Primary Data Collection: Consumer Survey

To investigate how consumers engage with DPPs and whether this influences their purchase intention and WTP for circular products, a standardized online survey was conducted in English using Qualtrics. This method allowed efficient and user-friendly data collection from geographically dispersed consumer groups within the EU (Evans & Mathur, 2005).

The survey empirically tested three hypotheses derived from the literature review (see Table 1) and captured additional descriptive and exploratory insights. Appendix A.1 provides the complete questionnaire, including all survey items and applied response formats. Survey limitations are discussed in Chapter 6.2.1.

#	Hypotheses
H1	Consumer engagement with DPPs is positively influenced by digital literacy, environmental concern, subjective norms, trust in DPPs, perceived usefulness, and perceived ease of use, and negatively influenced by information overload.
H2	The average stated purchase intention for circular consumer electronics products increases significantly after the introduction of DPPs.
H3	The average stated WTP for circular consumer electronics products increases significantly after the introduction of DPPs.

Table 1. Overview of Hypotheses Derived from Literature Review

Note. Own table.

Since DPPs are expected to become mandatory in the EU, the survey avoided unrealistic direct comparisons of products with and without DPPs. Instead, it first measured baseline purchase intention and WTP without mentioning DPPs. Participants were then introduced to the DPP concept through a short text and visual mockup, followed by scenario-based questions to assess behavioral change. This design isolated the impact of DPPs while controlling for prior attitudes. The survey also captured relevant psychological and informational determinants of DPP engagement, drawn from related fields (see Chapter 2.3). Table 2 summarizes the survey structure and rationale for each section, including links to the three hypotheses and relevant constructs.

#	Section	Rationale
1	Individual-Level Determinants	Captured individual characteristics (e.g., *digital literacy*) to test H1. These constructs are exogenous to the DPP intervention. In addition, *price sensitivity* was measured to explore its moderating role in *change in WTP*.
2	Baseline Consumer Behavior	Provided baseline input for H2 and H3 regarding current purchase intention and WTP for circular consumer electronics.
3	Refurbishment	Explored attitudes toward refurbished consumer electronics as a key CEBM.
4	DPP Introduction	Introduced core DPP functions through a concise explanation and visual aid to ensure shared understanding prior to scenario-based questions.
5	DPP-Specific Determinants	Measured *trust in DPPs*, *subjective norms*, *perceived usefulness*, and *perceived ease of use* to test H1 (in combination with Section 1).
6	Post-DPP Consumer Behavior	Assessed *DPP engagement* and behavioral change (purchase intention and WTP) after DPP exposure to test H1-H3.
7	Category Effects and Refurbishment	Captured product category relevance and intention to purchase refurbished consumer electronics after introducing DPPs.
8	Demographics	Enabled subgroup analysis and sample profiling.

Table 2. Structure and Rationale of Survey

Note. Own table.

Importantly, the aim was not to reassess whether consumers generally prefer sustainable products, as this is already well examined in literature (see Chapter 2.1.2.4). Rather, this study conceptualized DPPs as a tool for providing transparent and reliable information. By addressing barriers such as information asymmetries and limited trust in sustainability claims, DPPs may empower consumers to make more sustainable choices and encourage the purchase of more circular products. Behavioral effects beyond the point of sale, such as return and repair decisions, were excluded due to methodological constraints but are important areas for future research.

The survey employed various input types, including 5-point Likert scales, multiple choice questions, and sliders. For reliability and validity, established scales were applied and adapted to the context of this study wherever applicable. The chosen constructs were derived from the theoretical frameworks and models discussed in Chapter 2.3. Appendix A.2 provides a detailed

overview of all operationalized constructs, including their academic sources and contextual adaptations. Complementary items, such as demographics and selected behavioral questions, were developed in line with standard survey practices.

In total, 204 individuals participated in the survey, of which 20 responses were removed due to incompleteness (n = 19) or non-EU residency (n = 1). To further enhance data reliability and minimize satisficing behavior, an instructional manipulation check was embedded at the beginning of the survey, following the approach of Oppenheimer et al. (2009). 17 respondents failed the check and were excluded, resulting in a final sample size of n = 167. This approach contributed to the reliability and statistical power of the analysis.

While a sample size of approximately 384 respondents is generally recommended for very large populations such as EU consumers (Krejcie & Morgan, 1970), smaller samples are common in practice and can still yield statistically valid results when aligned with the research context, model complexity, and design (Memon et al., 2020). Therefore, despite being below this benchmark, the final sample size was considered sufficient, given the analytical focus, moderate model complexity, and limited time of this study.

3.2.2 Primary Data Collection: Expert Interviews

To both complement the survey and address the second dimension of the research question, this study conducted semi-structured expert interviews. Given the novelty of the research topic with limited prior theoretical and empirical insights, qualitative research was chosen to uncover perspectives that might be overlooked by deductive approaches (Bansal et al., 2018). Semi-structured interviews were particularly appropriate for this study, as they provide a balance between structured guidance and conversational flexibility, allowing both comparability across interviews and in-depth exploration (Kallio et al., 2016).

As shown in Table 3, the semi-structured interview guide consisted of six thematic sections to ensure a comprehensive exploration of the research topic. First, contextual questions were asked about the interviewees' roles and their familiarity with CE and DPPs. Sections 2 to 4 focused on anticipated consumer engagement with DPPs, the expected impact on consumer purchase behavior, and implications for the adoption of CEBMs. Section 5 explored strategic firm-level responses to DPPs, including whether firms restrict themselves to compliance or strategically leverage DPPs as resources for CEBM development. In the final section, interviewees were invited to share open reflections and raise additional relevant aspects. The complete interview guide is provided in Appendix B.1.

#	Section	Rationale
1	Introduction and Context	Understand the interviewee's role, organizational background, and familiarity with CE and DPPs.
2	Anticipated Consumer Engagement with DPPs	Explore expected consumer engagement scenarios with DPPs and identify key drivers and barriers.
3	Anticipated Impact on Consumer Behavior and Segmentation	Assess how DPPs may affect consumer purchase behavior, particularly purchase intention and WTP, and explore differences across consumer segments.
4	Implications for CEBM Adoption	Understand how consumer engagement with DPPs may influence the adoption of CEBMs.
5	Strategic Responses to Changing Consumer Behavior	Explore how firms may respond to DPPs – whether as compliance tools or strategic resources – including aspects of first-mover strategies, organizational resources and capabilities, and opportunities for CEBM adoption.
6	Open Reflection and Additional Aspects	Capture insights beyond predefined themes, including unforeseen challenges or broader concerns.

Table 3. Structure and Rationale of Interview Guide

Note. Own table.

Eleven interviews were conducted via Google Meet or Microsoft Teams, each lasting 30 to 45 minutes. Given the novelty of DPPs and the specific focus of this study, the sample size was considered sufficient to provide robust qualitative insights. This is also close to the benchmark of twelve interviews identified by Guest et al. (2006) as often sufficient to reach data saturation in relatively homogeneous populations.

Table 4 provides an overview of the interviewees, which represented diverse and relevant perspectives from consumer electronics firms, policymaking, research, and consulting. The interview partners were categorized into these four expert groups based on their professional background (see Appendix B.2). No major adjustments were made to the interview questions across the expert groups.

With prior consent, all interviews were recorded and transcribed for analysis. Appendix B.4 summarizes all interviews.

#	ID	Company / Organization Description	Position Description	Relevant Expertise
1	CE1	Global technology company supporting the electronics and retail sectors through data infrastructure	Senior manager, CIRPASS-2 expert group member	Expert in product data infrastructure and DPP content strategy; contributes to CIRPASS-2 use cases in consumer electronics
2	CE2	Multinational technology company with significant presence in the EU and a strong portfolio in consumer electronics	Program manager, CIRPASS-2 coordinator	Expert in EU DPP pilot coordination; explores DPP-based business models and value chain innovation
3	R&D1	Independent sustainability research institute working with policymakers and firms across Europe	Senior researcher and lead for CE and digital transformation topics	Expert in EU CE and DPP policy; advises policymakers and firms; co-author of key EU report on DPPs as CE transition enabler
4	POL1	European industry association representing electronics and technology sectors	Policy lead and chair of a European sustainability working group	Expert on EU sustainability and product legislation; leads industry dialogue on DPP regulation, including consumer electronics
5	CONS1	Specialized consultancy for DPP development with a focus on consumer accessibility, usability, and user-centered design	Designer and scientific researcher focusing on user-centered design of DPPs	Expert in circular and user-centered product design; applies user experience and interface design to enhance consumer engagement and support CEBMs
6	CE3	Multinational ICT company with a strong commitment to sustainability and circular product strategies, and a legacy in consumer electronics	Senior expert for sustainability and standardization	Expert in environmental and circularity standards in ICT; active in DPP-related industry initiatives and working groups; former sustainability specialist at a leading refurbishment company
7	CONS2	Multinational consultancy advising public and private sector on CE and sustainable product strategies	Principal consultant for CE and procurement strategy	Expert in CE strategy and policy across public and private sectors, including consumer electronics; in-depth DPP experience; involved in projects on WEEE and critical raw materials
8	CE4	European refurbishment company active in smart-phone repair and resale	Sustainability and policy lead	Expert in CE implementation from a refurbishment industry perspective; offers both regulatory and strategic insights
9	R&D2	Independent sustainability research institute; academic background	Senior researcher and lecturer; co-lead in CIRPASS-2 work package	Expert in CE and DPP implementation; combines EU project involvement, academic research, and systemic perspective
10	CE5	National industry association for electrical and consumer electronics manufacturers; embedded in European associations	Senior manager for sustainability policies	Expert in EU sustainability and Ecodesign policy; provides advice on ESPR implementation, including DPP requirements
11	POL2	European policymaking body; national environ-mental agency	Policy analyst for green digital transition and DPP-related initiatives	Expert in EU CE and digital policy; works on integrating DPPs as enablers for CEBMs

Table 4. Overview of Expert Interview Participants

Note. Own table.

3.3 Data Analysis Techniques

3.3.1 Quantitative Analysis: Consumer Survey

The quantitative analysis tested three hypotheses (H1-H3) using descriptive statistics, regression models, and non-parametric tests. For H1, a ordinal logistic regression was conducted to examine whether predictors such as *digital literacy* significantly influenced *DPP engagement*. Descriptive statistics complemented this analysis by capturing the overall level of *DPP engagement* and demographic effects. To test H2 and H3, paired-sample Wilcoxon signed-rank tests compared stated purchase intention and WTP for circular consumer electronics before and after the DPP introduction. Building on insights from the literature review, the moderating effect of *price sensitivity* on *change in WTP* was also assessed. Reported *DPP engagement* was used as the sole predictor to ensure conceptual clarity and model simplicity.

All analyses were conducted in R. For two-item constructs, internal consistency was evaluated using the Spearman-Brown coefficient, in line with methodological recommendations (Eisinga et al., 2013). For the regression analysis, the proportional odds assumption was tested to confirm the adequacy of the ordinal logistic model and variance inflation factors were calculated to rule out multicollinearity among predictors.

3.3.2 Qualitative Analysis: Expert Interviews

The qualitative data from the expert interviews were analyzed in MAXQDA using a structured coding system. The initial codebook was derived deductively from the theoretical perspectives introduced in Chapters 2.3 and 2.4. At the same time, the coding scheme was refined inductively during analysis to capture emerging themes from the interviews.

This approach enabled a systematic comparison of expert perspectives along key analytical dimensions such as consumer engagement with DPPs, anticipated behavioral outcomes, and firm-level strategic responses.

The coding was conducted at a detailed segment level, ensuring both analytical consistency and flexibility. The resulting code system (see Appendix B.3) included 723 coded segments from eleven interviews, distributed across several categories. This structure allowed for cross-case comparison and facilitated integration of empirical findings with the study's conceptual framework.

4. Results

4.1 Quantitative Findings

A total of 204 participants took part in the survey. After removing 19 incomplete responses, 17 participants who failed the instructional manipulation check, and 1 response from a participant residing outside the EU, a final sample of 167 valid responses was used for analysis.

The raw data were initially exported from Qualtrics and subsequently prepared in Excel. Based on this, all analyses and visualizations were conducted using R.

First, the internal consistency of all two-item constructs was assessed using the Spearman-Brown coefficient. All coefficients exceeded the commonly accepted threshold of 0.8, indicating high reliability and justifying their further use in the analysis (see Appendix A.3, Table 17).

4.1.1 Sample Overview

Figure 4 displays the demographic characteristics of the sample. Most participants were aged 25-34 ($n = 68$), held a high school diploma or equivalent ($n = 61$), and had an annual net income between €15,000 and €39,999 ($n = 57$). The gender distribution was skewed toward male respondents, with 100 men, 66 women, and 1 participant who preferred to not disclose their gender. Participants came from 17 countries in the EU, with the majority from Germany ($n = 89$), Portugal ($n = 22$), Poland ($n = 10$), Spain ($n = 10$), Italy ($n = 9$), and France ($n = 6$).

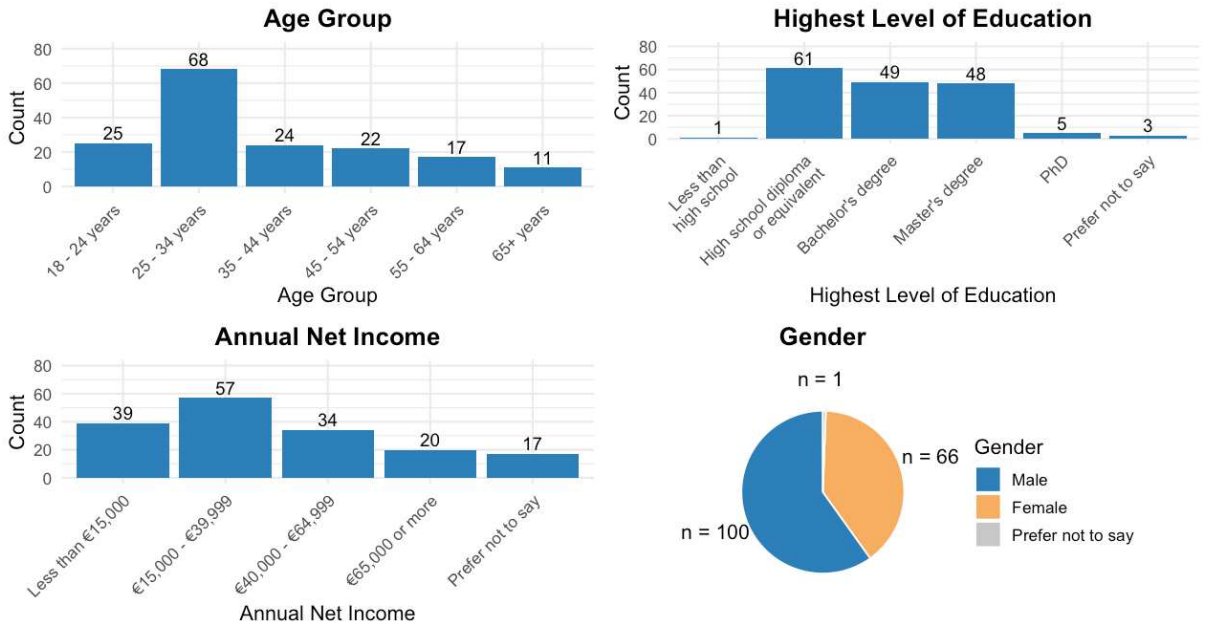

Figure 4. Sample Overview: Demographic Groups

Note: Own Figure

4.1.2 Past Circular Purchase Behavior

In this section, participants were asked whether they had previously chosen a consumer electronics product that explicitly claimed to be more circular. 38.3% (n = 64) answered "Yes", while 61.7% (n = 103) reported that they had not made such a choice in the past (see Figure 5).

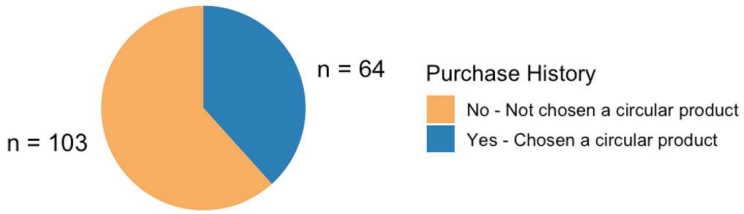

Figure 5. Share of Participants Who Chose Circular Consumer Electronics in the Past

Note. Own figure.

Participants who answered "No" were presented with a multiple choice question listing possible barriers derived from theory, while those who answered "Yes" were asked to indicate the drivers behind their decision.

The most frequently cited barrier was "I don't know how to identify circular or sustainable products" (n = 51), while the driver mentioned most often was "Environmental concerns" (n = 42) (see Figure 6).

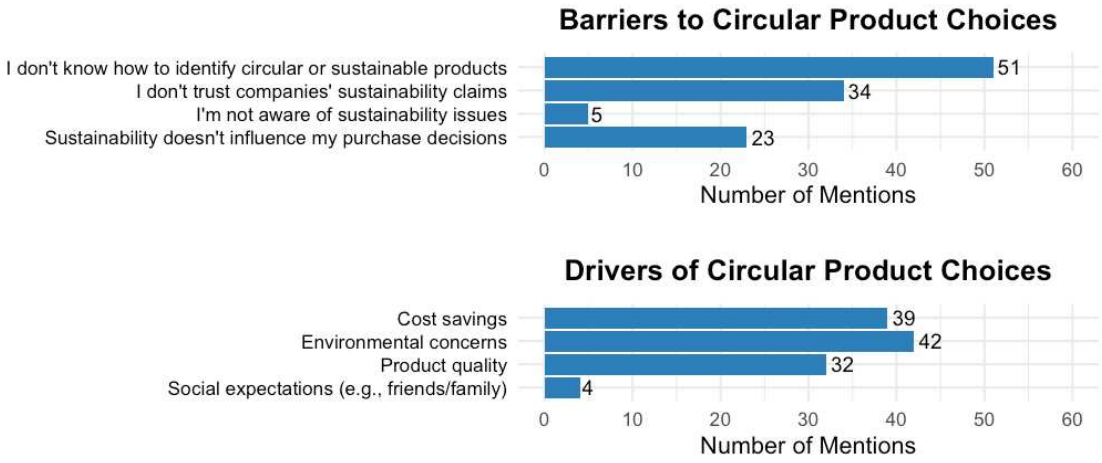

Figure 6. Reported Barriers and Drivers of Circular Product Choices

Note. Own figure. Multiple responses were allowed.

4.1.3 Consumer Engagement with Digital Product Passports

After participants were introduced to the concept of DPPs, their willingness to engage with DPPs in a purchasing context was assessed. *DPP engagement* was measured using two items on a 5-Point Likert scale and mean scores were calculated. Higher values reflected a stronger intention to interact with or make use of DPPs.

Figure 7 displays the distribution of the calculated mean scores. The distribution is right-skewed, suggesting that many participants reported relatively high levels of intended *DPP engagement*. The average score was $M = 3.99$ ($SD = 0.95$).

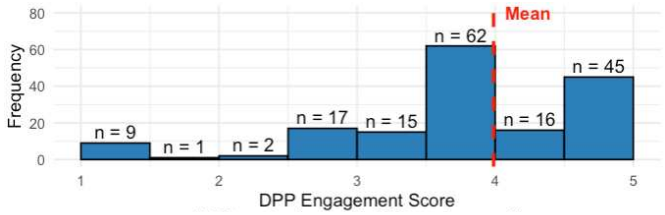

Figure 7. Distribution of DPP Engagement

Note. Own figure. Response scale ranged from 1 = "Strongly disagree" to 5 = "Strongly agree".

Additionally, a one-sided one-sample t-test was conducted to examine whether participants' intended *DPP engagement* was significantly higher than the neutral midpoint of 3. The results revealed that the average *DPP engagement* score was indeed significantly higher than 3, $t(166) = 13.39$, $p < .001$. This finding suggests that participants expressed a generally positive intention to engage with DPPs when introduced to the concept.

To explore potential variation in *DPP engagement* across demographic groups, boxplots were generated by *age group*, *highest level of education*, and *annual net income* (see Figure 8). Median scores were consistently above the neutral midpoint of 3, with only minor differences between groups. The lowest score appeared in the "Less than high school" subgroup, though this category included only one respondent and should be interpreted with caution.

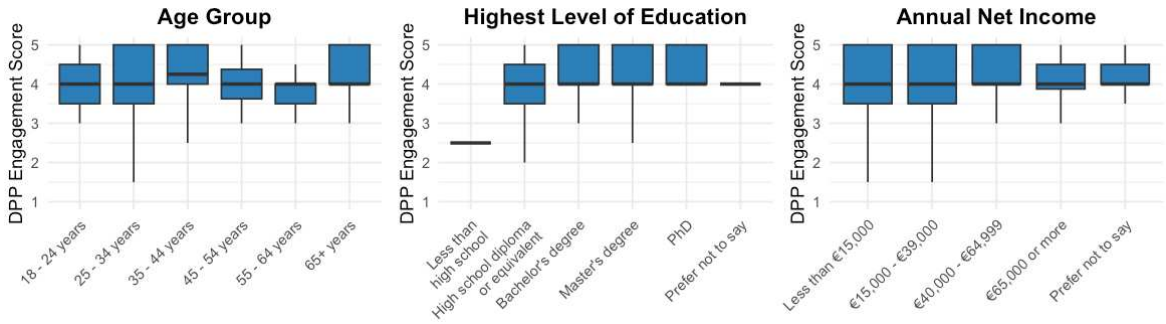

Figure 8. Differences in Reported DPP Engagement Across Demographic Groups

Note. Own figure. Response scale ranged from 1 = "Strongly disagree" to 5 = "Strongly agree".

Chapter 2.3 identified several factors from the existing literature as potential predictors of participants' *DPP engagement*. On this basis, H1 was formulated as follows:

> *Consumer engagement with DPPs is positively influenced by digital literacy, environmental concern, subjective norms, trust in DPPs, perceived usefulness, and perceived ease of use, and negatively influenced by information overload.*

To test this hypothesis, an ordinal logistic regression was conducted with *DPP engagement* as the dependent variable. This approach was chosen because the dependent variable was measured on an ordinal Likert scale, which makes ordinal regression more appropriate than linear regression as it does not rely on the assumption of interval-level measurement or normally distributed residuals.

The independent variables included all seven predictors specified in H1. For the analysis, all two-item constructs were aggregated into summated scores ranging from 2 to 10. By contrast, *trust in DPPs* and *information overload* were based on single items and therefore retained their original 1 to 5 scale. This procedure ensured that all predictors could be validly treated as ordinal inputs in the regression model, while avoiding mean scores that would produce non-discrete values not suited for ordinal regression.

The results showed that *perceived usefulness* (OR = 2.77, 95% CI [2.04, 3.84], $p < .001$) and *perceived ease of use* (OR = 1.61, 95% CI [1.25, 2.09], $p < .001$) had a statistically significant positive effect on *DPP engagement* (see Appendix A.3, Figures 21 and 22). This indicates that participants with higher perceptions of usefulness and ease of use were substantially more likely to report higher levels of engagement with DPPs.

By contrast, *digital literacy*, *environmental concern*, *subjective norms*, *trust in DPPs*, and *information overload* did not exert statistically significant effects (all $p > .05$). The proportional odds assumption was not violated according to a nominal effects test, which confirms the adequacy of the model (see Appendix A.3, Figure 23).

To assess potential multicollinearity among the predictors, variance inflation factors were calculated. All values were well below the commonly used threshold of 5, indicating that multicollinearity was not a concern in the regression model (see Appendix A.3, Figure 24).

Overall, the analysis revealed that *perceived usefulness* and *perceived ease of use* were statistically significant drivers of participants' intended *DPP engagement*, while no significant effect was shown for the other hypothesized predictors.

4.1.4 Impact on Purchase Intention for Circular Products

Participants were first asked about their preference for consumer electronics marketed as circular. After being introduced to the DPP scenario, they were then asked whether they would prefer such products if they were additionally verified through a DPP. This setup served to test H2:

> *The average stated purchase intention for circular consumer electronics products increases significantly after the introduction of DPPs.*

To determine the appropriate statistical test, a Shapiro-Wilk test was conducted to assess whether the difference in *purchase intention* before and after the DPP scenario was normally distributed. The results indicated a significant deviation from normality ($W = 0.92$, $p < .001$). Consequently, a non-parametric Wilcoxon signed-rank test was applied. The test revealed that the average stated *purchase intention* significantly increased after the DPP scenario ($V = 3184.5$, $p = .0014$), thus supporting H2.

Descriptive statistics revealed that the mean *purchase intention* increased from $M = 3.51$ ($SD = 0.93$) to $M = 3.66$ ($SD = 0.92$) after the DPP scenario. Figure 9 visualizes the distribution of *purchase intention* scores before and after the DPP scenario, illustrating a slight but consistent shift toward higher intentions to purchase circular consumer electronics.

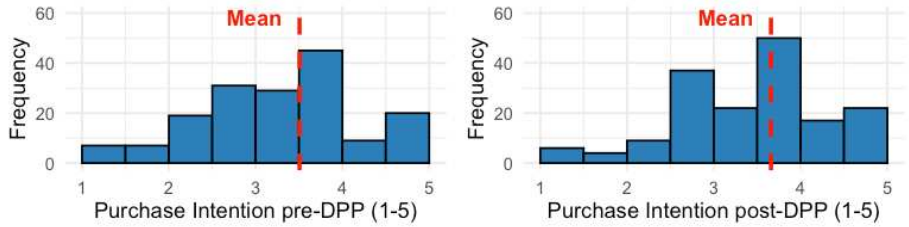

Figure 9. Purchase Intention Before and After the DPP Scenario

Note. Own figure. Response scale ranged from 1 = "Strongly disagree" to 5 = "Strongly agree".

Figure 10 illustrates how participants' *purchase intention* changed after being presented with the DPP scenario. 40.1% of respondents reported an increase in purchase intention, 41.9% showed no change, and 18% indicated a decrease. This result underlines the overall positive effect.

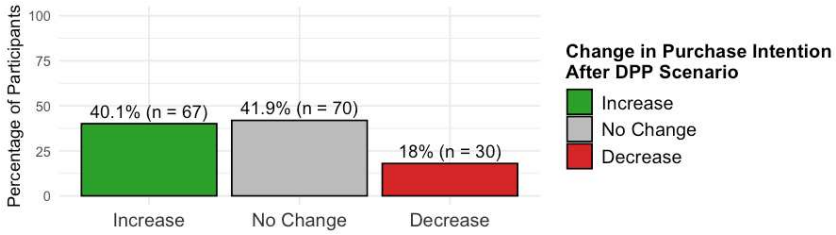

Figure 10. Change in Purchase Intention Following the DPP Scenario

Note. Own figure.

The boxplots in Figure 11 display the change in reported *purchase intention* following the DPP scenario, broken down by *age group*, *highest level of education*, and *annual net income*. Notable differences appear only in the categories "Less than high school" and "Prefer not to say" within the education group. However, the small subgroup sizes necessitate careful interpretation.

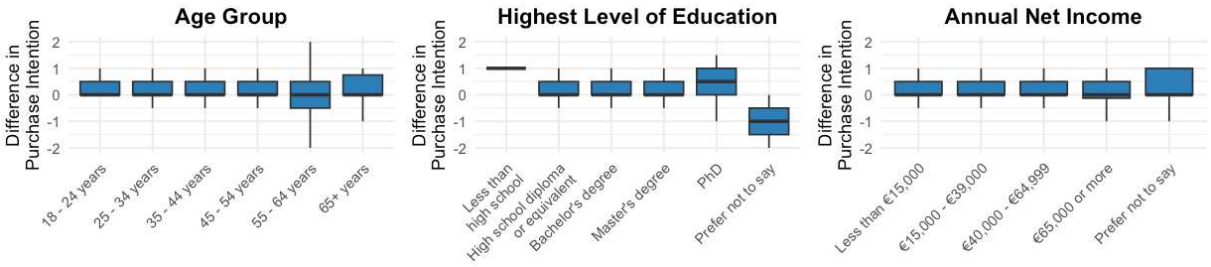

Figure 11. Differences in Reported Purchase Intention Across Demographic Groups

Note. Own figure. Boxplots display the change in purchase intention (post-DPP minus pre-DPP scenario).

Participants, who responded "Strongly disagree" or "Somewhat disagree" when asked whether they would prefer circularly promoted consumer electronics if verified through a DPP, were presented with a multiple choice question listing potential barriers to DPP influence on their purchase intention. By contrast, participants who responded with "Strongly agree" or "Somewhat agree" were asked about potential drivers.

As shown in Figure 12, the most frequently selected barriers were "Price remains the main factor for me" (n = 18) and "Sustainability doesn't influence my purchase decisions" (n = 10). Key drivers were "It would help me make more informed and confident decisions" (n = 78) and "I would trust the information more than current claims" (n = 73).

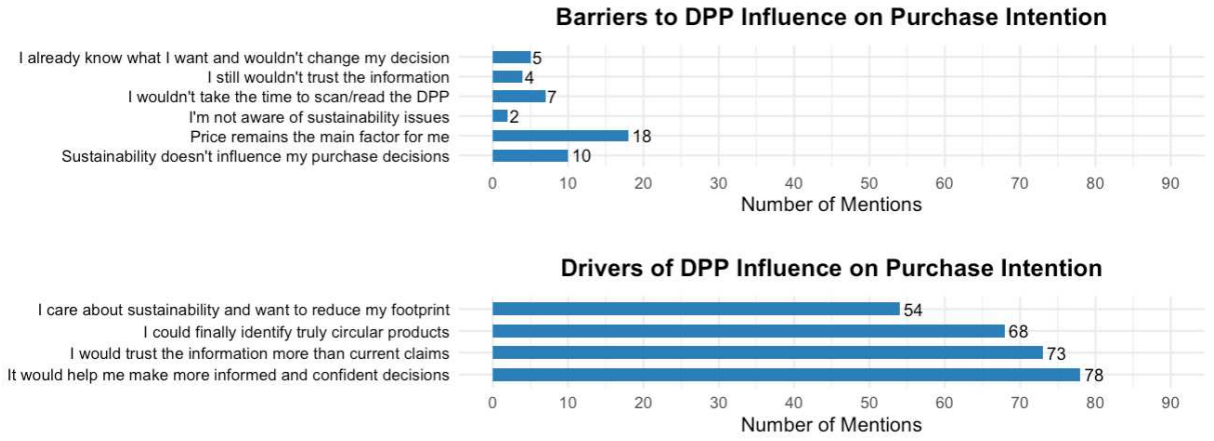

Figure 12. Reported Barriers and Drivers of DPP Influence on Purchase Intention

Note. Own figure. Multiple responses were allowed.

Participants were also asked to indicate the product category in which a DPP would most strongly influence their purchase decision. As shown in Figure 13, "home appliances (e.g., washing machines)" was selected most frequently (n = 78), while "headphones" received the fewest mentions (n = 7). These results suggest that the impact of DPPs on participants' purchase intention differs substantially across product categories.

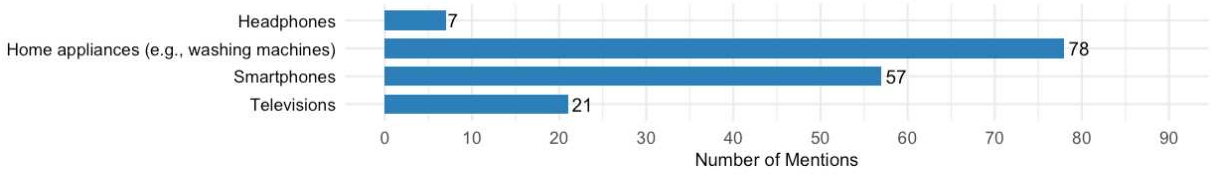

Figure 13. Product Categories Where DPPs Most Influence Purchase Decisions

Note. Own figure. Only one response per participant was allowed.

4.1.5 Impact on Willingness to Pay for Circular Products

Participants were also asked to indicate their WTP a premium for circular consumer electronics. They were presented with two technically identical products – one conventional and one marketed as more circular – and asked how much more they would be willing to pay for the latter. After the DPP concept was introduced, the question was repeated – this time assuming that the circular product was verified through a DPP. This served to test H3:

> *The average stated WTP for circular consumer electronics products increases significantly after the introduction to DPPs.*

To determine the appropriate statistical test, a *change in WTP* score was calculated by subtracting each participant's WTP before the DPP scenario from their WTP after it. A Shapiro-Wilk test was then performed to assess whether this difference score was normally distributed.

The results indicated a significant deviation from normality ($W = 0.62$, $p < .001$). Therefore, a non-parametric Wilcoxon signed-rank test was subsequently conducted. The test revealed a statistically significant increase in *change in WTP* after the DPP scenario ($V = 2668$, $p < .001$), thereby supporting H3.

Descriptive statistics showed a mean increase in *change in WTP* of 1.05 percentage points ($SD = 9.84$) after the DPP scenario. This indicates that, while the average change was small, there was considerable variation across participants.

Due to the high standard deviation, the distribution was further examined using a histogram, which revealed two outliers in the ranges of -80 to -70 and -70 to -60 percentage points (see Figure 14). These sharp decreases in *change in WTP* should be interpreted with caution, as it is unclear how a transparency-enhancing tool like a DPP could trigger such negative responses.

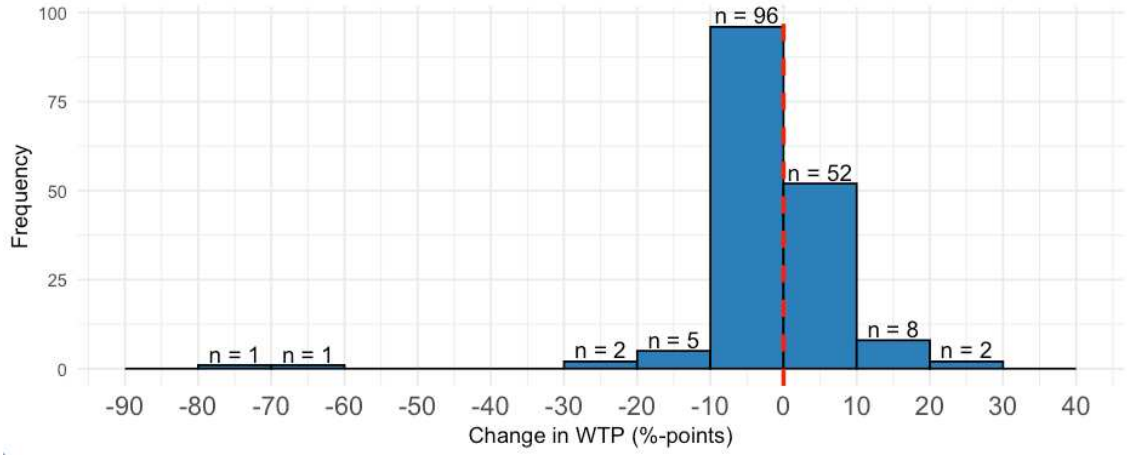

Figure 14. Distribution of Change in WTP (After vs. Before DPP Scenario)

Note. Own figure.

To exclude the two extreme outliers, an additional trimmed analysis was conducted, including only *change in WTP* values between -30% and +30%. Within this central range, the average increase in *change in WTP* was 1.87 percentage points ($SD = 6.51$), indicating a slightly stronger effect compared to the full sample.

As shown in Figure 15, 37.1% ($n = 62$) of participants reported an increased WTP after the DPP scenario, 48.5% ($n = 81$) showed no change, and 14.4% ($n = 24$) reported a decrease. This distribution reinforces the finding that the DPP intervention had a predominantly positive or neutral effect, with a smaller subgroup exhibiting reduced WTP.

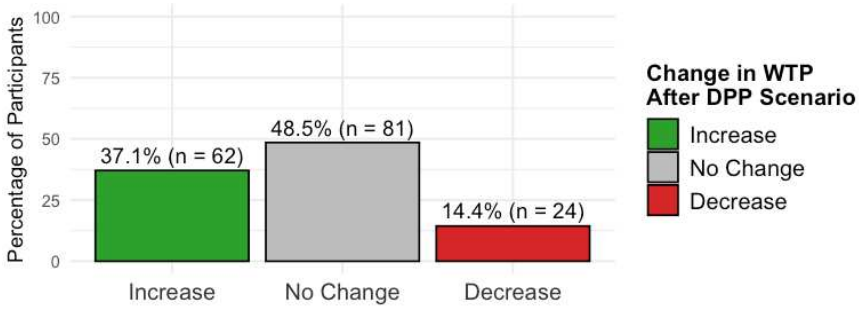

Figure 15. Change in WTP Following the DPP Scenario

Note. Own figure.

Figure 16 compares *change in WTP* across demographic groups. Overall, the distribution appears relatively consistent across categories. Extreme outliers were visually suppressed to enhance interpretability.

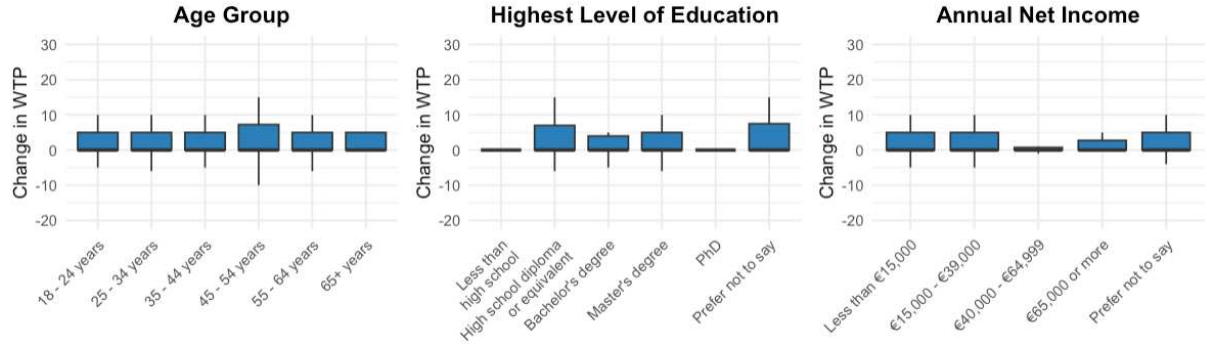

Figure 16. Differences in Reported Change in WTP Across Demographic Groups

Note. Own figure. Change in WTP was measured in percentage points.

To examine whether *price sensitivity* moderates the relationship between *DPP engagement* and *change in WTP*, the following linear regression with an interaction term was conducted:

$$\boldsymbol{Change\ in\ WTP} \sim \beta_0 + \beta_1(DPP\ Engagement) + \beta_2(Price\ Sensitivity) + \beta_3(DPP\ Engagement \times Price\ Sensitivity) + \varepsilon$$

For this purpose, both *DPP engagement* and *price sensitivity* were mean-centered. The results showed that *DPP engagement* had a significant positive effect on *change in WTP* ($\beta = 2.01$, $p = .015$), while *price sensitivity* alone was not a significant predictor ($\beta = -0.14$, $p = .869$). The interaction term was statistically significant ($\beta = -1.68$, $p = .012$), showing that the positive effect of *DPP engagement* on *change in WTP* decreased as *price sensitivity* increased (see Appendix A.3, Figure 25). Thus, *price sensitivity* acted as a negative moderator in this relationship.

4.1.6 Refurbishment Behavior

To account for a highly relevant CEBM in the consumer electronics sector, the survey included a section on refurbishment behavior. As shown in Figure 17, 44.9% (n = 75) of participants had previously purchased refurbished consumer electronics, while 55.1% (n = 92) had not.

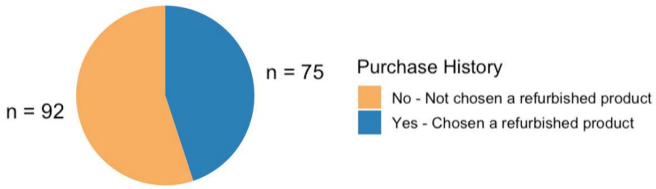

Figure 17. Share of Participants Who Chose Refurbished Consumer Electronics in the Past

Note. Own figure.

Participants who had never purchased refurbished consumer electronics were presented with a multiple choice list of barriers, while those who had made such purchases were asked to select the drivers behind their decision.

The most frequently mentioned barrier was "Concerns about product quality" (n = 45), while the most frequently cited driver was "Lower price" (n = 66) (see Figure 18).

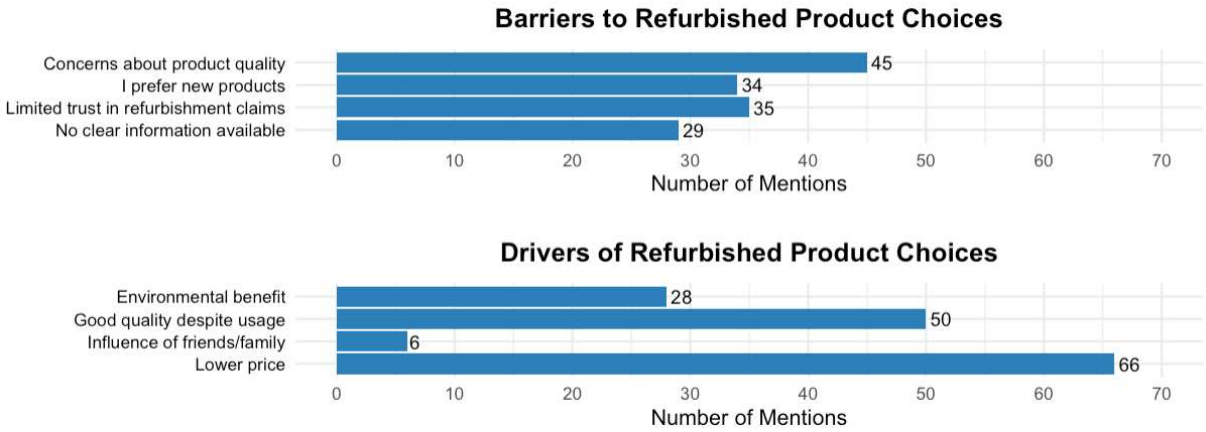

Figure 18. Reported Barriers and Drivers of Refurbished Product Choices

Note. Own figure. Multiple responses were allowed.

As with purchase intention and WTP for circular products, participants were asked about their intention to purchase refurbished consumer electronics both before and after the DPP scenario. A Shapiro-Wilk test indicated that the change in *refurbishment intention* was not normally distributed ($W = 0.87$, $p < .001$). Thus, a non-parametric Wilcoxon signed-rank test was applied, revealing a significant increase in *refurbishment intention* after the DPP scenario ($V = 3372$, $p < .001$). Complementary descriptive statistics showed an increase in the mean *refurbishment intention* from $M = 2.93$ ($SD = 1.11$) to $M = 3.42$ ($SD = 1.13$), supporting the positive shift.

4.2 Qualitative Findings

Based on the interviews conducted with experts across industry, research, and policy (see Chapter 3.2.2), this chapter presents the qualitative findings on how DPPs are expected to shape consumer behavior and firm-level responses. The analysis was guided by the structured MAXQDA coding system (see Appendix B.3), which combined theory-based categories with inductively refined themes. This ensured systematic comparison of perspectives and consistency with the study's conceptual framework.

4.2.1 Consumer Engagement Scenarios with Digital Product Passports

Interviewees described various scenarios in which consumers might interact with DPPs throughout the product lifecycle. R&D1 explicitly distinguished three key stages: the point-of-sale, the usage phase, and the EoL stage. This conceptually aligns with the "purchase", "use", and "end of use" phases established in the literature (Ricardo, 2021), despite the differing terminology. While the primary focus of this study is on the point of sale, several interviewees also emphasized the relevance of consumer engagement scenarios during the usage and EoL phases. Therefore, this section includes the most frequently mentioned scenarios from these phases to provide a more comprehensive understanding of how DPPs can support the CE transition through consumer engagement.

Several interviewees (CE1, CE3, CONS1, CONS2, POL2, R&D1) anticipated that consumers could actively engage with DPPs at the point of sale to identify more sustainable and circular products by comparing indicators such as repairability or carbon footprint. These interactions are typically envisioned to occur via data carriers such as QR codes on packaging or dedicated product web portals (CE1, CE2, POL1, POL2, R&D1). CONS2 emphasized that the extent of consumer engagement with DPPs at the point of sale is likely to vary depending on the product category. POL1 shared this view and noted that DPPs are unlikely to be used for low-cost products, as consumers spend little time on such decisions. For high-value products, however, DPPs may play a more central role and are increasingly described as "the main vehicle for product information", particularly in the context of sustainability and circularity. CE2 was more cautious and stressed that consumers are unlikely to interact with DPPs if they are implemented merely for compliance, while meaningful engagement could emerge if added value or incentives are provided. In contrast, CE4 fundamentally questioned whether DPPs are suitable as consumer-facing tools at all, pointing to the overwhelming amount of technical information they may contain, their non-consumer-friendly format, and the practical challenges of individualizing them for each product.

CE1 referred to a “dual use case”, highlighting that DPPs are relevant both at the point of sale and during the subsequent usage phase, in which also several other interviewees described concrete consumer interaction scenarios. Most commonly, these related to repair, such as accessing repair instructions (CE1, CE2, CONS1, POL2, R&D1), ordering spare parts (CE2, CONS1, POL2, R&D1), or identifying service providers (CE2, R&D2). In this context, POL2 noted that the Ecodesign Directive includes requirements to ensure that consumers can obtain spare parts and repair instructions. CE1 illustrated a specific use case for washing machines, where DPPs could help consumers operate appliances more effectively and reduce service requests by providing targeted usage information, such as product manuals. This perspective is supported by CE3, who emphasized that improved traceability through DPPs could enable more efficient use and maintenance of products.

Interviewees also described EoL scenarios in which consumers are likely to interact with DPPs, thereby promoting more circular behavior. Disposal and recycling of consumer electronics were mentioned most frequently. CE3 and R&D1 emphasized that DPPs can support consumers in proper disposal by providing return locations and instructions. CE4 did not describe a specific scenario but referred to the common lack of trust in recycling information, which DPPs could strengthen through greater transparency. In contrast, CE1, POL1, and R&D2 questioned whether DPPs remain effective after consumer disposal. While CE1 stated practical barriers to scanning DPPs in the recycling process, R&D2 pointed out that the limited product scope of DPPs may discourage disposal firms from investing in new processes. POL1 referred to the SCIP database, whose contents were rarely used in practice despite significant input efforts. Additionally, CE3, CONS2, and POL1 highlighted that DPPs can support structured take-back schemes by enabling traceability and providing return-related instructions, thus facilitating higher recovery rates. Beyond informational support, CE3 emphasized that DPPs can be linked to loyalty programs to incentivize circular consumer behavior. Similarly, R&D2 suggested that consumers could be motivated through features such as point-based reward systems.

4.2.2 Drivers and Barriers to Consumer Engagement

All interviewees emphasized that DPPs are not yet mandatory in the consumer electronics sector and that their final design and content remain undefined. Consequently, all statements regarding anticipated consumer engagement were hypothetical and linked to various influencing factors.

Tables 5 and 6 summarize the most frequently mentioned potential drivers and barriers. The categories were developed inductively based on expert responses and reflect a broad spectrum of individual, contextual, informational, and design-related aspects.

#	Category	Drivers
1	Awareness & Familiarity	Consumer awareness; routine formation through repeated use; visibility at the point of sale (e.g., integration into search filters).
2	Trust & Credibility	Trust in DPPs and sustainability information; transparency and standardization; third-party verification.
3	Environmental Attitudes	Personal environmental values.
4	Information Relevance & Clarity	Perceived relevance and actionability of information; avoidance of information overload.
5	Usability & Design	Intuitive and accessible design (e.g., access via QR codes or NFC); clear structure and navigation; engaging design elements (e.g., gamification, personalization); positive user experience; identity fit.
6	Value-Added Services	Service access; repair and maintenance instructions; take-back and recycling options; incentives (e.g., discounts, loyalty programs).
7	Purchase Decision Support	Relevant product information (e.g., sustainability, circularity); product comparison metrics; perceived economic benefits (e.g., durability).

Table 5. Identified Drivers of Consumer Engagement with DPPs

Note. Own table.

#	Category	Barriers
1	Awareness & Familiarity	Low consumer awareness of DPPs and their benefits; lack of routines for accessing product information; limited DPP visibility at the point of sale.
2	Trust & Credibility	Confusion due to competing (eco-)labels and certifications; doubts about the reliability and neutrality of DPPs; use of non-mandatory data to obscure mandatory disclosures.
3	Consumer Attitudes & Priorities	Environmental values often outweighed by price sensitivity; limited awareness of product sustainability aspects.
4	Information Relevance & Clarity	Excessive or overly technical information with low relevance; absence of clear and comparable sustainability benchmarks; lack of individualized information to match consumer needs.
5	Usability & Design	Low usability or poor user interface design; scanning or interacting with DPPs perceived as effortful; perceived technical complexity of DPPs may discourage less digitally confident consumers.
6	Motivation & Perceived Value	Lack of perceived added value or usefulness; absence of incentives or rewards for engagement.

Table 6. Identified Barriers to Consumer Engagement with DPPs

Note. Own table.

Awareness and accessibility were highlighted by several interviewees as key prerequisites for consumer adoption of DPPs (CONS1, CE1, CE3, CE5, POL2, R&D1, R&D2). CONS1 emphasized the need to raise initial awareness before a “learning by doing” effect can occur. R&D1 emphasized that high accessibility could lead to quick DPP adoption, a point CE1 illustrated by suggesting integration of DPPs into online shop filters to support consumers’ decision-making at the point of sale. R&D2 further noted that fragmented solutions with multiple separate DPP apps could hinder adoption, highlighting the need for integration into existing consumer interfaces.

Trust in DPPs and sustainability information was another frequently mentioned factor (CE1, CE3, CE5, CONS1, CONS2, POL2, R&D2). While CE3 viewed verified and transparent data in DPPs as a key lever for strengthening consumer trust in product information, CONS1 emphasized that trust also depends on the timeliness of the information provided.

Most interviewees highlighted that the design of DPPs and the type and amount of information included can act as either a driver or a barrier. According to CONS1, who is actively involved in the development of prototypes, DPPs should offer smart, intuitive, and interactive user experience that immediately conveys added value and relevance to consumers rather than the impression of product manuals. CE3 similarly warned that without proper design, DPPs might risk overwhelming consumers due to perceived complexity. Several interviewees also emphasized that not only the format but also the relevance of information is critical to consumer engagement (CE3, CONS1, POL1, POL2, R&D1). DPPs should prioritize actionable content while avoiding irrelevant, overly technical, or generic information. POL1 and POL2 highlighted that there is a greater risk in overwhelming consumers than in under-informing them and therefore advocated for a simplified DPP focused on essential and usable information. Building on concerns about information overload, R&D1 and CE5 further warned that firms might engage in greenwashing by using non-mandatory data to obscure critical mandatory disclosures.

Several interviewees also emphasized that DPPs must go beyond serving as sole information tools. CE2 cautioned that most consumers are unlikely to engage with DPPs if they serve only to meet regulatory requirements, without offering any additional value. According to CE1, CE2, and CE3, such value-added services may include repair instructions, spare part ordering, trade-in programs, or consumer incentives such as loyalty programs.

In addition, several interviewees noted that consumer engagement with DPPs is likely to differ across user segments. The following section presents these segment-specific influences in more detail.

4.2.3 Segment-Specific Factors Influencing Consumer Engagement

CONS1, CONS2, and R&D1 emphasized that engagement with DPPs is likely to vary across consumer segments. R&D1 anticipated higher engagement among environmentally conscious, well-educated, and tech-savvy consumers, as well as those motivated by economic considerations such as product longevity. CONS1 expected younger consumers to be particularly receptive due to their digital competencies and highlighted the importance of

tailoring DPPs to distinct user segments, given their diverse expectations regarding information design and service features. CONS2 added a temporal and contextual perspective, identifying sustainability-oriented consumers as likely early adopters, with broader engagement following a long adoption curve, influenced by the perceived relevance of DPPs across product categories.

4.2.4 Impact on Purchase Intention and Willingness to Pay

The expert interviews revealed differing perspectives on the impact of DPPs on consumers' purchase intention and WTP for circular products. R&D1 and CONS1 anticipated a positive impact. In addition to ecological motivation, R&D1 also presented an economic rationale. He argued that by making aspects such as product quality, longevity, and reparability more visible, DPPs could encourage consumers to accept a higher initial price in the expectation of longer product use and lower lifetime costs. CONS1 attributed the anticipated positive effect to the ability of DPPs to combine interactive and user-friendly experiences with additional services, thereby going beyond static information and enhancing consumer receptiveness. Similarly, CE3 anticipated that DPPs could influence consumer behavior, particularly among environmentally conscious consumers and when tied to concrete incentives such as trade-in programs.

CE2 took a more conditional view, emphasizing that any positive impact of DPPs on purchase intention and WTP would depend on the presence of tangible consumer benefits. He argued that such effects are likely only if DPPs go beyond mere compliance and communicate differentiating product features that can be strategically positioned as unique selling points. In addition, he highlighted the potential of DPPs to support value-added services and new business models that could be monetized by firms. CONS2 expressed a cautious view regarding the broad behavioral impact of DPPs but emphasized a different rationale. While he acknowledged that many consumers prefer circular products, he noted that only a small, environmentally conscious consumer segment is willing to pay more, which he considered insufficient to offset their typically higher costs. Instead, he emphasized the role of DPPs in enabling a "data-driven circular economy" and therefore making circular products more cost-competitive. R&D2 noted that DPPs could shape consumer choices, but only expects "a small bubble of sustainability-oriented consumers" to be influenced in the near term. POL2 added that while many consumers express a higher WTP for sustainable products, "there is always a bias between what people say and what they actually buy", underscoring the need to translate stated interest into actual purchasing behavior.

CE1 was highly skeptical about the impact of DPPs on WTP, arguing that most consumers prioritize price and quality over sustainability, particularly in light of recent economic and geopolitical developments. While he remained skeptical about a broad impact on purchase decisions, he acknowledged younger generations tend to be more open to circular options such as refurbished products, driven by lifestyle preferences. CE4 and POL1 did not explicitly comment on the impact of DPPs on purchase intention and WTP.

4.2.5 Consumer Perspective on Refurbishment

Several interviewees highlighted refurbishment as a particularly promising application area for DPPs within the consumer electronics sector. Their responses reflected both the relevance of DPPs for improving information flows along the value chain and their potential to strengthen consumer trust and support informed decision-making.

CE1 and CE4 named several consumer-related barriers to refurbishment. For CE1, a central barrier is the lack of trust, as consumers often cannot assess what has been modified in refurbished consumer electronics. CE4, from a European refurbishment company, also noted trust issues due to the limited transparency and emphasized safety and quality concerns, using the example of smartphone batteries that originate outside of Europe. This aligns with R&D1, who emphasized the distinction between products refurbished within the EU and those imported under a refurbished label, suggesting that the location of refurbishment may play a role in how refurbishment is evaluated. CONS2 added that sustainability claims are generally difficult for consumers to interpret and trust. In addition, CE4 mentioned further barriers, such as design limitations, restricted access to original parts, or part pairing. However, they lie beyond the scope of this consumer-focused study.

Several interviewees (CE1, CE3, CONS2, POL2, R&D2) highlighted the potential of DPPs to foster refurbishment from a consumer perspective. CE3 emphasized that DPPs can strengthen consumer trust, noting that they "can build confidence in refurbished or second-hand electronics by providing verifiable information histories and their current status". He therefore considers consumer engagement with DPPs, through reduced uncertainty in refurbishment markets, as a lever to advance the CE transition. CE1, CONS2, and POL2 also pointed to consumer trust as a key driver that is strengthened by DPPs providing insights into the timing and scope of previous refurbishments. CONS2 further noted that such transparency can serve as a differentiator for firms, especially in markets where consumers struggle to verify sustainability

claims. R&D2 added that by improving refurbishment processes through greater transparency, DPPs could indirectly provide financial benefits to consumers.

While POL1 acknowledged that consumers may benefit from increased transparency, particularly through authenticity and traceability of products, she saw the primary role of DPPs in supporting refurbishment processes on the business side. Taking a more critical view, CE4 expressed skepticism toward DPPs as trust-building tools for consumers. She questioned whether detailed information, such as the number of previous owners, would truly foster trust. Although she regarded individualized DPPs as a potentially useful tool, she considered them impractical due to the effort involved and the risk of information loss. Instead, she highlighted that it is up to refurbishment firms to build consumer trust via communication campaigns.

4.2.6 Strategic Management Insights

The consumer-related interview findings make it clear that the introduction of DPPs alone as a transparency instrument is not sufficient to sustainably change consumer behavior in line with a CE. For consumers to actively engage with DPPs and foster circular behavior, firms must go beyond the point of sale and offer additional services and added value. Mere compliance with the upcoming DPP regulation in the consumer electronics sector is therefore not enough. Rather, the decisive factor is whether firms understand DPPs as a strategic tool and actively leverage them to promote CEBMs. As POL2 emphasized, digital tools such as the DPP can make a significant contribution to "ensuring that all stakeholders receive the information they need to enable circular business models and various R strategies".

This highlights why the strategic corporate perspective is essential for understanding the full impact of DPPs. The potential emerging on the consumer side can only be translated into broader circularity when firms go beyond minimum regulatory requirements. Against this backdrop, the following section examines how firms respond to DPPs and which factors facilitate their strategic use.

4.2.6.1 Firm Responses to Digital Product Passports

The interviews revealed that firms' attitudes toward DPPs currently vary widely. While some take a purely compliance-driven approach, others see DPPs as a strategic tool for innovation, differentiation, and the development of CEBMs.

A fundamental reason for the reluctance lies in the regulatory uncertainties surrounding DPPs in the consumer electronics sector. All interviewees emphasized that the timeline and

requirements have not yet been finalized, which is causing many firms to adopt a wait-and-see attitude. CE1 summed this up with “nobody is going to move until there is a set date”.

At the same time, several interviewees (CE2, CE3, CONS1, POL2, R&D1, R&D2) reported that first firms are already developing prototypes and use cases for DPPs. According to R&D2 and POL2, this mainly concerns larger and digitized firms. CE3 also emphasized that reactions vary between product categories. In addition, some interviewees referred to their early involvement in the EU project CIRPASS-2, which is driving the development and testing of DPPs.

Overall, the interviews made it clear that firm responses depend on several conditions. Alongside timing and regulatory clarity, organizational factors such as digital infrastructure also determine whether DPPs are seen merely as a compulsory task or as a strategic tool.

4.2.6.2 First-Mover Advantages and Risks

Although it is clear that DPPs will be mandatory in the consumer electronics sector, the timeline and requirements have not yet been finalized. Firms therefore must decide whether to wait for the regulatory requirements to be published or to begin implementing initial approaches. This raises the question of what first-mover advantages and risks arise. The interviews revealed an ambivalent picture: alongside clearly identified advantages of early preparation, the interviewees also pointed to considerable risks.

A key advantage is that prototyping and pilot projects allow expertise to be built up at an early stage and structures to be prepared to facilitate later implementation (CE1, CE2, CONS1, CONS2, R&D1, R&D2). CE1 described this as follows: “If companies start now, then they already have everything in place when it becomes mandatory.” The interviewees frequently mentioned advantages related to the value chain, especially in terms of data availability. POL1 noted that much of the information required for DPPs is already available, but that additional information is needed. According to CE5 and R&D2, the collection of this data involves significant effort. Consequently, POL1 recommended entering into dialogue with value chain actors at an early stage. POL2 added that some firms already pay extra if suppliers deliver data in the desired format, which POL1 confirmed: “There’s now one market for products and a second market for data.”

In contrast, CE5 and R&D2 emphasized that investments in data collection would be premature as long as the required data points remain unclear. POL2 also pointed out: “Once the regulation has been published, firms usually have a transition period of 1.5 to 2 years before the regulation

takes effect." Nevertheless, regardless of regulatory requirements, he advised identifying key information requirements for products and CEBMs as well as reviewing existing standards for suitability. POL1 also advocated investing in strengthening supply chains regardless of regulation, thereby improving data quality and product knowledge.

Additional first-mover advantages mentioned included improved customer loyalty through ongoing touchpoints from the beginning, monetization of new services, avoidance of competitive disadvantages due to late action, and reduction of service and warranty costs through better-informed customers (CE1, CONS1).

At the same time, the interviewees highlighted significant risks that can be classified into three categories: regulatory uncertainty, high investment and resource demands, and competitive risks. Several interviewees (CE1, CE2, POL1, R&D1, R&D2) pointed to high investment costs for digital infrastructure, data management, and governance, which could be misplaced if standards are unclear. R&D1 summed this up: "Firms are hesitant to invest heavily before regulation and standardization are clear, as early investments may later turn out to be misaligned or wasted." CE4 added operational challenges in terms of granularity and maintenance. On the competitive side, CE5 identified the risk that early investments could be exploited by imitators, while CONS2 fundamentally doubted that first-mover advantages would take effect until a critical mass of market participants was reached: "I think you need the critical mass of everyone being on it for the benefits to be realized."

Overall, firms find themselves in a difficult situation. On the one hand, regulatory uncertainties are hampering early investment, while on the other hand, waiting too long threatens to result in a loss of competitiveness (R&D2).

4.2.6.3 Organizational Resources and Capabilities

The interviewees emphasized that the ability of firms to use DPPs strategically depends heavily on the resources and capabilities they possess. While regulatory compliance may be achievable for most firms, leveraging DPPs beyond compliance and as a source of competitive advantage requires a broader organizational foundation. Based on the expert interviews, seven categories of organizational resources and capabilities were identified (see Table 7).

#	Category	Organizational Resources & Capabilities
1	Consumer-Facing Capabilities	Ability to use DPPs strategically in consumer interactions, service offerings (e.g., repair, take-back, PaaS), and differentiation.
2	Digital Infrastructure & Data Management	Robust IT systems, databases, and interoperability solutions; governance of data access.
3	Knowledge & Innovation Capabilities	Expertise in sustainability, data analysis, and projects (e.g., pilot projects, CIRPASS-2 involvement).
4	Leadership & Strategic Commitment	Top management support, long-term sustainability vision, and commitment to allocate resources for DPP implementation.
5	Organizational Learning	Ability to adapt, build expertise over time, and continuously improve DPP-related processes; dynamic learning from pilots.
6	Scale & Resource Availability	Financial and human resources, organizational size, and structural capacity to comply with and go beyond regulatory requirements.
7	Value Chain Knowledge & Integration	Capability to access, validate, and share supplier data; collaboration across global supply chains and with external partners (e.g., recyclers, refurbishers, service providers).

Table 7. Identified Organizational Resources and Capabilities for Strategic Use of DPPs

Note. Own table.

The interviewees most frequently mentioned resources and capabilities related to the value chain, digital infrastructure, and data management. Several interviewees (CE2, CE3, R&D1, R&D2) stressed that strong value chain capabilities are essential to co-create circular solutions with other actors, though CE5 and POL2 noted information and power asymmetries: large firms often have bargaining power to access data, while smaller ones face barriers. POL2 therefore summarized: “The question of what position the respective firms have in their value chain and whether they receive the information they need is very relevant.” In addition, several interviewees (CE1, CE5, CONS2, POL2, R&D2) emphasized that a robust digital infrastructure is necessary to ensure the reliability and scalability of DPPs. While CE1, based on previous experience, particularly highlighted governance aspects such as identity and access management, CONS2 and R&D2 stressed digitization and interoperability across systems.

Beyond these factors, several interviewees (CE2, CE3, CE4, CONS1) underlined the importance of consumer-facing capabilities for making DPPs accessible and engaging for users, extending customer relationships into secondary markets, and building trust through transparency. CE1, R&D1, and R&D2 also described DPP implementation as a gradual learning process requiring organizational learning capabilities. As R&D2 summarized: “The entire development process from scratch to a running DPP takes 1 to 2 years. This also involves a learning process within the company.” Knowledge and innovation capabilities further support strategic use, enabling firms to leverage DPPs for new customer services, system thinking, and ecosystem collaboration (CE2, CONS1, R&D1, R&D2).

In addition, CE5 and POL1 emphasized that larger firms often have more suitable internal structures and resources, while smaller firms face resource constraints. CE5 concluded: "The larger it is, the easier it should be." Finally, leadership commitment was emphasized (CE3, CONS2) as crucial for resource allocation.

4.2.6.4 Strategic Opportunities for Circular Economy Business Models

The expert interviews highlighted that firms may derive strategic opportunities from DPPs beyond their regulatory function. As one consultant noted, "Since companies have to do the work anyway, it is obviously advantageous to derive further added value from DPPs with a minimum of extra work" (CONS1). Similarly, CE2 emphasized that "the differentiating factor is whatever we do with the DPP in addition to mere compliance", stressing that differentiation may not primarily depend on the speed of adoption but on strategic use. POL2 further underlined that DPPs can provide the information base needed to enable CEBMs and R strategies across value chains. Overall, most interviewees perceive DPPs as an enabler for circularity by providing necessary data, enhancing consumer trust, and fostering more sustainable value chains. Against this backdrop, five categories of strategic opportunities for CEBMs were identified (see Table 8).

#	Category	Strategic Opportunities for CEBMs
1	After-Sales Services	DPPs enable enhanced repair, maintenance, and warranty services, supporting extended product lifetimes and new revenue streams.
2	Data-Driven & Digital Services	Access to product lifecycle data allows for personalized services, predictive maintenance, reporting simplification, and increased consumer trust.
3	Ecosystem & Partnership Models	DPPs facilitate collaboration with recyclers, refurbishers, and service providers, enabling new ecosystem-based circular business opportunities.
4	PaaS	Ownership remains with the manufacturer, incentivizing durability and long-term value creation through leasing, subscription, or pay-per-use models.
5	Refurbishment & Second-Life Models	Reliable product and usage data strengthen refurbishment practices, reduce costs, and improve consumer confidence in second-hand products.

Table 8. Identified Strategic Opportunities for CEBMs

Note. Own table.

Refurbishment and second-life models were most frequently cited as direct beneficiaries. CE4, working at a European refurbishment company, underlined that the DPP "is a transparency tool which gives us a lot of information about devices that we absolutely do not have at the moment", while CE2 stressed the opportunity to connect with secondary customers. Similarly, CONS2 highlighted the potential of tracking product changes: "If changes are logged in the DPP, which is a possibility, then this can make a true difference – not only for consumers, but also for businesses recovering those." Altogether, refurbishment and second-life models currently face uncertainty and high costs due to missing information, which undermines consumer trust (CE1,

CE4, CE5, CONS2, POL2). By closing these gaps, DPPs could lower operational barriers and unlock new opportunities for scaling these CEBMs (CE2, POL1, POL2, R&D2).

After-sales services were also seen as important, as DPPs can facilitate repair and maintenance through standardized access to spare parts, repair instructions, and self-help services, thereby extending product lifecycles (CE1, CE2, POL2). Several interviewees (CE1, CE2, CE3, CONS1, POL1, POL2, R&D1, R&D2) pointed to enhanced customer loyalty through ongoing touchpoints, trade-in schemes, incentive programs, and personalized offers, with CE2 noting: "you can also add new services which you can monetize and exploit in different ways". Finally, CE2 pointed to the possibility of using DPPs for brand differentiation by creating additional value beyond compliance. This aligns with CONS1, who described DPP projects where corporate identity was integrated to strengthen positioning against competitors.

Data-driven and digital services were mentioned as another key opportunity. Lifecycle information provides a basis for predictive maintenance, sustainability reporting, and impact-based pricing models (CE2, CE3, R&D1, R&D2).

Ecosystem and partnership models were highlighted for fostering collaboration across repair, recycling, and related services. Transparent product data can improve take-back and reverse logistics systems (CONS2, POL1), drive recycling innovation by guiding consumers in disposal and ensuring material transparency for assessing recovery potential (CE3, POL2, R&D1), and support integrated service ecosystems where secondary markets and services are bundled into comprehensive circular offerings (CE2, R&D2).

PaaS models were cited less frequently (CE3, POL2), but interviewees noted that lifecycle data could support leasing and subscription services where ownership remains with the manufacturer. CE3 emphasized that consumer engagement with DPPs could act as a catalyst for circularity by enabling shared services such as PaaS.

Beyond these categories, interviewees also mentioned additional opportunities to strengthen CEBMs. POL1 emphasized that standardized data formats through DPPs could replace today's fragmented systems and facilitate collaboration across value chains. CE2 highlighted that implementing DPPs could help firms acquire missing value chain knowledge, while CE5 noted that DPPs could contribute to fair competition by excluding non-compliant products.

These findings illustrate the strategic opportunities that DPPs can create for CEBMs. To fully grasp their implications, they will be further discussed in Chapter 5.6 in light of established management theories.

5. Discussion

5.1 Baseline Circular Behavior and Structural Barriers

Before examining the effects of DPPs, existing consumer behavior regarding circular consumer electronics offerings was assessed. This baseline helps to contextualize the relevance and necessity of DPPs by revealing current barriers to circular purchase decisions.

Although the mean environmental concern among survey participants was relatively high (M = 3.79), only 38% reported having previously purchased circular consumer electronics. This discrepancy reflects the attitude-behavior gap described by Atkinson and Rosenthal (2014), where pro-environmental attitudes do not consistently translate into concrete actions.

The interpretation is supported by the reported drivers and barriers to circular product choice (see Chapter 4.1.2). While the option "environmental concerns" was most frequently cited as a driver (n = 42), only five participants selected "I'm not aware of sustainability issues". This suggests that lack of awareness was not the limiting factor. Rather, the most frequently mentioned barriers were "I don't know how to identify circular or sustainable products" (n = 51) and "I don't trust companies' sustainability claims" (n = 34). These findings align with concerns raised by the European Commission (2021) regarding the absence of standardized, reliable sustainability information, which leads to information asymmetries and undermines consumers' ability to identify truly circular products. Information asymmetries were also emphasized by CONS1 and CONS2, who highlighted trust issues and a lack of transparency as major obstacles to sustainable purchasing.

In addition, CONS1 and R&D1 observed that many consumers tend to stick to familiar purchasing habits, which corresponds to the status quo bias described by Grafström and Aasma (2021) and further reduces consumer engagement with CE offerings.

To address these barriers, DPPs have gained relevance as regulatory tools to improve product transparency and support informed consumer purchase decisions (European Union, 2024a). This functionality was confirmed by most interviewees (CE3, CONS1, CONS2, POL1, POL2, R&D1, R&D2), but they also emphasized that the potential value of DPPs extends beyond transparency, by enabling additional consumer services and trust-enhancing mechanisms.

However, the effectiveness of DPPs in promoting more circular consumer behavior and contributing to CE depends on whether consumers engage with them. The following section therefore examines key factors influencing anticipated consumer engagement with DPPs.

5.2 Factors Influencing Consumer Engagement

The survey results indicate that consumers generally have a positive attitude toward DPPs. The average reported engagement score was $M = 3.99$ ($SD = 0.95$), suggesting that participants are generally willing to interact with DPPs during purchase decisions. This aligns with views expressed by several interviewees (CE1, CE3, CE5, CONS1, CONS2, POL2, R&D1), who anticipated openness among consumers, depending on the exact implementation.

However, the survey assumed prior awareness of DPPs, as participants were first introduced to the concept before being asked about their intended engagement. Awareness was not measured, since DPPs are not yet mandatory in the consumer electronics sector and reliable responses were therefore unlikely. While DPPs are expected to be accessible via established data carriers such as QR codes (Giess & Moeller, 2025), it remains uncertain whether consumers will proactively scan them or recognize their value. Given that several interviewees emphasized low consumer awareness as a key barrier, actual engagement may therefore be lower than survey results suggest, especially during the early stages of DPP implementation. CONS1, for instance, stressed the need for targeted campaigns to raise awareness and clearly communicate the added value of DPPs to consumers.

The ordinal logistic regression analysis found that only *perceived usefulness* and *perceived ease of use* were statistically significant predictors of *DPP engagement*. Accordingly, H1 was only partially supported. This finding closely aligns with the TAM proposed by Davis (1989), which identifies both constructs as joint determinants of behavioral intention. Consistent with the model, *perceived usefulness* exhibited a stronger effect in the survey. Expert interviews supported the relevance of both predictors. Several interviewees emphasized that consumers are more likely to engage with DPPs if they perceive clear benefits, with CE2 noting: “If you can provide benefits to scanning as a company, then people will definitely do that”. Perceived ease of use was likewise emphasized by multiple interviewees, with CE3 warning that “DPPs risk overwhelming rather than informing” if not designed intuitively.

The other predictors – *digital literacy*, *environmental concern*, *subjective norms*, *trust in DPPs*, and *information overload* – were not statistically significant. This contrasts with prior studies in related research, which had suggested relevance for these constructs (Ajzen, 1991; Malhotra, 1982; Panopoulos et al., 2023; Yu et al., 2017).

Although the additional predictors did not yield significant effects in the survey, qualitative insights add valuable context. Both the higher engagement of sustainability-conscious

consumers and the importance of trust in DPPs and sustainability information were emphasized by several interviewees. Most interviewees also described the amount of information provided by DPPs as a critical factor, with POL1 highlighting that too much information may pose a greater risk than too little, thereby underlining the risk of information overload. This concern is reinforced by Dalhammar et al. (2024), who argue that the presence of multiple eco-labels for EEE can reduce clarity – a point also raised by CE1. Subjective norms were not mentioned by the interviewees, indicating low perceived influence. This is consistent with Paul et al. (2016), who noted that previous research based on the TPB has identified subjective norms as the weakest predictor of behavioral intention in sustainability contexts. While CONS1 pointed to digital competencies as a relevant factor, the lack of statistical significance in the survey may be due to a ceiling effect ($M = 4.53$), likely related to the online survey format via Qualtrics attracting digitally literate participants.

CONS1, CONS2, and R&D1 also expected DPP engagement to vary across consumer segments. This could not be confirmed in the survey, where *DPP engagement* scores by *age group*, *highest level of education*, and *annual net income* showed no significant variations. However, the two educational subgroups "less than high school" ($n = 1$) and "PhD" ($n = 5$) were underrepresented, limiting the reliability of subgroup comparisons.

Overall, DPP engagement appears to be primarily driven by perceived usefulness and perceived ease of use, confirming key assumptions of the TAM. While other factors were not statistically significant, qualitative insights suggest they may still influence DPP engagement in practice.

5.3 Impact on Purchase Intention and Willingness to Pay

5.3.1 Effects on Purchase Intention and Category Differences

Survey results show that participants' *purchase intention* for circular consumer electronics increased after exposure to the DPP scenario. The average *purchase intention* rose from $M = 3.51$ ($SD = 0.93$) to $M = 3.66$ ($SD = 0.92$), with a Wilcoxon signed-rank test confirming the significance of this change ($V = 3184.5$, $p = .0014$), supporting H2.

The segment-specific factors anticipated by several interviewees and findings by Panopoulos et al. (2023) indicated that *purchase intention* could vary across consumer segments. However, this was not observed in the survey for age, education, and income. Only the underrepresented educational subgroups "Less than high school" and "PhD" showed recognizable variation.

Additional insights emerged from participants' responses to the drivers and barriers influencing their *purchase intention* for circular consumer electronics verified through DPPs. The most

cited barrier was “Price remains the main factor for me” (n = 18), which aligns with the high *price sensitivity* reported in the sample (M = 4.18). This suggests that some participants expected a higher price for circular consumer electronics – a perception confirmed not only by CONS2 from a practical standpoint but also supported by Grafström and Aasma (2021) and Kirchherr et al. (2018), who highlight that systemic barriers continue to undermine the competitiveness of circular alternatives. R&D1, however, offered an alternative perspective, arguing that some consumer segments may choose circular consumer electronics precisely for economic reasons due to longer product lifespans and lower total cost of ownership. This raises the question of whether DPPs could help communicate such long-term economic benefits through lifecycle data and therefore also foster circular purchase behavior among economically motivated consumer segments.

While the other barriers were only rarely selected ($n \leq 10$), all four drivers received high support. “It would help me make more informed and confident decisions” (n = 78) and “I could finally identify truly circular products” (n = 68) highlight the DPP’s potential to reduce information asymmetries and facilitate sustainable choices – an effect emphasized by the European Union (2024a), Thunyaluck and Valilai (2024), and interviewee CONS1.

The frequently selected driver “I would trust the information more than current claims” (n = 73) points to the relevance of signaling theory, as introduced by Spence (1973). The signaling function attributed to eco-labels, helping consumers evaluate environmental claims they cannot verify themselves (Atkinson & Rosenthal, 2014), may similarly apply to DPPs. This interpretation was reinforced by CONS2 and CE3. While CONS2 noted that environmental claims such as recycled content are often difficult for consumers to verify, CE3 emphasized that verifiable environmental data provided through DPPs can strengthen consumer trust.

The survey results also indicated that the impact of DPPs on purchase decisions may vary by product category. “Home appliances (e.g., washing machines)” (n = 78) and “Smartphones” (n = 57) were selected far more often than “Headphones” (n = 7). Such variations were also anticipated by interviewees. CONS2 expected differences across product type, while POL1 emphasized that higher-priced products tend to lead consumers to seek more information. As smartphones and appliances typically involve higher upfront costs, these findings may suggest that product price influences the perceived relevance of DPPs. However, other category-specific aspects – such as repairability, as emphasized by R&D1 – may also play a role.

5.3.2 Effect on Willingness to Pay and Moderating Factors

As presented in the results section, participants were asked how much more they would be willing to pay for a circular consumer electronics product compared to a conventional one – first when it was merely marketed as more circular and then when it was verified through a DPP. The stated WTP, measured as a percentage premium, increased on average by 1.05 percentage points following the DPP scenario. A Wilcoxon signed-rank test confirmed this effect as statistically significant, supporting H3. When excluding two extreme outliers who reported a 60 to 80 percentage point decrease in WTP, the average increase rose to 1.87 percentage points. No significant differences were found across age, income, or education.

Although 37.1% of participants reported a higher WTP after the DPP scenario and only 14.4% a lower one, the overall effect remains limited. This may explain the divergent views expressed by interviewees in Chapter 4.2.4. CE2 emphasized that DPPs must offer tangible consumer benefits to meaningfully influence WTP. However, as several interviewees noted, it remains unclear how DPPs will ultimately be implemented in the consumer electronics sector and their design is expected to be a critical factor influencing the potential behavioral impact. For this reason, the survey scenario was deliberately restricted to the transparency and verification functions of DPPs. Since CE2 also stressed the importance of going beyond compliance and CONS1 highlighted that DPPs will vary across firms, significant differences in the impact of DPPs on WTP can be expected. The overall effect may increase if firms clearly communicate tangible benefits to consumers, something that was not included in the survey design.

Further context is provided by Boyer et al. (2021), who distinguish three consumer segments, with only circular enthusiasts showing high WTP for circular products, while no effect was observed among price-sensitive consumers. In the present survey, *price sensitivity* significantly moderated the relationship between *DPP engagement* and *change in WTP*, suggesting that DPPs are more effective among less price-sensitive consumers. The overall sample showed a high average *price sensitivity* ($M = 4.18$), likely limiting the potential WTP effect.

In summary, DPPs were found to moderately increase both purchase intention and WTP for circular consumer electronics by enhancing transparency and trust. However, price sensitivity remained a key barrier in both cases, suggesting that clearly communicating both environmental and economic benefits will be crucial.

5.4 Refurbishment as a Key Application Area of Digital Product Passports

In the survey, 45% of participants reported prior purchases of refurbished consumer electronics – substantially more than in the European Commission (2018) study, where only 10% had experience with second-hand products. This suggests that refurbishment has gained relevance in recent years.

According to CE4, consumers typically choose refurbished consumer electronics for economic or environmental reasons, which is supported by the survey. “Lower price” (n = 66) was cited far more frequently than “Environmental benefit” (n = 28), reinforcing the sample’s high price sensitivity. The rarely selected driver “Influence of friends/family” confirms the limited role of subjective norms also seen for DPP engagement.

All four barriers were frequently selected. “I prefer new products” (n = 34) likely reflects status quo bias (Grafström & Aasma, 2021), while “Concerns about product quality” (n = 45), “Limited trust in refurbishment claims” (n = 35), and “No clear information available” (n = 29) could offer an interesting application area for DPPs by reducing information asymmetries and trust gaps.

Interviewees CE3 and CONS2, as well as Adisorn et al. (2021), highlighted the potential of DPPs to strengthen trust through standardized, verifiable data on product history and condition. This potential was reflected in the survey, where the average purchase intention for refurbished products increased from M = 2.93 (SD = 1.11) to M = 3.42 (SD = 1.13) after the DPP scenario, with a Wilcoxon signed-rank test confirming statistical significance.

However, CE4 expressed general skepticism about the suitability of DPPs as consumer-facing tools. She questioned whether data such as the number of previous owners would foster trust and argued that trust-building should be the responsibility of refurbishment providers through communication campaigns. While she acknowledged current trust challenges, she argued that DPPs often contain overly technical information and are therefore more valuable for value chain actors than for end consumers. Although she considered personalized DPPs potentially useful, she regarded them as impractical due to the associated effort and risk of data loss.

This view only partially aligns with other interviewees. While most agreed that the usefulness of DPPs depends on content and format – consistent with CE4 – they were less skeptical about the role of DPPs in refurbishment. CONS1, for instance, viewed personalized DPPs as feasible and is already working on prototypes. Moreover, the frequently cited barrier “Limited trust in refurbishment claims” and broader concerns about information asymmetries undermining

consumer trust (European Commission, 2021) underscore the need for credible signals, supporting the signaling role of DPPs (Spence, 1973; Atkinson & Rosenthal, 2014).

Overall, DPPs could help reduce consumer-side barriers to refurbishment. However, regulatory compliance alone is unlikely to be sufficient. Firms must adapt content and presentation to consumer needs to unlock the full potential of DPPs in refurbishment.

5.5 From Consumer Behavior to Circular Economy Implications

The survey results and expert interviews suggest that DPPs can positively influence consumer behavior, particularly by increasing purchase intention and WTP for circular consumer electronics. While both effects were statistically significant, their magnitude was relatively small, with price sensitivity emerging as a major barrier. This raises the question of whether the resulting consumer demand is strong enough to incentivize firms to adopt CEBMs.

As outlined in Chapter 2.3.3, economic incentives are an important driver for the development and adoption of CEBMs (OECD, 2019a; Bain & Company, 2025). Moreover, evolving consumer preferences can act as a catalyst for circular business model innovation and strategic differentiation, potentially enabling competitive advantages (Geissdoerfer et al., 2023; Teece, 2010). According to interviewee CONS2, DPPs could help firms credibly communicate sustainability performance, thereby supporting strategic positioning. Based on this foundation, the observed effects in the survey appear necessary but not sufficient to drive large-scale adoption of CEBMs – for example, through higher pricing for circular offerings enabled by increased WTP.

This assessment is reinforced by the expert interviews. Multiple interviewees emphasized that regulatory compliance alone will not unlock the full potential of DPPs. Instead, firms must adopt a strategic approach that goes beyond transparency at the point of sale. Engagement opportunities were also identified in the usage and EoL phases (see Chapter 4.2.1). CE2 noted that consumers will only engage meaningfully if tangible benefits are clearly communicated. CE1, CE2, and CE3 mentioned examples such as repair services, trade-in programs, or loyalty features.

Moreover, CONS1 and R&D1 pointed out that firms will have considerable flexibility in how they design and implement DPPs. This means that the consumer-facing impact of DPPs will depend not only on regulatory design but also on firm-specific strategies. If implemented thoughtfully and extended beyond basic compliance, DPPs could meaningfully contribute to circularity and support firms in strengthening their sustainability ambitions.

In summary, while DPPs have the potential to foster circular demand, the observed effects on purchase intention and WTP were modest. A stronger impact may emerge if firms not only meet regulatory requirements but also align DPPs to consumer needs through targeted features and credible communication.

5.6 Strategic Management Implications

The interview results presented in Chapter 4.2.6 illustrate the diverse firm perspectives on DPPs, ranging from compliance-driven approaches to strategic considerations. This chapter discusses the findings in light of established management theories and literature reviewed in Chapter 2 to examine the broader strategic implications of DPPs for firms and their potential role in fostering CEBMs.

Overall, the findings suggest that consumer engagement with DPPs can only translate into broader adoption of CE practices if firms move beyond compliance and strategically leverage DPPs, supported by the necessary resources, capabilities, and business model innovation.

5.6.1 Strategic Responses to Institutional Pressure

The range of firm-level responses to DPPs described in section 4.2.6.1 can be classified using the institutional explanatory approaches discussed in section 2.4.1. Fundamentally, the interviews showed that firms initially view DPPs as a regulatory obligation. This corresponds to the assumption of institutional theory (DiMaggio & Powell, 1983), according to which organizational change is shaped less by competition and efficiency gains and more by institutional expectations. In this context, coercive isomorphism is particularly relevant due to EU regulatory requirements. Mimetic isomorphism is evident in the fact that first movers already experiment with prototypes, while other firms wait and may imitate successful approaches. Standardization initiatives and coordination projects such as CIRPASS-2 may also contribute to the alignment of organizational practices through normative isomorphism.

The interview results can also be linked to Galleli and Amaral (2025), who show that sustainability initiatives respond not only to regulatory pressure, but also to societal expectations and cultural norms. While many firms implement DPPs as a mere obligation or out of strategic self-interest, CE2 emphasized: “It’s societally relevant that everyone wants to make a better world. So, I think in that case, DPPs can definitely help to create a circular economy world.” Other interviewees (CE1, CE5, R&D1, R&D2) highlighted the potential of DPPs to meet societal expectations for transparency. At the same time, R&D1 pointed out the risk that firms could use non-mandatory data to obscure critical mandatory disclosures. This

reflects the spectrum from greenwashing to full strategic integration of environmental goals, as described by Galleli and Amaral (2025). In addition, rising consumer demand for circular products (European Commission, 2018; European Environment Agency, 2025b) may reinforce social expectations for transparency. By increasing the visibility of sustainability-related data, DPPs could intensify normative pressures and push firms to adopt more circular practices. Overall, these findings expand on previous studies, which emphasize the relevance of institutional theory in explaining regulatory and societal drivers of DPP implementation, but so far lack deeper theoretical contextualization (Chaudhuri et al., 2024; Zhang & Seuring, 2024).

For a more detailed analysis, Oliver's (1991) typology of strategic responses provides a suitable classification. Acquiescence is evident in the expectation that firms will implement DPPs once the requirements have been finalized. Compromise is reflected in the currently dominant wait-and-see attitude. Initial elements of manipulation appear when firms attempt to shape regulatory requirements in their favor, for example by integrating non-mandatory data to present themselves as particularly transparent and sustainable.

Altogether, this illustrates that corporate responses are situational and dynamic in nature – depending on regulatory clarity, resources, and internal priorities. Currently, DPP adoption is predominantly regulation-driven, while at the same time there is growing demand for circular products and increasing normative expectations.

5.6.2 Early Adoption and Diffusion Dynamics

The ambivalent perceptions of early adoption expressed in the interviews can be well explained by Rogers' Diffusion of Innovation Theory. Accordingly, the adoption speed of innovations is influenced by perceived attributes such as relative advantage, compatibility, complexity, trialability, and observability (Rogers, 2003). These dimensions are clearly reflected in the empirical findings.

Interviewees identified several aspects that align with relative advantage, namely the perceived benefits of DPPs compared to the current absence of such systems. These included improved customer loyalty through ongoing touchpoints (CE1, CONS1) and reduced service costs (CE1). Compatibility was reflected in the emphasis on preparing existing processes for future regulatory requirements. Several interviewees (CE5, POL1, POL2, R&D2) stressed that early data collection and supplier engagement could ensure smoother alignment once DPPs become mandatory. Moreover, several interviewees (CE1, CE2, POL1, R&D1, R&D2) emphasized the complexity arising from the required digital infrastructure, data collection and management,

and governance structures. Opportunities for trialability and observability were seen in pilot projects and prototypes, which empower firms to experiment with DPPs, build expertise, and develop use cases (CE2, CE3, CONS1, POL2, R&D1, R&D2).

Altogether, these attributes enable an assessment of the ambivalent perceptions of early adoption. On the one hand, the interviews revealed clear opportunities in terms of relative advantage, compatibility, and trialability. On the other hand, complexity and regulatory uncertainty could represent barriers that delay adoption.

Beyond these dynamics, Orgalim (2024) presents a more optimistic view by emphasizing that early adoption of DPPs may allow firms to position themselves as sustainability leaders and achieve market differentiation. This perspective, however, was not confirmed in the expert interviews. Instead, CE2 expressed skepticism regarding substantial first-mover advantages, arguing that compliance-related components will eventually become commoditized, thereby limiting competitive differentiation.

Overall, it will be crucial for firms to strike the right balance. While they should avoid investing too early amid existing regulatory uncertainties, timely preparation is necessary to establish organizational structures and avoid jeopardizing competitiveness. POL2 emphasized that it does not make sense to speculate about possible future mandatory fields, especially since a transition period of one to two years is usually provided after the publication of the regulation. At the same time, regardless of compliance requirements, firms should examine what information is relevant to their own strategic goals and to potential CEBMs, and how DPPs can support their collection and use. This balanced approach allows firms to benefit from early learning effects without exposing themselves to excessive risks.

5.6.3 Digital Product Passports as Strategic Tool

The interviews suggest that the strategic relevance of DPPs depends on whether firms possess appropriate resources and capabilities. To contextualize this potential, the following discussion first applies the RBV to examine the role of firm-specific resources before turning to complementary perspectives on adaptability and change.

The RBV states that firms can achieve sustainable competitive advantages if their resources are valuable, rare, imperfectly imitable, and non-substitutable (Barney, 1991). In the context of DPPs, the interviewees frequently mentioned digital infrastructure and data management, value chain knowledge, and consumer-facing capabilities. Firms that possess such resources are better positioned to use DPPs strategically beyond compliance. At the same time, several interviewees

emphasized that the successful use of DPPs requires a continuous learning and adaptation process, for example through gradual integration into existing business processes. This highlights a central limitation of RBV: external shocks and changing consumer preferences are not sufficiently taken into account (Priem & Butler, 2001; Kraaijenbrink et al., 2010). However, the DPP regulation can be understood as such a shock.

Dynamic Capabilities address this gap by explaining how firms integrate, build, and reconfigure competences to respond to regulatory shocks and changing market conditions (Teece et al., 1997; Eisenhardt & Martin, 2000). Barreto (2010) conceptualizes Dynamic Capabilities as multidimensional, with adaptability at their core.

The interviews revealed that firms are already actively utilizing such capabilities. Pilot projects and CIRPASS-2 involvement help to identify opportunities early on ("sense opportunities and threats"). CONS1 also emphasized the importance of dialogue and building awareness to reveal potential. Moreover, the interviews illustrate the difficulty of making timely decisions in the face of regulatory uncertainty, as many firms postpone investments until requirements are finalized. In addition, consumer-facing capabilities were emphasized, as they enable firms to embed DPPs in customer-oriented strategies ("make market-oriented decisions"). CE2 stressed that the added value of DPPs can only be fully exploited if they are used beyond the point of sale to build customer loyalty and retention. Finally, the interviews made it clear that organizational learning and management support are necessary to further develop the resource base and structures ("change the firm's resource base").

These findings are consistent with research on Dynamic Capabilities in sustainability transitions. Moon and Lee (2021) show that electronics manufacturers translate regulatory requirements and consumer expectations into eco-innovations using Dynamic Capabilities – a pattern that was also reflected in the interviews. Dagilienė et al. (2024) emphasize the importance of zooming-out capabilities, particularly adaptation to regulation and consumer acceptance, which is comparable to the identified consumer-facing capabilities. Teece (2007) also points out that regulatory restructuring can create new markets. This potential also emerged in the interviews, for example regarding refurbishment and second-life models, which could be professionalized and scaled through transparent DPP data.

Overall, it is evident that the role of DPPs extends far beyond compliance. While Chapter 5.5 demonstrated how DPPs can stimulate consumer demand and thus provide initial incentives for business model innovation, the analysis presented in this section illustrates that firms must also

have the necessary resources and capabilities to actually translate this demand into viable CEBMs. Opportunities such as refurbishment, after-sales services, and ecosystem models can only be successfully realized if consumer engagement coincides with organizational preparation. Only then can DPPs become a truly strategic tool for the CE.

6. Conclusion

6.1 Synthesis of Findings

6.1.1 Summary of Key Findings

This study aimed to investigate how consumer engagement with DPPs influences purchase decisions for circular consumer electronics and what this implies for CE adoption. Drawing on a mixed-methods approach combining a consumer survey (n = 167) and expert interviews (n = 11), several key findings were identified.

First, the findings from both the survey and expert interviews suggest that consumers are generally willing to engage with DPPs. In the survey, only *perceived usefulness* and *perceived ease of use* emerged as statistically significant predictors of *DPP engagement*, aligning with the assumptions of the TAM. However, interviewees mentioned several additional factors shaping engagement, including information relevance and clarity, usability, design, environmental attitudes, and trust. Some experts also noted that initial consumer awareness is expected to be low, indicating that engagement will likely develop over time and that targeted communication will be essential in early implementation phases.

Second, DPPs were found to increase both purchase intention and WTP for circular consumer electronics. While both effects were statistically significant, their magnitude was limited. High price sensitivity was identified as a central barrier, reflected in both the regression results and multiple choice questions. Although interviewees anticipated variations across consumer segments, no significant differences were identified across age, education, or income groups. However, clear differences were observed across product categories, suggesting that the perceived relevance of DPPs varies by product type.

Third, refurbishment emerged as a particularly relevant application area for DPPs. Common consumer-side barriers – such as low trust in refurbishment claims and quality concerns due to information asymmetries – may be reduced through transparent, standardized product information provided by DPPs. This was supported by the survey, which showed a significant increase in purchase intention for refurbished consumer electronics after the DPP scenario. Several interviewees underlined this potential but emphasized that a user-centric design is critical for ensuring consumer trust and engagement.

Finally, while the measured effects of DPPs on consumer behavior appear necessary, they are not sufficient to drive large-scale adoption of CEBMs. The expert interviews showed that firm responses vary widely, ranging from compliance-driven to strategic approaches. Critical

enablers for leveraging DPPs strategically include digital infrastructure, value chain integration, consumer-facing capabilities, organizational learning, and leadership commitment. At the same time, firms face ambivalent first-mover dynamics. While pilot projects and early preparation can build expertise and competitive readiness, regulatory uncertainty and high investment costs create substantial risks. Beyond compliance, interviewees emphasized that DPPs can serve as enablers of new CEBMs, such as refurbishment, after-sales services, and PaaS. Overall, the potential of DPPs to foster CE adoption lies in their dual role: stimulating consumer demand and providing firms with a strategic instrument to develop and scale CEBMs.

6.1.2 Theoretical Implications

This study offers several theoretical contributions at the intersection of consumer behavior, strategic management, and CE in the context of DPPs.

First, while prior literature has mostly focused on the regulatory and technical aspects of DPPs, the consumer perspective remains underexplored – particularly in the consumer electronics sector. This study addresses this gap by offering empirical insights into how consumers perceive and respond to DPPs. Expert interviews confirmed that consumer behavior in this context is still poorly understood and that DPPs were originally intended primarily to improve information flows in the value chain. By addressing this gap, the study also contributes to overcoming the limited recognition of consumers and business models as enablers of circularity, as previously noted by Kirchherr et al. (2017).

Moreover, the study adds to the TAM by confirming the central role of perceived usefulness and perceived ease of use in shaping consumer engagement with DPPs. Interview findings suggest that constructs such as usability and design may complement the TAM in sustainability-driven digital contexts, where standard TAM predictors might not fully capture the nuances of consumer engagement.

The findings also extend signaling theory to the context of DPPs by showing that DPPs can function as credible external signals that help reduce information asymmetries around environmental claims for circular products. This aligns with earlier work on eco-labels (e.g., Atkinson & Rosenthal, 2014) and reinforces the importance of verified and standardized data in strengthening consumer trust.

Beyond consumer-related theories, the study also contributes to the strategic management literature by contextualizing DPPs within frameworks such as the RBV and Dynamic Capabilities. This perspective highlights that the strategic value of DPPs depends on the ability

of firms to mobilize resources and capabilities and to adapt to regulatory and market dynamics. In doing so, the study contributes to the emerging discussion of DPPs as strategic tools rather than mere compliance instruments.

Finally, by linking consumer demand effects with firm-level responses, the findings underline the role of DPPs as potential enablers of CEBMs. This contributes to bridging consumer behavior and strategic management research in the context of CE adoption, offering a more holistic understanding of how digital tools can support systemic transitions.

6.1.3 Practical Implications

While consumers show general openness to DPPs, meaningful engagement and behavioral impact depend on several factors. Beyond perceived usefulness and perceived ease of use, interviewees emphasized the importance of clear and relevant information, intuitive design, and overall usability. To avoid overwhelming consumers, firms should balance transparency with simplicity and, where possible, tailor content to different consumer segments.

Although DPPs slightly increased purchase intention and WTP for circular consumer electronics, high price sensitivity remains a major barrier. To maximize their impact, firms should not treat DPPs merely as compliance tools but leverage them strategically to differentiate circular offerings. Value-added services such as repair support, trade-in programs, or loyalty features can strengthen consumer engagement across the product lifecycle. In particular, refurbishment represents a promising use case, as DPPs can reduce trust and quality concerns through transparent product histories.

At the same time, the strategic use of DPPs requires adequate organizational resources and capabilities. Firms should invest in digital infrastructure, value chain integration, and consumer-facing capabilities, while using pilot projects and collaborations to build expertise. However, they must also balance the opportunities of early adoption with the risk of high costs and regulatory uncertainty, adopting a cautious but proactive approach.

Finally, the findings also yield important implications for policymakers. To ensure consumer acceptance, regulations should prioritize intuitive and user-friendly design rather than overly technical requirements. Clear rules on mandatory versus optional data are needed to avoid information overload and ensure visibility of essential content. Moreover, harmonized standards and guidelines can reduce uncertainty for firms, lower investment risks, and encourage early action.

6.2 Limitations

6.2.1 Consumer Survey

While the consumer survey provided valuable insights, several methodological limitations must be acknowledged.

First, the survey design faced inherent challenges due to the status of DPPs. As DPPs are not yet mandatory in the consumer electronics sector and their exact structure and content remain undefined, the scenario had to rely on a hypothetical design. To ensure realism, it included product information often associated with DPPs in the literature (e.g., European Union, 2024a). Nevertheless, the abstract nature of the scenario may not fully reflect future user experiences.

Furthermore, the survey introduced the DPP concept through a short scenario, which created a level of awareness among participants. While this was necessary for measuring DPP engagement, it assumes prior exposure that may not exist in real-world settings. Expert interviews indicated that limited consumer awareness could be a key barrier, particularly in the early stages of DPP implementation.

Although the sample of $n = 167$ generated robust data, some subgroups were underrepresented – most notably "Less than high school" ($n = 1$) and "PhD" ($n = 5$). This limited the reliability of comparisons across education levels and was reflected in the interpretation.

The sample also showed a ceiling effect for *digital literacy* ($M = 4.53$), likely due to the online survey format. As expert interviews suggested higher engagement among digitally literate consumers, this may have introduced a positive bias, limiting the generalizability of results.

Moreover, all data were self-reported and collected via a single questionnaire, introducing potential common method bias and social desirability effects, particularly in a sustainability context. While anonymity was ensured and questions were neutrally phrased with participants encouraged to answer honestly, such bias cannot be fully ruled out.

Finally, the survey measured behavioral intentions rather than actual behavior. While behavioral intention is a well-established predictor of actual behavior (Ajzen, 1991), the attitude-behavior gap may cause discrepancies between what people say and what they do – particularly in sustainability contexts.

Despite these limitations, the survey provides important insights. Methodological decisions were made carefully to ensure realism, transparency, and data quality, which lays a strong foundation for further research.

6.2.2 Expert Interviews

The semi-structured expert interviews provided valuable qualitative insights by including diverse perspectives from industry, policy, and research. While this breadth strengthened the exploratory character of the study, it also limited its depth. To mitigate this, particular attention was paid to including multiple experts from consumer electronics firms.

The selection of interview partners was also influenced by the early stage of DPP development, particularly in the consumer electronics sector, which made it more difficult to identify professionals with concrete implementation experience. As a result, some contributions were more forward-looking or reflective of expectations rather than established practices.

Finally, like most qualitative interviews, the data are subject to interpretive and interviewer bias. To reduce these risks, a standardized interview guide was followed, and key themes were cross-validated throughout the analysis to ensure consistency.

6.3 Future Research

Given the early stage of DPP development, several important research gaps remain.

First, the consumer perspective is still underrepresented in DPP literature. While related research on eco-labels offers some guidance, DPPs entail broader functionalities, extending beyond the point of sale to usage and EoL phases. Future studies should explore consumer interaction across stages of the product lifecycle to better understand engagement and behavioral impact.

Second, expert interviews underlined that the content and presentation of information are critical to consumer engagement with DPPs. More research is needed to identify effective formats, personalized strategies, and ways to avoid information overload.

Third, once DPPs are implemented in practice in the consumer electronics sector, real-world studies should examine how consumers respond in actual retail and post-purchase contexts. This would address current limitations related to hypothetical scenarios and self-reported intentions, and help assess whether DPPs are noticed and used in decision-making.

Fourth, future research should expand to broader and more diverse consumer segments, especially those with lower digital literacy. While this study provided initial insights into segment-related factors such as price sensitivity, further research should explore how different consumer profiles engage with DPPs in practice and which design approaches foster interaction.

Finally, while this study provided initial explorative insights into the strategic implications of DPPs, future research should investigate them more systematically. This includes examining in greater depth which firm-specific resources and dynamic capabilities enable firms to leverage DPPs beyond compliance, how organizations manage the ambivalent dynamics of early adoption, and under what conditions DPPs support the scaling of CEBMs such as refurbishment, after-sales services, or PaaS. Moreover, future work could explore the systemic role of DPPs as a connecting mechanism between consumers, firms, and policymakers in driving CE transitions.

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Appendices

Appendix A: Consumer Survey

A.1 Outline of Consumer Survey

Initial Page: Introduction

The initial page of the consumer survey aimed to give participants a general idea of the survey's topic and to ask for their consent to participate. DPPs were not explicitly mentioned at this stage, as the following sections first measured the baseline consumer behavior before introducing the DPP scenario.

Dear participant,

Thank you for taking part in this anonymous survey, conducted as part of my Master's thesis in the double degree Master in Management program at Católica Lisbon School of Business & Economics and ESCP Business School.

This research aims to better understand how consumers make purchase decisions for consumer electronics (e.g., smartphones, televisions) and how certain types of product information may influence these decisions.

The survey takes about **5-8 minutes**. Your responses are completely anonymous and used solely for academic purposes. There are no right or wrong answers, your honest opinion is highly appreciated.

If you have any questions, feel free to contact me at:
s-jblechschmidt@ucp.pt or jan.blechschmidt@edu.escp.eu

By clicking "Next", you confirm your consent to participate.

Thank you very much for your valuable contribution!

Figure 19. Consumer Survey: Initial Page

Note. Own figure.

Page 1: Individual-Level Determinants

#	Construct	Items	Input Type	Possible Answers	Condition
Q1.1	**Information Overload**	"I often feel overwhelmed by the amount of information when buying consumer electronics (e.g., smartphones, televisions, washing machines)."	5-Point Likert scale	5-Point Likert scale	none
Q1.2	**Instructional Manipulation Check**	"I read all questions carefully and answer them conscientiously. (As a check for careful reading, please select "Neither agree nor disagree")."	5-Point Likert scale	5-Point Likert scale	none
Q1.3	**Environ-mental Concern**	"I am very concerned about the environment." "I would be willing to reduce my consumption to help protect the environment."	5-Point Likert scale	5-Point Likert scale	none
Q1.4	**Price Sensitivity**	"I am willing to compare prices across multiple stores to find low prices when buying consumer electronics." "The money I save by finding low prices for consumer electronics is usually worth the time and effort."	5-Point Likert scale	5-Point Likert scale	none
Q1.5	**Digital Literacy**	"I know how to use a browser and navigate between websites." "I can evaluate online product information to make informed purchase decisions."	5-Point Likert scale	5-Point Likert scale	none

Table 9. Consumer Survey: Individual-Level Determinants

Note. Own table.

Page 2: Pre-DPP Consumer Behavior

#	Construct	Items	Input Type	Possible Answers	Condition
Q2.1	**Purchase History**	"Have you ever actively chosen a product that claimed to be more circular when buying consumer electronics? In this survey, circular consumer electronics refer to devices designed or processed in a way that extends their lifecycle – such as being repairable, recyclable, or refurbished."	Yes/No	"Yes"; "No"	none
Q2.2	**Circular Choice Barriers**	"What were the reasons you did not choose a product that claimed to be more circular? (Multiple answers possible)"	Multiple Choice	"I'm not aware of sustainability issues"; "Sustainability doesn't influence my purchase decisions"; "I don't know how to identify circular or sustainable products"; "I don't trust companies' sustainability claims"; "Other:" [Open Field]	If Q2.1 = "No"
Q2.3	**Circular Choice Motives**	"What were the reasons you chose a product that claimed to be more circular? (Multiple answers possible)"	Multiple Choice	"Environmental concerns"; "Social expectations (e.g., friends/family)"; "Cost savings"; "Product quality"; "Other:" [Open Field]	If Q2.1 = "Yes"
Q2.4	**Purchase Intention Consumer Electronics**	"Do you plan to purchase any consumer electronics (e.g., smartphones, headphones, kitchen appliances) within the next 12 months?"	Yes/No /Maybe	"Yes"; "No"; "Maybe"	none
Q2.5	**Purchase Intention pre-DPP**	"If I were to purchase consumer electronics, I would consider choosing products that claim to be more circular for ecological reasons." "If I were to purchase consumer electronics, I would definitely intend to choose products that claim to be more circular."	5-Point Likert scale	5-Point Likert scale	none
Q2.6	**WTP pre-DPP**	"Assuming you were to purchase a consumer electronics product and two products were technically identical: How much more would you be willing to pay for a product that claims to be more circular compared to a conventional one? Please estimate in percentage terms. For reference, 10% would correspond to an extra €50 on a €500 product."	Slider	0-100%	none

Table 10. Consumer Survey: Pre-DPP Consumer Behavior

Note. Own table

Page 3: Refurbishment

#	Construct	Items	Input Type	Possible Answers	Condition
Q3.1	**Refurbishment History**	"Have you ever purchased refurbished consumer electronics?"	Yes/No	"Yes"; "No"	none
Q3.2	**Refurbishment Barriers**	"What were the reasons for not purchasing a refurbished product? (Multiple answers possible)"	Multiple Choice	"Concerns about product quality"; "No clear information available"; "Limited trust in refurbishment claims"; "I prefer new products"; "Other:" [Open Field]	If Q3.1 = "No"
Q3.3	**Refurbishment Motives**	"What were the reasons for purchasing a refurbished product? (Multiple answers possible)"	Multiple Choice	"Lower price"; "Environmental benefit"; "Good quality despite usage"; "Influence of friends/family"; "Other:" [Open Field]	If Q3.1 = "Yes"
Q3.4	**Refurbishment Intention pre-DPP**	"I intend to purchase refurbished consumer electronics in the near future."	5-Point Likert scale	5-Point Likert scale	none

Table 11. Consumer Survey: Refurbishment

Note. Own table.

Page 4: Introduction to DPP Scenario

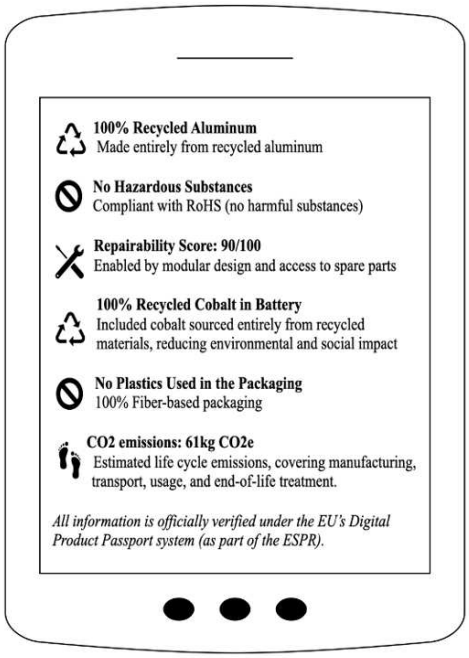
The **Digital Product Passport (DPP)** is an upcoming EU-wide initiative to increase transparency and trust in product sustainability.

It provides standardized, verified, and easily accessible digital information about products, such as:

- Environmental footprint (e.g., CO_2 emissions)
- Material origin
- Repairability and recyclability
- Presence of hazardous substances

The DPP can be accessed by scanning a QR code on the product.
It is expected to become mandatory for most consumer electronics in the EU.

Please refer to the example below. The values shown are for illustration purposes only.



For the following questions, please assume that a DPP would be available when purchasing consumer electronics.

Figure 20. Consumer Survey: Introduction to DPP Scenario

Note. Own figure.

Page 5: DPP-Specific Determinants

#	Construct	Items	Input Type	Possible Answers	Condition
Q4.1	**Trust in DPPs**	"I would trust sustainability information provided in a DPP, as it is verified by official EU standards."	5-Point Likert scale	5-Point Likert scale	none
Q4.2	**Subjective Norms**	"People who influence my behavior think that I should use the DPP when buying consumer electronics." "People who are important to me think that I should consider the DPP when making a purchase decision."	5-Point Likert scale	5-Point Likert scale	none
Q4.3	**Perceived Usefulness**	"Using a DPP would help me make more informed purchase decisions." "I would find the DPP to be useful when buying consumer electronics."	5-Point Likert scale	5-Point Likert scale	none
Q4.4	**Perceived Ease of Use**	"Interacting with the DPP would not require much effort." "I would find the DPP to be easy to use."	5-Point Likert scale	5-Point Likert scale	none

Table 12. Consumer Survey: DPP-Specific Determinants

Note. Own table.

Page 6: Post-DPP Consumer Behavior

#	Construct	Items	Input Type	Possible Answers	Condition
Q5.1	**DPP Engage-ment**	"Assuming I have access to the DPP, I intend to scan it when buying consumer electronics." "Given access to the DPP, I predict that I would pay attention to the sustainability information it provides."	5-Point Likert scale	5-Point Likert scale	none
Q5.2	**Purchase Intention post-DPP**	"If I were to purchase consumer electronics, I would consider switching to more circular products for ecological reasons, if they were verified through a DPP." "If I were to purchase consumer electronics, I would definitely intend to purchase more circular products, if they were verified through a DPP."	5-Point Likert scale	5-Point Likert scale	none
Q5.3	**Purchase Intention post-DPP Barriers**	"What are the main reasons why a DPP would not influence your purchase decision in favor of a more circular option? (Multiple answers possible)"	Multiple Choice	"I still wouldn't trust the information"; "I'm not aware of sustainability issues"; "Sustainability doesn't influence my purchase decision"; "I wouldn't take the time to scan/read the DPP"; "Price remains the main factor for me"; "I already know what I want and wouldn't change my decision"; "Other:" [Open Field]	If Q5.2 < 3
Q5.4	**Purchase Intention post-DPP Motives**	"What are the main reasons why a DPP would influence your purchase decision in favor of a more circular option? (Multiple answers possible)"	Multiple Choice	"I could finally identify truly circular products"; "I would trust the information more than current claims"; "It would help me make more informed and confident decisions"; "I care about sustainability and want to reduce my footprint"; "Other:" [Open Field]	If Q5.2 > 3
Q5.5	**WTP post-DPP**	"Assuming you were to purchase a consumer electronics product and it was verified through a DPP: How much more would you be willing to pay for a more circular product compared to a conventional one?"	Slider	0-100%	none

Table 13. Consumer Survey: Post-DPP Consumer Behavior

Note. Own table.

Page 7: Category Effects and Refurbishment

#	Construct	Items	Input Type	Possible Answers	Condition
Q6.1	**Category-specific Relevance**	"In which of the following product categories would sustainability information through a DPP most influence your purchase decision? (Please only choose one answer)"	Single Choice	"Smartphones"; "Headphones"; "Televisions"; "Home appliances (e.g., washing machines)"; "Other:" [Open Field]	none
Q6.2	**Refurbish-ment Intention post-DPP**	"I intend to purchase refurbished consumer electronics in the near future if they include a DPP that transparently verifies their condition, repair history, and environmental footprint."	5-Point Likert scale	5-Point Likert scale	none

Table 14. Consumer Survey: Category Effects and Refurbishment

Note. Own table.

Page 8: Demographics

#	Construct	Items	Input Type	Possible Answers	Condition
Q7.1	**Age Group**	"What is your age?"	Single Choice	"Under 18"; "18-24 years"; "25-34 years"; "35-44 years"; "45-54 years"; "55-64 years"; "65+ years"	none
Q7.2	**Gender**	"What is your gender?"	Single Choice	"Female"; "Male"; "Non-binary / Third gender"; "Prefer not to say"	none
Q7.3	**Country of Residence**	"In which country do you currently reside?"	Dropdown menu	All countries	none
Q7.4	**Highest Level of Education**	"What is the highest level of education you have completed?"	Single Choice	"Less than high school"; "High school diploma or equivalent"; "Bachelor's degree"; "Master's degree"; "PhD"; "Prefer not to say"	none
Q7.5	**Annual Net Income**	"What is your approximate annual net income (after taxes)?"	Single Choice	"Less than €15,000"; "€15,000-€39,999"; "€40,000-€64,999"; "€65,000 or more"; "Prefer not to say"	none

Table 15. Consumer Survey: Demographics

Note. Own table.

A.2 Overview of Constructs and Operationalization

#	Construct	Operationalization
Q1.1	Information Overload	Based on the theoretical framework of Eppler & Mengis (2004), information overload was operationalized as the individual perception of being overwhelmed by a sustainability information excess during purchase.
Q1.2	Instructional Manipulation Check	The item was created based on Oppenheimer et al. (2009), who introduced the instructional manipulation check.
Q1.3	Environmental Concern	Two items of Paul et al. (2016) were used for the measurement.
Q1.4	Price Sensitivity	Price sensitivity was measured using two items adapted from the price consciousness scale by Lichtenstein et al. (1993). Both items were reworded to reflect the specific focus of this study and positively framed to allow for direct aggregation.
Q1.5	Digital Literacy	Two items were chosen and adapted based on the four-dimensional framework by van Deursen & van Dijk (2011) and contextualized for this study.
Q2.1	Purchase History	Behavioral self-report, no validated scale applied.
Q2.2	Circular Choice Barriers	Standard follow-up question, no validated scale applied.
Q2.3	Circular Choice Motives	Standard follow-up question, no validated scale applied.
Q2.4	Purchase Intention Consumer Electronics	Behavioral self-report, no validated scale applied.
Q2.5	Purchase Intention pre-DPP	Two items were chosen and adapted from Paul et al. (2016). The wording was modified to reflect the context of circular consumer electronics. To capture a more deliberate behavioral intention, the first item also integrated the notion of actively choosing circular consumer electronics over conventional ones.
Q2.6	WTP pre-DPP	WTP was assessed using a direct contingent valuation approach. Given that WTP can be considered a concrete and singular construct, a single-item measure was deemed appropriate in line with Bergkvist & Rossiter (2007).
Q3.1	Refurbishment History	Behavioral self-report, no validated scale applied.
Q3.2	Refurbishment Barriers	Standard follow-up question, no validated scale applied.
Q3.3	Refurbishment Motives	Standard follow-up question, no validated scale applied.
Q3.4	Refurbishment Intention pre-DPP	Measured using one item adapted from Paul et al. (2016) to capture green purchase intention. Refurbishment was included due to the relevance of this CEBM in the consumer electronics sector. However, since refurbishment is not a core focus of the study, only one item was used to limit survey length and reduce dropout risk.
Q4.1	Trust in DPPs	Trust in DPPs was measured as a belief in the institutional reliability of the information provided, in line with the concept of structural assurance as a dimension of institution-based trust proposed by McKnight et al. (2002).
Q4.2	Subjective Norms	Subjective norms were measured based on the TAM2 model (Venkatesh & Davis, 2000), with item wording adapted to the context of DPP use.
Q4.3	Perceived Usefulness	The operationalization followed the same approach and source as in Q4.2.
Q4.4	Perceived Ease of Use	The operationalization followed the same approach and source as in Q4.2.
Q5.1	DPP Engagement	The operationalization followed the same approach and source as in Q4.2.
Q5.2	Purchase Intention post-DPP	The operationalization followed the same approach and source as in Q2.5. In addition, the wording was modified to assess the effect of verified DPP information on purchase intention.
Q5.3	Purchase Intention post-DPP Barriers	Standard follow-up question, no theoretical framework applied.
Q5.4	Purchase Intention post-DPP Motives	Standard follow-up question, no theoretical framework applied.
Q5.5	WTP post-DPP	The operationalization followed the same approach and source as in Q2.6.
Q6.1	Category-specific Relevance	Explorative category relevance question, no theoretical framework applied.
Q6.2	Refurbishment Intention post-DPP	The operationalization followed the same approach and source as in Q3.4.

Table 16. Consumer Survey: Overview of Constructs and their Operationalization

Note. Own table.

A.3 Supplementary Tables and Figures

The following section presents additional tables and figures that were created as part of the quantitative analysis. While some of these results are referred to in the main chapters, the full details and statistical outputs were not included directly and are therefore provided here for completeness.

Spearman-Brown Coefficients of Constructs

#	Construct	Spearman-Brown Coefficient
1	Environmental Concern	0.843
2	Price Sensitivity	0.813
3	Digital Literacy	0.846
4	Circular Purchase Intention (pre-DPP)	0.825
5	Subjective Norms	0.920
6	Perceived Usefulness	0.877
7	Perceived Ease of Use	0.882
8	DPP Engagement	0.884
9	Circular Purchase Intention (post-DPP)	0.876

Table 17. Spearman-Brown Coefficients of Constructs

Note. Own table.

Descriptive Statistics of Constructs

#	Construct	Mean	SD	Min	25th Percentile	Median	75th Percentile	Max
1	Information Overload	3.31	1.32	1	2.00	4.00	4.00	5
2	Environmental Concern	3.79	0.97	1	3.00	4.00	4.50	5
3	Price Sensitivity	4.18	0.90	1	4.00	4.50	5.00	5
4	Digital Literacy	4.53	0.84	1	4.50	5.00	5.00	5
5	Purchase Intention pre-DPP	3.51	0.93	1	3.00	3.50	4.00	5
6	Refurbishment Intention pre-DPP	2.93	1.11	1	2.00	3.00	4.00	5
7	Trust in DPPs	4.00	0.94	1	4.00	4.00	5.00	5
8	Subjective Norms	3.10	0.99	1	3.00	3.00	4.00	5
9	Perceived Usefulness	3.98	0.94	1	3.50	4.00	5.00	5
10	Perceived Ease of Use	3.98	0.85	1	3.50	4.00	4.75	5
11	DPP Engagement	3.99	0.95	1	3.50	4.00	5.00	5
12	Purchase Intention post-DPP	3.66	0.92	1	3.00	4.00	4.00	5
13	Refurbishment Intention post-DPP	3.42	1.13	1	3.00	4.00	4.00	5

Table 18. Descriptive Statistics of Constructs

Note. Own table.

Output of Ordinal Logistic Regression (Hypothesis 1)

```
> summary(model_clm2)
formula:
DPP_Engagement_ord ~ Digital_Literacy_c + Environmental_Concern_c + Subjective_Norms_c + Trust_c + Perceived_Usef
ulness_c + Perceived_Ease_of_Use_c + Information_Overload_c
data:    DPPEngagement2

 link  threshold nobs logLik  AIC    niter max.grad cond.H
 logit flexible  167  -195.11 420.22 8(0)  4.13e-11 5.5e+02

Coefficients:
                       Estimate Std. Error z value Pr(>|z|)
Digital_Literacy_c      -0.17539    0.11988  -1.463 0.143435
Environmental_Concern_c  0.16255    0.10499   1.548 0.121571
Subjective_Norms_c       0.13528    0.09584   1.412 0.158092
Trust_c                 -0.16952    0.22589  -0.750 0.452988
Perceived_Usefulness_c   1.02045    0.16071   6.349 2.16e-10 ***
Perceived_Ease_of_Use_c  0.47745    0.13045   3.660 0.000252 ***
Information_Overload_c  -0.22279    0.13122  -1.698 0.089550 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Threshold coefficients:
     Estimate Std. Error z value
2|3   -6.7241     0.7556  -8.900
3|4   -5.7390     0.6425  -8.933
4|5   -5.4484     0.6004  -9.075
5|6   -5.0134     0.5462  -9.178
6|7   -2.8849     0.3423  -8.428
7|8   -1.7367     0.2676  -6.489
8|9    1.2522     0.2249   5.568
9|10   2.0161     0.2503   8.055
```

Figure 21. Output of Ordinal Logistic Regression (Hypothesis 1)

Note. Own figure.

Odds Ratios and 95% Confidence Intervals (Hypothesis 1)

```
> round(results, 3)
                          OR 2.5 % 97.5 %
Digital_Literacy_c      0.839 0.662  1.063
Environmental_Concern_c 1.177 0.959  1.449
Subjective_Norms_c      1.145 0.950  1.385
Trust_c                 0.844 0.538  1.310
Perceived_Usefulness_c  2.774 2.043  3.842
Perceived_Ease_of_Use_c 1.612 1.252  2.092
Information_Overload_c  0.800 0.616  1.032
```

Figure 22. Odds Ratios and 95% Confidence Intervals (Hypothesis 1)

Note. Own figure.

Nominal Effects Test for Proportional Odds Assumption (Hypothesis 1)

```
> nominal_test(model_clm2)
Tests of nominal effects

formula: DPP_Engagement_ord ~ Digital_Literacy_c + Environmental_Concern_c + Subjective_Norms_c + Trust_c + Perce
ived_Usefulness_c + Perceived_Ease_of_Use_c + Information_Overload_c
                      Df  logLik    AIC LRT Pr(>Chi)
<none>                   -195.11 420.22
Digital_Literacy_c
Environmental_Concern_c
Subjective_Norms_c
Trust_c
Perceived_Usefulness_c
Perceived_Ease_of_Use_c
Information_Overload_c
```

Figure 23. Nominal Effects Test for Proportional Odds Assumption (Hypothesis 1)

Note. Own figure.

Variance Inflation Factors for Predictors of DPP Engagement (Hypothesis 1)

```
> vif(lm(DPP_Engagement ~ Digital_Literacy_c + Environmental_Concern_c +
+          Subjective_Norms_c + Trust_c + Perceived_Usefulness_c +
+          Perceived_Ease_of_Use_c + Information_Overload_c,
+        data = DPPEngagement2))
     Digital_Literacy_c Environmental_Concern_c      Subjective_Norms_c                Trust_c
               1.218694                1.726029                1.547241               1.870245
 Perceived_Usefulness_c Perceived_Ease_of_Use_c  Information_Overload_c
               2.922288                1.918516                1.231563
```

Figure 24. Variance Inflation Factors for Predictors of DPP Engagement (Hypothesis 1)

Note. Own figure.

Moderation Analysis: Interaction Effect on WTP

```
Residuals:
    Min      1Q  Median      3Q     Max
-71.333  -1.966  -1.017   3.503  28.667

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                     1.4443     0.7457   1.937   0.0545 .
WTP3$DPP_Engagement_centered    2.0143     0.8174   2.464   0.0148 *
WTP3$PriceSensitivity_centered -0.1442     0.8696  -0.166   0.8685
WTP3$Interaction               -1.6779     0.6615  -2.537   0.0121 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 9.429 on 163 degrees of freedom
Multiple R-squared:  0.09923,   Adjusted R-squared:  0.08265
F-statistic: 5.985 on 3 and 163 DF,  p-value: 0.0006788
```

Figure 25. Moderation Analysis: Interaction Effect on WTP

Note. Own figure.

Appendix B: Expert Interviews

B.1 Interview Guide

#	Question
Q1.1	Could you briefly describe your role and how it relates to circular economy topics within your organization?
Q1.2	How would you assess the current relevance of circular economy principles for *your organization / the consumer electronics sector*?
Q1.3	To what extent are you or your organization already familiar with the concept of Digital Product Passports?
Q1.4	Are there any specific actions or preparations already being taken within *your organization / the consumer electronics sector* in anticipation of the implementation of Digital Product Passports?
Q1.5	Do you consider Digital Product Passports to be both a driver for circular economy adoption and a strategic tool for *your organization / the consumer electronics sector*?
Q2.1	Do you expect consumers to actively engage with the information provided through Digital Product Passports?
Q2.2	In your opinion, what are the main drivers and barriers to consumer engagement with Digital Product Passports?
Q3.1	How do you think Digital Product Passports will influence consumer purchase behavior, particularly their purchase intention and willingness to pay for circular consumer electronics?
Q3.2	Are there particular consumer segments that you expect to be more responsive to Digital Product Passports?
Q4	In what ways could consumer engagement with Digital Product Passports influence the adoption of circular economy business models in *your organization / the consumer electronics sector*?
Q5.1	What strategic opportunities do you foresee emerging from potential changes in consumer behavior linked to Digital Product Passports?
Q5.2	To what extent do you think early movers in Digital Product Passport implementation can gain a competitive advantage?
Q5.3	Are there already concrete steps or strategic initiatives being pursued in response to anticipated changes in consumer behavior related to Digital Product Passports?
Q5.4	In your view, what internal capabilities or organizational strengths are most important for companies to successfully adapt to or benefit from Digital Product Passports?
Q6	Are there any additional aspects regarding Digital Product Passports and circular economy adoption that you think should not be overlooked, particularly in relation to consumer behavior?

Table 19. Interview Guide

Note. Own table.

B.2 Groups of Expert Interview Partners

The interview partners were assigned to four expert groups to reflect different professional perspectives on DPPs and CE practices.

#	Expert Group	Included Interviewees	Rationale
1	Company Experts from the Consumer Electronics Sector	CE1, CE2, CE3, CE4	Provide firm-level perspectives from organizations involved in the production, refurbishment, and standardization of consumer electronics. Enable insights into the practical implications of DPPs and CE practices from an industry viewpoint.
2	Consultants	CONS1, CONS2	Offer in-depth practical expertise on DPP implementation, circular product strategies, and consumer engagement from a cross-company perspective.
3	Policy Experts	POL1	Represent EU-level policymaking and legislation processes related to DPPs and CE. Provide insights into regulatory expectations and behavioral anticipations.
4	Researchers	R&D1	Contribute academic and interdisciplinary perspectives on CE, DPPs, consumer behavior.

Table 20. Groups of Expert Interview Partners

Note. Own table.

B.3 MAXQDA

Number of Coded Segments per Expert Interview

Figure 26. Number of Coded Segments per Expert Interview (MAXQDA)

Note. Own figure.

Code Matrix of Expert Interviews

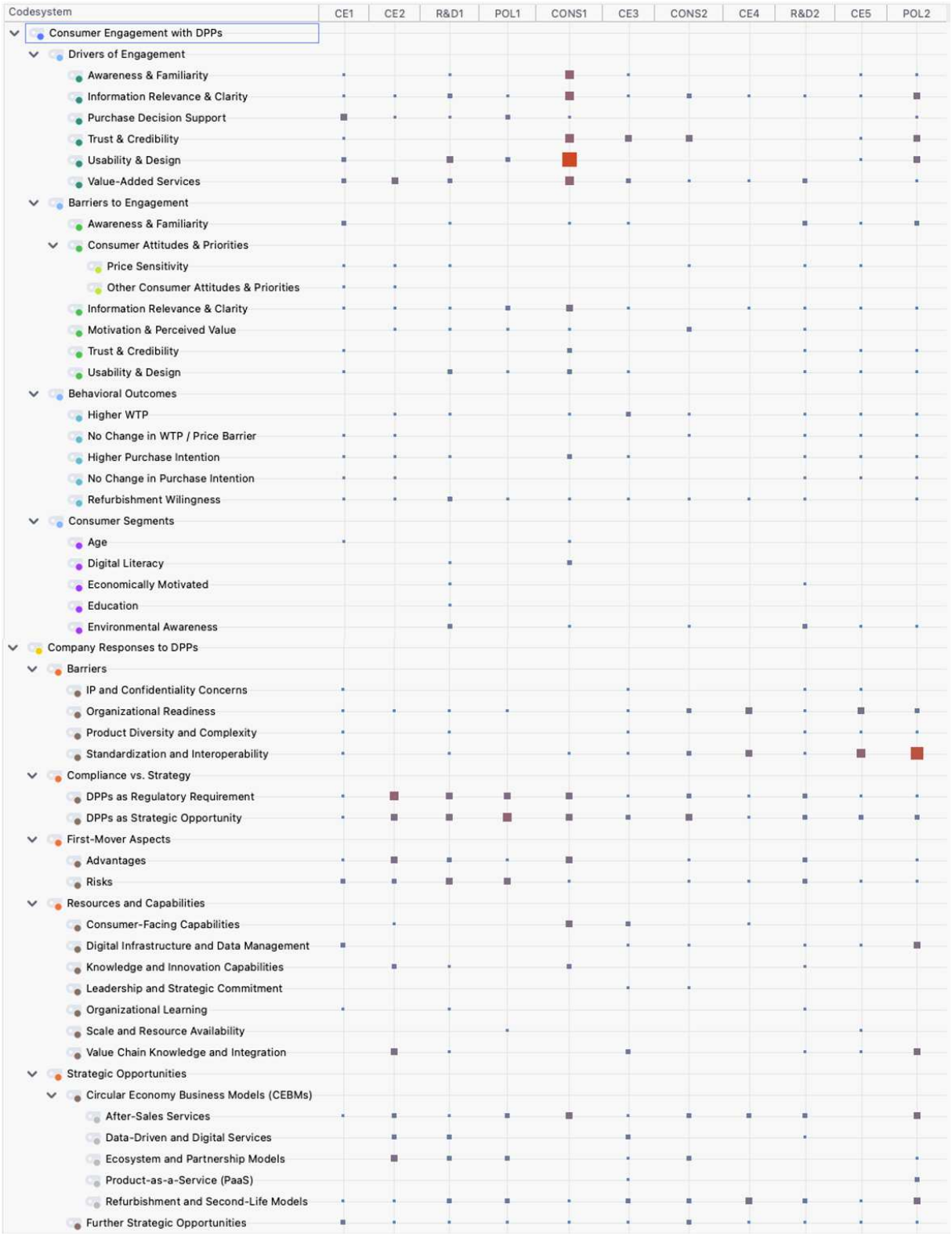


Figure 27. Code Matrix of Expert Interviews (MAXQDA)

Note. Own figure.

B.4 Summary of Interviews

#	ID	Date
1	CE1	12 June 2025

Section 1: Introduction and Context

The interviewee is a senior manager at a global technology company, member of the CIRPASS-2 expert group, and works on preparing systems and services for future DPP use.

Section 2: Anticipated Consumer Engagement with DPPs

He described a "dual use case" in which DPPs serve both compliance and consumer-facing functions, with QR codes linking to product webpages that combine mandatory data and service content. He argued that consumers will only use DPPs if information is actionable: "You need to have something which is actionable, which changes behavior." He emphasized integration into visible decision points such as web shop filters and noted competition with existing eco-labels, which are often underused.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

The interviewee was skeptical about DPPs significantly shaping purchase decisions or WTP, stressing that price and quality dominate consumer choices. He argued sustainability has lost importance under current geopolitical conditions. Still, he observed a generational shift: younger consumers increasingly choose refurbished products as part of lifestyle and identity.

Section 4: Implications for CEBM Adoption

He acknowledged that DPPs could strengthen consumer trust in refurbishment by providing transparency, comparing this to used car markets. Yet he noted challenges of standardization and limited efficiency gains, quoting a refurbisher: "It won't save me a lot of cost because I need to do the intake anyhow."

Section 5: Strategic Responses

Due to regulatory uncertainty, "nobody is going to move until there is a set date." Still, he highlighted potential first-mover advantages: "If companies start now, then they already have everything in place when it becomes mandatory." He saw opportunities for customer loyalty, lower warranty costs, and QR-based consumer touchpoints, but emphasized high investment needs. Regarding CEBMs, he pointed to refurbishment and trust-building, but also to governance and standardization challenges.

Section 6: Open Reflection and Additional Aspects

He doubted that recyclers would scan individual products and stressed governance issues.

#	ID	Date
2	CE2	12 June 2025

Section 1: Introduction and Context

The interviewee is a program manager at a multinational technology company and is involved in projects such as CIRPASS-2. With a background in blockchain traceability and cross-sector interoperability, he shapes his company's strategic approach to DPPs.

Section 2: Anticipated Consumer Engagement with DPPs

He stressed that consumer engagement depends on implementation. Static technical data is unlikely to attract users, while incentives and value-added services could make DPPs relevant. Examples include repair instructions, spare parts ordering, or trade-in functions. Regulation should guarantee transparency, whereas firms can differentiate themselves through additional consumer-facing features.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

He was cautious about large-scale behavioral effects. Environmentally conscious consumers may engage, but most will remain driven by price and convenience. DPPs can only influence purchase choices if firms highlight clear and tangible benefits. Loyalty schemes, repair options, or trade-in programs could make DPPs appealing across different segments, though compliance alone will not shift mainstream behavior.

Section 4: Implications for CEBM Adoption

He sees DPPs as strategic infrastructure for enabling CEBMs. They can help firms connect with secondary users, extend trade-in or service schemes, and introduce performance-based pricing. More broadly, DPPs provide lifecycle data that improves supply chain transparency, supports impact-based innovation, and allows firms to design smart, data-driven models.

Section 5: Strategic Responses

He argued that "the differentiating factor is whatever we do with the DPP in addition to mere compliance." Early movers may gain advantages by testing value-added services, though success depends on resources such as value chain knowledge and consumer-facing capabilities. He mentioned strategic opportunities like regionalized marketing, sustainability rewards, and data-driven services.

Section 6: Open Reflection and Additional Aspects

He noted that EU leadership could globalize DPP adoption, as non-EU firms must comply.

#	ID	Date
3	R&D1	12 June 2025

Section 1: Introduction and Context

The interviewee is a senior researcher at a European institute, leading work on CE and digital transformation. He advices policymakers and industry through projects such as CIRPASS-2, framing DPPs as enablers of sustainable transformation rather than compliance tools.

Section 2: Anticipated Consumer Engagement with DPPs

He emphasized that consumer engagement depends on usability and design. If well implemented, DPPs could support informed choices at purchase, repairability during use, and proper disposal at EoL. Each stage offers potential entry points, but only with intuitive design and relevant content.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

He expects user-friendly DPPs to influence behavior, particularly among sustainability-oriented, educated, and technically curious consumers. Regarding WTP, he highlighted ecological motivation and product quality. Durable or repairable products documented in DPPs could justify higher prices, even for economically motivated buyers.

Section 4: Implications for CEBM Adoption

He noted that DPPs can enable new CEBMs and strengthen existing ones. Refurbishment within the EU was cited as a business model which particularly benefits from DPPs. Consumer demand for battery replaceability or spare parts availability could create a feedback loop, shaping product design and strategy.

Section 5: Strategic Responses

Mandatory consumer-facing data will push firms to benchmark themselves and adapt communication strategies. While he sees limited first-mover advantages on the consumer side, B2B applications such as supply chain transparency are more compelling. Firms with strong digital infrastructure and value chain integration will be best placed to use DPPs strategically. He concluded: “Firms are hesitant to invest heavily before regulation and standardization are clear, as early investments may later turn out to be misaligned or wasted.”

Section 6: Open Reflection and Additional Aspects

He stressed that rollout will be gradual and fragmented, with consumer aspects lagging behind technical progress. In addition, he noted that current debates focus on data standards and technology, while issues of usability and consumer motivation remain underexplored.

#	ID	Date
4	POL1	13 June 2025

Section 1: Introduction and Context

The interviewee chairs a European sustainability working group and represents national industry interests at EU level. With long-standing involvement in CE and Ecodesign debates, she advises firms on upcoming DPP requirements.

Section 2: Anticipated Consumer Engagement with DPPs

She was cautious about short-term consumer engagement, noting that DPPs were initially designed for value chain communication. However, she expects their role to grow as a central vehicle for product information, particularly for high-value products. She warned that the risk of overwhelming consumers is greater than under-informing them and advocated a gradual approach with only relevant information to build habits.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

According to her, DPPs can support informed purchase decisions but will not themselves grade or rank products. While not directly increasing WTP, she highlighted their potential to strengthen refurbishment by verifying product history and authenticity. For consumer-facing comparisons, additional tools or standards would be required.

Section 4: Implications for CEBM Adoption

She emphasized that DPPs could facilitate reverse logistics, dismantling, component reuse, and recycling by embedding structured data, thereby supporting more efficient secondary markets and scaling of CEBMs.

Section 5: Strategic Responses

Strategically, she saw opportunities to reduce administrative burdens while also using DPPs as platforms for consumer communication, branding, and services. She stressed the importance of early engagement with value chain partners to ensure reliable data: “There’s now one market for products and a second market for data.” She remained reluctant to recommend heavy investments before formats are finalized but noted potential for refurbishment and take-back systems. Required capabilities include technical know-how and strong knowledge of one’s products and value chains.

Section 6: Open Reflection and Additional Aspects

She stressed that business models should emphasize longevity, modularity, and service-based value, with DPPs as enablers.

#	ID	Date
5	CONS1	17 June 2025

Section 1: Introduction and Context

The interviewee is a design researcher at a DPP consultancy and sustainability-focused institute, specializing in user-centered design and intuitive digital platforms.

Section 2: Anticipated Consumer Engagement with DPPs

She expressed confidence in long-term engagement but emphasized that success depends on appealing, intuitive design. Current routines are tied to physical documentation, so adoption will take time. Engagement requires smart interfaces and interactive features, as consumers will not revisit DPPs if they resemble user manuals. Trust and digital affinity were seen as drivers, while lack of awareness and familiarity remain barriers. She described adoption as a "learning by doing" process, where repeated interaction builds habits.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

The interviewee believes that well-designed DPPs can increase purchase intention and WTP for circular products through clarity, transparency, and personalization. Younger, digital literate, and sustainability-oriented consumers were identified as most receptive. She stressed that adaptive design is necessary to meet diverse needs, from tutorials for tech-savvy users to service contacts for less digital groups.

Section 4: Implications for CEBM Adoption

She emphasized that DPPs can streamline processes in repair, reuse, and PaaS models, supporting both existing and new CEBMs. As digital interfaces, they reduce friction, enhance transparency, and embed circularity across the customer journey.

Section 5: Strategic Responses

She advised firms to engage with DPPs early to avoid chaotic last-minute compliance. Early involvement enables infrastructure development and exploration of value-added services. DPPs should be integrated into corporate identity to build loyalty and differentiation: "Since companies have to do the work anyway, it is obviously advantageous to derive further added value from DPPs with a minimum of extra work." She also cautioned against defensive design practices that obscure usability, warning of greenwashing risks.

Section 6: Open Reflection and Additional Aspects

While highlighting the risk of overpromising, she concluded that DPPs could re-establish product value and foster long-term engagement.

#	ID	Date
6	CE3	17 June 2025

Section 1: Introduction and Context

The interviewee is a standardization expert, working on international circularity standards for ICT and actively involved in industry discussions on DPPs.

Section 2: Anticipated Consumer Engagement with DPPs

He believes consumers will engage with DPPs if trust, transparency, and traceability are ensured, particularly in second-hand markets. DPPs can reinforce brand reputation and sustainability claims, though awareness and usability remain barriers, especially for less tech-savvy users. He noted that if DPPs are poorly designed, they risk appearing complex and discouraging engagement.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

The interviewee expects DPPs to influence consumer behavior by boosting confidence in refurbished products and motivating environmentally conscious purchases. WTP may rise if DPPs are linked to incentives such as trade-in bonuses or repair discounts. He emphasized that effects will differ across consumer segments, with sustainability-conscious buyers showing greater responsiveness.

Section 4: Implications for CEBM Adoption

DPP-enabled consumer engagement can support PaaS models through lifecycle tracking. Verified information facilitates responsible consumption, disposal, and recovery processes. In addition, DPPs strengthen resale and refurbishment markets by providing verifiable product histories and incentivizing take-back schemes.

Section 5: Strategic Responses

The interviewee stressed that while compliance is a driver, firms should view DPPs strategically. They can differentiate brands, support innovation, and enable new business models such as subscription services. First-mover advantages include building consumer trust and shaping standards, though risks lie in costs and complexity, particularly for SMEs. To fully leverage DPPs, firms require robust data infrastructure, strong leadership commitment, and collaboration across functions and value chains. He sees opportunities for circular strategies through enhanced transparency, consumer incentives, and secondary market development.

Section 6: Open Reflection and Additional Aspects

He highlighted the importance of interoperability and international standard alignment.

#	ID	Date
7	CONS2	18 June 2025

Section 1: Introduction and Context

The interviewee is a principal consultant for CE at a multinational consultancy, advising public institutions and private firms on policy, waste legislation, and circular strategies.

Section 2: Anticipated Consumer Engagement with DPPs

He expects gradual adoption along the innovation curve, with sustainability-conscious consumers as early adopters. Detailed records of manufacturers, refurbishment, and component replacements could enhance trust and utility, though relevance will vary by product type and complexity.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

He was skeptical about broad effects on WTP, arguing that higher costs limit circular products' appeal despite consumer preferences. Only a small segment may respond positively to verified DPP data. Instead, he stressed the systemic function of DPPs: "The final objective of the DPP should be to enable a more data-driven circular economy rather than enhancing the personal choice." Reliable data on product flows and material recovery could inform policies and incentives, ultimately lowering costs and improving competitiveness of circular alternatives.

Section 4: Implications for CEBM Adoption

The interviewee considered refurbishment, remanufacturing, and recycling as particularly relevant for DPPs, which could document repairs and usage, guide material recovery, and improve sorting. However, he was skeptical about usability in low-tech facilities. He argued that technically complex or high-value products would benefit most by unlocking scale.

Section 5: Strategic Responses

He observed that most firms perceive DPPs as a burden, though specialists see potential. He doubted strong first-mover advantages: "I think you need the critical mass of everyone being on it for the benefits to be realized." Still, early movers may gain experience and test approaches. He noted opportunities for differentiation through attributes such as recycled content, improved traceability for reverse logistics, and support for refurbishment if product changes are logged. He emphasized that robust digital infrastructure and leadership commitment are essential for strategic use.

Section 6: Open Reflection and Additional Aspects

He envisions DPPs to evolving into a central tool for evidence-based CE governance.

#	ID	Date
8	CE4	20 June 2025

Section 1: Introduction and Context

The interviewee is a sustainability and policy lead at a European refurbishment company, focusing on CE legislation such as Ecodesign, waste, and Right to Repair.

Section 2: Anticipated Consumer Engagement with DPPs

She was skeptical about DPPs as consumer-facing tools, arguing their content is too technical and better suited for actors in the value chain. While recognizing trust issues in the second-hand market, she noted: "I am not sure if the DPP is the right tool for that." Instead, she suggests simplified formats, such as eco-labels, might resonate more with consumers.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

She did not expect DPPs to influence consumer behavior, since most buyers base refurbishment decisions on price or environmental reasons. To her, building trust depends on warranties, transparency, and marketing rather than technical DPPs.

Section 4: Implications for CEBM Adoption

She considered DPPs potentially valuable for refurbishers to trace device history, repairs, and part origins: "The DPP would actually be an ID card for people in the economic value chain." Still, she doubted sufficient granularity would be achieved for consumer use. She stressed that access to genuine parts and repair manuals is critical, while practices such as serialization and part pairing restrict independent refurbishment.

Section 5: Strategic Responses

The interviewee underlined that refurbishment firms must invest in marketing and education to build trust. She reiterated skepticism toward DPPs as consumer tools but acknowledged their value for industrial processes, calling them "a transparency tool which gives us a lot of information about devices that we absolutely do not have at the moment." However, she warned of challenges in ensuring data granularity and long-term maintenance.

Section 6: Open Reflection and Additional Aspects

She expressed concerns about governance and data rights in DPPs. She also emphasized that long-term maintenance costs and responsibilities remain unclear, which could create uncertainty for smaller market actors. In her view, the ultimate success of DPPs will depend on whether regulators can balance industry needs with practical usability.

#	ID	Date
9	R&D2	24 June 2025

Section 1: Introduction and Context

The interviewee is an academic researcher with consulting experience in CE and digitalization. He has led research and advisory projects and published on the topic. His expertise covers DPP development across sectors, focusing on data and system requirements for CE practices.

Section 2: Anticipated Consumer Engagement with DPPs

He expects consumers to interact with DPPs but stressed usability barriers. The development of separate apps risks fragmentation and inconvenience. Integration into existing services such as digital wallets would be essential. He noted that regulation will be the main driver of consumer use, as market incentives remain limited.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

He anticipated that DPPs could shape consumer choices, but mainly among environmentally conscious segments. For most, price will remain decisive, as sustainable products are often more expensive. He therefore expected only "a small bubble of sustainability-oriented consumers" to engage actively in the near term, unless additional financial or service benefits are offered.

Section 4: Implications for CEBM Adoption

He underlined that DPPs could lower barriers to circular practices by providing transparency on material composition, product history, and usage data (e.g., battery cycles). This could improve recycling and refurbishment and extend product lifetimes. System-level approaches integrating repair, take-back, and recycling into DPPs could reduce lifecycle costs and support new revenue streams.

Section 5: Strategic Responses

He described firm responses as largely compliance-driven, with many waiting for regulatory clarity. Some large firms are piloting. Implementation, he noted, typically requires "a learning process within the company" lasting one to two years, involving IT, supplier coordination, and data digitization. He stressed the need for robust IT systems, value chain collaboration, and ecosystem partnerships. Strategic opportunities could arise from loyalty schemes or bundled services, but require a systemic view that many firms still lack.

Section 6: Open Reflection and Additional Aspects

Looking forward, he stressed that the rollout of DPPs will be gradual and fragmented.

#	ID	Date
10	CE5	4 July 2025

Section 1: Introduction and Context

The interviewee is a senior manager for sustainability policies of a national industry association for consumer electronics, closely linked to European bodies. DPPs are not yet a daily priority but are increasingly relevant for members, particularly in relation to the ESPR.

Section 2: Anticipated Consumer Engagement with DPPs

She described DPPs as an opportunity to unify product information into one channel, replacing fragmented eco-labels. For this to succeed, DPPs must be intuitive, transparent, and self-explanatory. However, she stressed that consumer awareness is decisive. Drawing an analogy to e-waste disposal schemes, she noted that even long-established systems often remain poorly understood, suggesting similar hurdles for DPPs.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

She expects sustainability-minded consumers to benefit most, since they already seek product information. Expanding this group will be difficult, as many consumers remain driven by price. While transparency may influence decisions, she questioned whether consumers will pay more for circular products.

Section 4: Implications for CEBM Adoption

She highlighted potential for models such as leasing, where manufacturers retain ownership and recover components at EoL. DPPs could also improve market oversight by curbing non-compliant imports and supporting reliable sustainability claims.

Section 5: Strategic Responses

Large firms are structurally better placed to implement DPPs, though both large and small firms struggle with detailed supplier data, especially from outside Europe. She warned of risks if firms overload DPPs with non-mandatory information or copy competitor data. Governance must reward serious effort and prevent free-riding. Refurbishment, while practiced, remains marginal and unlikely to become a major profit driver. Strategically, she sees DPPs as tools for compliance, differentiation, and transparency, but stressed outcomes hinge on regulatory clarity and system design.

Section 6: Open Reflection and Additional Aspects

She cautioned that DPPs must replace, not duplicate, existing databases, as parallel reporting would undermine efficiency.

#	ID	Date
11	POL2	4 July 2025

Section 1: Introduction and Context

The interviewee works in policymaking with a focus on digital tools for sustainability and how DPPs can advance CE objectives. He noted that resource extraction drives a large share of emissions and argued that DPPs could provide the information needed for CEBMs.

Section 2: Anticipated Consumer Engagement with DPPs

He described DPPs as going beyond energy labels, which cannot capture detailed product data such as battery health. Adoption, however, depends on simplification: most consumers only use basic scales, while deeper data remain unused.

Section 3: Anticipated Impact on Consumer Behavior and Segmentation

He noted that consumers often state a higher WTP for sustainable products but warned of a gap between intentions and purchases. He expected DPPs to influence decisions when durability, efficiency, or repairability are clear, though trust will take time to establish, similar to energy labels.

Section 4: Implications for CEBM Adoption

He emphasized that DPPs could support PaaS, reuse, refurbishment, and recycling. Verified data could reduce uncertainty in second-hand markets and strengthen leasing models, while recyclers may later benefit from improved sorting. Still, he warned that data transfer has costs and stressed that credibility depends on accuracy and verifiability.

Section 5: Strategic Responses

He described firm responses as mixed: digitalized firms are piloting, while many other firms wait. Larger firms can demand supplier data, while smaller ones struggle. He underlined: “The question of what position the respective companies have in their value chain and whether they receive the information they need is very relevant.” On early movers, he added: “Once the regulation has been published, companies usually have a transition period of 1.5 to 2 yeas before the regulation takes effect.” He saw benefits in early learning but stressed alignment with strategy.

Section 6: Open Reflection and Additional Aspects

He noted that DPPs should consolidate fragmented systems, but governance based on manufacturer declarations requires strong oversight.

AI Usage Acknowledgement

AI-based tools were used at specific stages of this master's thesis to assist with selected tasks, while ensuring transparency and academic integrity throughout the process.

- **Literature Search:** AI was employed to support the exploratory keyword search to identify potentially relevant academic sources. All cited literature was independently retrieved, reviewed, and verified by the author.
- **Language Support:** AI tools were used to enhance the clarity, grammar, and consistency of the written English. All conceptual content, arguments, and the overall structure were developed independently by the author.
- **Summarization of Expert Interview Transcripts:** AI was used to support the summarization of expert interview transcripts included in the appendix. All summaries were carefully reviewed and revised to ensure accuracy and faithful representation.

At no point did AI tools replace critical analysis, conceptual development, or methodological decision-making. The author remains fully responsible for the academic content, interpretations, and conclusions presented in this work. Potential limitations of AI tools – such as factual inaccuracies, bias, or knowledge gaps – were carefully considered and mitigated.