

The Digital Product Passport (DPP) for the Circular Economy: Recommendations for policy, business and IT Version 1.2 May 2024



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Abstract	The objective of this study is to identify drivers, barriers, opportunities, challenges, and actionable recommendations for the successful implementation and delivery of Digital Product Passports (DPPs) within the scope of the ESPR. This report details 10 drivers, 28 barriers, 32 opportunities, and 30 challenges, and offers 67 recommendations for policymakers, businesses, IT firms, and IT service providers.					
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24	Textile Exchange	TextileExchange	US					
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Preparing the ground for the gradual piloting and deployment of DPPs from 2023 onwards, focusing on developing a roadmap for prototypes in three value chains: electronics, batteries and textiles.

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	List of Abbreviations and Acronyms
BIM	Building Information Modelling
CE	Circular Economy
CIRPASS	Collaborative Initiative for a Standards-based Digital Product Passport for Stakeholder- Specific Sharing of Product Data for a Circular Economy
CSR	Corporate Social Responsibility
CSRD	Corporate Sustainability Reporting Directive
DBOC	Drivers, Barriers, Opportunities, and Challenges
DPCCE	Digital Product Conformity Certificate Exchange
DPP	Digital Product Passport
EPR	Extended Producer Responsibility
ESG	Environmental, Social, and Governance
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
GPP	Green Public Procurement
IP	Intellectual Property
IT	Information Technology
NFC	Near Field Communication
NGO	Non-Governmental Organisation
PESTEL	Political, Economic, Sociocultural, Technological, Environmental, and Legal
OEM	Original Equipment Manufacturer
QR	Quick Response
REACH	Registration, Evaluation, Authorisation, and Restriction of Chemicals
RFID	Radio Frequency Identification
SCIP	Substances of Concern In articles as such or in complex objects (Products)
SME	Small and Medium-sized Enterprise
SPARQL	SPARQL Protocol and RDF Query Language
WEEE	Waste from Electrical and Electronic Equipment



1. Executive Summary

1.1. Objectives

The main objective of this report is to **identify actionable recommendations for the successful implementation of the Digital Product Passport (DPP)** in the European Union – within the scope of the Eco-design for Sustainable Products Regulation (ESPR). Core interests include the impact of the DPP in advancing sustainability and the circular economy (CE), as well as facilitating regulatory compliance. We begin by understanding the current landscape by identifying the drivers and barriers that support or hinder the implementation of DPPs. We then focus on emerging opportunities and challenges from the future use and application of the DPP. Furthermore, we provide tailored recommendations to pave the way for widespread DPP adoption across different stakeholder groups while considering the drivers, barriers, opportunities, and challenges identified. Policymakers receive recommendations regarding further regulatory necessities for the implementation and operation of the DPP and its underlying systems. Businesses, information technology (IT) firms, and IT service providers receive recommendations on implementation, functionalities, future development, collaboration, technologies, business models, and other relevant topics related to the DPP.

1.2. Drivers, Barriers, Opportunities, and Challenges

1.2.1. Method

Identifying and ranking drivers, barriers, opportunities, and challenges (DBOCs) involved desk research of literature and results from other CIRPASS activities, as well as empirical work in the form of workshops and a survey. To guide the empirical work, we selected categories for analysing the DBOCs based on an extended PESTEL framework. This framework typically covers political, economic, sociocultural, technological, environmental, and legal aspects. However, we adapted it to include two categories relevant to operationalising the circular economy: 'knowledge and education' and 'value chain and physical infrastructure'. The resulting framework comprised seven categories. To identify relevant DBOCs, we conducted online workshops with experts from the CIRPASS consortium, where DBOCs were identified, aggregated, and categorised. Finally, we conducted an extensive survey with registered CIRPASS stakeholders to assess the perceived relevance of each DBOC to the implementation and delivery of DPPs and their awareness among stakeholders.

1.2.2. Key Findings

100 DBOCs – **10** drivers, **28** barriers, **32** opportunities, and **30** challenges – were identified and assessed during this study. Participants perceived most of the identified DBOCs as highly relevant to the implementation and delivery of DPPs. However, the perceived awareness among stakeholders is lower than their relevance, indicating a need for increased communication, education, and information efforts. Overall, the DBOCs encompass a wide variety of topics, such as education and training, circular strategies, standards, international supply and value chain, policy and regulation, business models, and ecosystems, among others. This variety provides valuable insights for different actors and stakeholders in a circular ecosystem.





Drivers: The relatively low number of drivers compared to barriers suggests two main aspects influencing the development of DPPs. First, evolving market expectations for sustainable and circular products/services. Second, the importance of regulatory changes enforcing DPP development. We suggest that these themes are mutually reinforcing; as the DPP system matures due to regulation, market expectations and economic incentives could further drive DPP introduction.

Barriers: The identified barriers reflect the low maturity of the field and perceived uncertainties among stakeholders due to the emerging nature of the DPP. In particular, they underscore 1) knowledge and resource constraints, 2) market and cultural dynamics, and 3) complexities in value chains, the IT architecture and the regulatory framework. Overall, communication, education, and information efforts, combined with reliable standards and regulatory clarity, will be crucial for introducing DPPs into the market.

Opportunities: Stakeholders perceive multiple chances the DPP provides for the circular economy, sustainability, and regulatory compliance. Moreover, they highlight potential business advantages related to data and technology integration while also underscoring chances for compliance and governance. Our findings support the hypothesis that the DPP is an important vehicle for enhancing and strengthening the European twin green and digital transition.

Challenges: They provide insight into the difficulties that stakeholders expect when rolling out the DPP in the coming years. First, they portray concerns about data quality and management when collaborating with and relying on external actors. Second, they address the need for regulatory and standards alignment. Finally, they highlight the difficulties in creating a sound environment for DPP development. Overall, creating and enforcing clear rules and standards, along with a transparent and interoperable system, will be essential to instil trust in the *DPP system* (i.e., the IT standards and protocols needed to make DPPs work) and ensure the success of the DPP.

1.3. Recommendations

1.3.1. Method

The recommendations were identified following a three-stage Delphi study with experts from the CIRPASS consortium and registered stakeholders. This study aimed to seek consensus on 1) the content of the recommendations, 2) the perceived contribution of the DPP to the circular economy, and 3) the priority level for policymakers of the respective recommendations. In the first round, we collected recommendations for policymakers, businesses, and IT firms through open-ended questions. In the second round, we sought consensus on the content of an initial set of 62 recommendations obtained from the first round. Participants were asked to rate their agreement on a five-point Likert scale. In the final round, we sought consensus on the content, the perceived contribution of the DPP to the circular economy, and the priority level for policymakers of a final list of 67 recommendations. Additional recommendations were generated after analysing the feedback from the second round. The recommendations were categorised based on the Better Regulation Toolbox of the European Commission.





1.3.2. Key Findings

During this study, **67 recommendations** for policymakers, businesses, IT firms and IT service providers were identified, assessed and validated. Overall, our results suggest that the recommendations in this report can help drive the successful introduction of the DPP.

Firstly, significant alignment exists among the topics identified in the DBOC and the Delphi studies. Likewise, the consensus data of the Delphi study showed uniformity, suggesting a general consensus on the relative importance of the topics identified and assessed.

Secondly, there was high participation from stakeholders in the IT and manufacturing industries, highlighting low awareness and knowledge about DPPs among other stakeholders such as consumers, circular economy operators, and civil society actors. These findings underscore again the need for communication, education, and information efforts.

Thirdly, the recommendations span a wide variety of topics, yet some overarching themes are evident for the implementation and delivery of DPPs. Recommendations are clustered in the following categories:

- Economic instruments: Key themes include funding for research, innovation, open-source solutions, and small and medium enterprises (SMEs), as well as increasing penalties for misuse.
- Education and information instruments: Focal points relate to supporting training, education, and information campaigns, as well as creating guidelines with best practices. Supporting collaboration mechanisms between private and public organisations is also relevant.
- Legally binding policy instruments: They should emphasise policy coherence, standards and data exchange alignment, and security measures. This ensures interoperability across sectors and instils trust in the DPP system. Clearly defining a timeline, specifying data requirements for the DPP, and outlining policy changes are also needed.
- **Soft policy instruments:** Policymakers could promote investments and collaboration among stakeholders, standardise data quality assurance, and drive DPP adoption through green public procurement.
- General recommendations for policymakers: Transparency, sustainability, and circularity should remain central during the development of DPPs. Moreover, policymakers should prioritise practical applications for the DPP and stakeholder engagement for policy improvements. Measuring circular flows, using DPP data for reporting, standardising business terminology, and ensuring knowledge building are also relevant.
- **Recommendations for businesses:** Firms should deploy pilot projects, engage with stakeholders to map their requirements, and prepare for the implementation of DPPs. Moreover, protecting customer data is key to generating trust in the DPP. Finally, firms should adapt their strategy and business practices towards sustainability.
- **Recommendations for IT firms:** These firms should build know-how and launch pilot projects to explore the potential of the DPP. They could also focus on collaborating with users to design user-friendly and secure applications. Finally, using open-source solutions and avoiding vendor lock-in is crucial to ensure the interoperability of the DPP system.





Overall, policymakers should prioritise circularity, sustainability, and transparency when designing policy to maintain the focus of the DPP as an enabler of the circular economy. They should ensure the building of knowledge, alignment and participation of stakeholders, as well as a level playing field, with a particular focus on SMEs. Funding for implementation and research should also be considered. Businesses and IT firms should prioritise launching pilot projects and collaborating with stakeholders along the value chain to prepare for the deployment of DPPs.

1.4. Further work

Due to the early stage of development of the DPP, further research and implementation work are required to reach maturity. Below, we summarise key observations to align expectations and develop DPPs in the EU:

- Internationalisation and collaboration: DPPs receive high interest beyond European Union (EU) borders, suggesting the need for further international collaboration. Efforts should focus on making DPPs interoperable globally and aligning international standards.
- Integration of emerging technologies: Future research projects and implementation work should consider investments in newer technologies such as distributed ledgers, the Internet of Things, and Artificial Intelligence to enhance the functionality of the DPP.
- **Data availability and quality assurance:** DPPs should ensure the availability of all data relevant to the circular economy. This would improve the quality of the information and streamline paperwork.
- **Transparency and education:** Given the novelty of DPPs and tight regulatory timelines, communication about current developments is crucial. Educational and informational campaigns are needed to create awareness about regulatory changes and implementation practices.
- Addressing Controversies: Although most recommendations achieved consensus, certain aspects of the DPP implementation are still controversial and require further study, discussion, and understanding.
- Industry Alignment and Evolution: Despite minor differences across industries, perspectives on DPPs remain aligned due to the early phase of the DPP introduction. However, this may change as DPPs mature, industry-specific policy is introduced, and experiences with implementation are reported. Regular research on DPPs is recommended as the DPP progresses.



...



2. Introduction



Figure 1: Overview of the content of this report¹

Introducing Digital Product Passports into the European Union is an important step towards advancing digital capabilities and ensuring the circular economy readiness of the EU's economy. DPPs aim at simplifying digital access to product information to facilitate the operationalisation of the circular economy, circular and sustainable business models, as well as legal compliance². Among other benefits, DPPs shall contribute to reducing administrative costs, streamline data management, enable novel ecosystem architectures, optimise product flows, mitigate supply chain risks, improve sustainable and circular product design, allow for new revenue streams, and ensure a competitive advantage³.

DPPs are embedded into a plethora of upcoming legislative work and processes within the EU⁴, with the Ecodesign for Sustainable Products Regulation⁵ and the Battery Regulation⁶ at the forefront. While the Battery Regulation came into effect first, the ESPR is expected to lay out the basic rules of play for DPPs across most industries and as a reference for following regulations and directives. However, given these ambitions, the development of the DPP comes with a degree of uncertainty regarding its effects and requirements. Identifying potential drivers and barriers to DPP adoption and rollout while making ensuing opportunities and challenges transparent can support policymakers in managing the legislative and regulatory processes. Additionally, it may assist businesses, IT firms, and IT service providers who will introduce DPPs for their products and clients. These stakeholder groups may also require advice on the implementation process based on research and the insights of experts from various backgrounds.

⁶ Regulation (EU) 2023/1542 of 12 July 2023 concerning batteries and waste batteries.



¹ The goals of DPPs are based on the CIRPASS call for proposals (DIGITAL-2021-TRUST-01).

² See Galatola 2024.

³ See King et al. 2023.

⁴ See Galatola 2024.

⁵ At the point of publishing this report in spring 2024, the ESPR has been approved by the European Parliament and is expected to come into full effect in summer 2024.



This report strives to provide the aforementioned insights (Figure 1). Hence, it identifies the drivers and barriers that support or hinder the introduction of DPPs and lays out the opportunities and challenges likely to emerge from the large-scale use and application of DPPs. These drivers, barriers, opportunities, and challenges were identified based on a literature analysis, online workshops with CIRPASS partners, and a survey among registered CIRPASS stakeholders.

Recommendations are provided for three distinct target groups: 1) policymakers, 2) businesses, and 3) IT firms and IT service providers (in the following simply referred to as "IT firms"). They were derived from the literature, the results of other CIRPASS activities, and a three-stage Delphi Study involving CIRPASS partners and registered CIRPASS stakeholders.

Specificities of CIRPASS's target sectors – batteries, electronics, and textiles – are pointed out where possible. However, due to the early phase of both DPPs and the DPP system⁷, and the still ongoing development of regulations, few sector-specific characteristics were identified. Even within workshops focusing on just one industry with sector-specific experts, minimal variance between sector DBOC and recommendations was found. Therefore, DBOCs and recommendations elicited in this report are to be seen as overarching and relevant for all target sectors.

The findings, and especially the recommendations offered here, complement the recommendations provided in other CIRPASS reports. Since we analyse and collect recommendations on all aspects of the DPP, the results are extensive and diverse enough that each set of aspects of the DPP deserves its own report and, therefore, its own set of recommendations – e.g., referring to technology, standardisation, and data. Thus, the reader is encouraged to consider the recommendations and roadmaps proposed in other CIRPASS reports.

This report is structured as follows: We first present relevant concepts used in this report. Then, we present the analysis of the current DBOCs, starting with this study's distinct goals and methods. Based on this, the identified drivers, barriers, opportunities, and challenges of DPPs and their introduction to the European Union's economy are shown. The second part contains the study on recommendations for the aforementioned target groups. We start by laying out the objectives and methods for this study and then present our findings. The report closes with an overall discussion of the results and an outlook towards further work required in this nascent field.

⁷ The DPP-system is the set of IT standards and protocols that will be needed to make the DPPs work. <u>https://cirpassproject.eu/faq/</u>.





3. DPPs for the Circular Economy

The circular economy is one of the most important approaches to advance sustainability and replace our "make-take-waste" system of production and consumption. The vision of the circular economy implies a restorative system that rebuilds natural capital and recovers products and materials for further use⁸. In a CE, products and components shall be kept in closed biological and technical loops⁹ at their highest value and utility over multiple lifetimes¹⁰. Relevant activities for products that circulate throughout technical loops include lifetime extension strategies such as maintenance, repair, reuse, refurbishment, and remanufacturing, and product lifetime closing strategies, that is, recycling¹¹.

Despite the CE's potential economic and environmental benefits, firms face multiple barriers to adopting new circular business models, innovating their processes and activities, and adopting circular design practices. Firms are embedded in a network and enabling closed loops with ecosystem partners, pursuing common goals, and sharing information implies higher collaboration efforts¹². A critical hindrance to collaboration is the information gap in the value chain. Firms typically lack detailed information about the products in the ecosystem, such as their condition, location, or composition¹³.

DPPs and digital technologies, such as the Internet of Things or artificial intelligence, could help firms bridge the information gap that prevents an efficient adoption of the circular economy¹⁴. They can be seen as the glue that brings together actors of a circular ecosystem¹⁵. DPPs are envisioned to be the central point of information for the circular economy. According to current and emerging European regulations, they shall deliver information about original product attributes and a product's life cycle. Examples include product composition, product environmental footprint, repair or disassembly instructions, and end-of-life handling, among others.

Against this background, DPPs and digital technologies could dissolve the barriers that prevent ecosystem-wide collaboration and circular product flows in terms of information gaps. Combined with sustainability and circularity goals enforced by policy, they could be a crucial building block of a smart circular economy¹⁶, as they collect and manage product data across multiple economic actors and processes. In addition, they could enable circular business models¹⁷ and alternative ways of value creation based on data, such as product rentals, leasing, pay-per-use, or contracts based on performance¹⁸.

¹² See Hansen and Schmitt 2020.

¹⁸ See Alcayaga et al. 2019.



⁸ See Morseletto 2020.

⁹ See Ellen MacArthur Foundation 2013.

¹⁰ See Stahel 2019.

¹¹ See Stahel 1991.

¹³ See Wilts and Berg 2017.

¹⁴ See Alcayaga and Hansen 2022.

¹⁵ See Circular Economy Initiative Deutschland 2021a.

¹⁶ See Kristoffersen et al. 2020.

¹⁷ See Lüdeke-Freund et al. 2019.



4. Drivers, Barriers, Opportunities, and Challenges for the deployment of DPPs

4.1. DBOCs: Objective

The objective of this first study is to **identify drivers**, **barriers**, **opportunities**, **and challenges to the implementation and delivery of Digital Product Passports**, both in general and specific to the value chains of batteries, electronics, and textiles. Below, we describe the key terms of this section. The main difference between them relies on their temporal dimension. Both drivers and barriers refer to current dynamics, while opportunities and challenges refer to future situations that may or may not emerge during the implementation of DPPs.

- **Drivers:** These are the forces or catalysts that guide progress towards a goal or achievement of a desired outcome¹⁹. Drivers include the current dynamics that support the implementation and delivery of DPPs.
- **Barriers:** These are impediments or obstacles that impede progress towards a goal or achievement of a desired outcome²⁰. Barriers involve the current dynamics that hinder the implementation of DPPs.
- **Opportunities:** These are situations or occasions that offer a chance to undertake a specific action²¹. Opportunities involve favourable circumstances that may arise during the implementation of DPPs.
- **Challenges:** These are situations or occasions that require considerable effort, skill, and determination to undertake a specific action²². Challenges involve potential dangers that may emerge during the implementation of DPPs.

4.2. Method: Mixed-Methods approach

The foundation of this study rests upon a literature analysis, the work already performed in other CIRPASS activities, and a series of four online expert workshops conducted over two months with CIRPASS partners. These workshops were instrumental in kickstarting the process of identifying and understanding the DBOCs associated with the implementation and delivery of DPPs. Finally, we conducted a survey with registered CIRPASS stakeholders to evaluate the perceived relevance of the identified DBOCs to the implementation and delivery of DPPs and the awareness of key stakeholders.

²² Based on <u>https://www.collinsdictionary.com/dictionary/english/challenge</u>, <u>https://www.merriam-webster.com/dictionary/challenge</u>.



 $\bullet \bullet \bullet$

¹⁹ Based on <u>https://www.collinsdictionary.com/dictionary/english/catalyst</u>,

https://www.collinsdictionary.com/dictionary/english/drive, https://www.merriam-webster.com/dictionary/drive. ²⁰ Based on <u>https://www.collinsdictionary.com/dictionary/english/barrier</u>, <u>https://www.merriam-webster.com/dictionary/barrier</u>.

²¹ Based on <u>https://www.collinsdictionary.com/dictionary/english/opportunity</u>, <u>https://www.merriam-webster.com/dictionary/opportunity</u>.



4.2.1. Extended PESTEL framework

A comprehensive view of DBOCs should include and identify several macro-environmental factors that impact firms and industries. One approach that encompasses several dimensions is the PESTEL framework²³. Initially developed as an environmental scanning tool to assist top management in planning future courses of action²⁴, the framework has been expanded to include the following dimensions: Political (P), Economic (E), Sociocultural (S), Technological (T), Environmental (E), and Legal (L).

However, there are specific dimensions that are relevant for the operationalisation of the circular economy as suggested by current literature²⁵. Therefore, we adapted the PESTEL framework to address the latest insights from research and included two additional dimensions: 'Knowledge and education' and 'Value chain and physical infrastructure'. Regarding the former, as both DPPs and the circular economy are new topics, education or training to raise awareness and develop skills are fundamental. Regarding the latter, in order to accelerate the introduction of DPPs and the operationalisation of the circular economy, it is crucial to expand and develop the physical infrastructure that supports product collection, take-back, and sorting for continued use, reuse, and recycling. The following dimensions were used during the analysis of DBOCs:

- 1. Regulatory and institutional (PESTEL: Political and Legal)
- 2. Economic and market (PESTEL: Economic)
- 3. Social and cultural (PESTEL: Sociocultural)
- 4. Technological and technical infrastructure (PESTEL: Technological)
- 5. Environmental (PESTEL: Environmental)
- 6. Knowledge and education (insights from circular economy literature)
- 7. Value chain and physical infrastructure (insights from circular economy literature)

4.2.2. DBOC Online expert workshops

We conducted four online workshops with CIRPASS partners between May and June 2023. Each was held in a two-day format and concentrated on one of the four relevant domains (or sectors) of the CIRPASS project – cross-sectoral, batteries, electronics, and textiles. Held first, the cross-sectoral workshop provided a general introduction to the workshop series and allowed the identification of overarching DBOCs. Then, three workshops were conducted, each focusing on a specific industry (batteries, electronics, and textiles). All workshops were held online using a virtual board with digital post-its and a video conference tool. They included the following steps:

- Day 1:
 - A presentation of key insights from the literature for the corresponding domain or sector.

²⁵ Based on Aguilar 1967, Circular Economy Initiative Deutschland 2021b, Kirchher et al. 2018, Tura et al. 2019, Vermunt et al. 2019.



²³ See Gillespie 2007.

²⁴ See Aguilar 1967.



- Questions and issues were tackled in the context of the dimensions: Economic and market, Technological and technical infrastructure, Value chain and physical infrastructure.
- Individual work by the participants to identify key DBOCs and assign them to a specific dimension.
- A guided discussion to explain and enrich the identified DBOCs and cluster them.
- Day 2:
 - Questions and issues were tackled in the context of the dimensions: Regulatory and institutional, Social and cultural, Environmental, Knowledge and education.
 - \circ Individual work and a guided discussion (same as day 1).
 - The remaining open issues and unclear aspects were gathered and discussed.

4.2.3. DBOC Survey design

After aggregating and categorising the DBOCs identified during the workshops, a survey with the aggregated DBOCs was conducted to evaluate their relevance and awareness. The survey was sent to 793 registered CIRPASS stakeholders and was conducted in November and December 2023.

Before starting the survey, participants were directed to the introductory page of the respective survey. They were informed about the study objective and context. Informed consent was also obtained from all participants before the survey started by informing them that their data was treated according to GDPR and the CIRPASS privacy policy. In accordance with common standards of research ethics, participation in the survey was voluntary; that is, there were no mandatory content-related questions, allowing participants to answer questions on a voluntary basis and withdraw at any time.

Further, participants were asked three mandatory questions to gather statistical information about participation based on categories defined by the CIRPASS project. These categories were the stakeholder group, the industry they belong to, and the country of their operations.

The study consisted of four main parts, one for each DBOC. For each of the aggregated DBOC statements, participants were asked to rate their relevance and awareness on a five-point Likert scale ranging from 0 = "strongly disagree" to 4 = "strongly agree" (see Figure 2 for an example). Specifically, participants were asked:

• How relevant is each DBOC to the implementation and delivery of DPPs?

0

0

• How aware are key stakeholders (policymakers, businesses, IT service providers, and other social actors such as research organisations and citizens) about each DBOC?

D1 Ne cre	D1 - Regulatory push and pull effects: New and upcoming regulations around sustainability, such as the ESPR and delegated acts, require the development and implementation of DPPs, creating a regulatory push for eco-innovations.								
		Strongly agree	Agree	Neutral	Disagree	Strongly disagree			
	D1 is very relevant	0	0	0	0	0			

0

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Figure 2: Exemplary driver statement with a scale to measure the perceived relevance and awareness.

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Stakeholders are aware of D1



4.3. Demographic results of the DBOC study

4.3.1. DBOC: Online expert workshops

Although we conducted four workshops for each distinct domain or sector (cross-sectoral DPPs / DPP system, batteries, electronics, and textiles), the results have been integrated into general statements, as no significant deviations could be identified between the different domains. We suggest that this is caused by the early stage of sector-specific development with no ESPR delegated acts published and the Battery Regulation not being formally adopted at the time of the workshops. Notwithstanding this, the results of the specific domains or sectors have been addressed and used as examples in the DBOCs presented below. In total, the workshop process resulted in 702 statements. These were aggregated and clustered into 100 DBOC statements divided as follows:

- 10 drivers,
- 28 barriers,
- 32 opportunities, and
- 30 challenges.

In Table 1 below, we summarise the information about the number of participants, the duration of the workshop in minutes, and the total number of individual statements of each workshop.

 Workshop 1:
 Workshop 2:
 Workshop 3:
 Workshop 4:
 Total

	Workshop 1: Cross- Sectoral DPPs / DPP System	Workshop 2: Batteries	Workshop 3: Electronics	Workshop 4: Textiles	Total
Individual participants	43	32	34	37	59*
Duration (min)	161	166	147	180	654
Individual statements	288	145	99	170	702

*Total of individual participants (some experts participated in several workshops)

Table 1: DBOC online expert workshops

4.3.2. DBOC: Survey participants

In total, 128 responses (out of the 793 contacted stakeholders) were received from the survey on the relevance and awareness of the DBOCs. As seen in Figure 3, stakeholders with activities in 16 EU countries participated. Germany was the country with the most participation, with 29 participants. In addition, a significant proportion had global operations (17) and operations in non-EU European countries (13). These three stakeholder groups represent together 46% of the total participants.







Figure 3: Participants by location of firm's activities (DBOC survey)

As seen in Figure 4, a wide range of stakeholder groups are among the participants. The three top participant groups account for almost 50% of the participants and have a high level of representation in the survey: technical solution providers (24%), manufacturers (16%), and research institutes (9%). However, the stakeholder groups that participated in the study are not a representative sample of all the economic actors potentially affected by the introduction of DPPs.





Figure 4: Participants by stakeholder group (DBOC survey)

With regard to industry participation, IT & digital and textiles account for 51% of the respondents. Although batteries and electronics are relevant sectors for the CIRPASS project, the participation of these stakeholders was low, at 2% and 12%, respectively (Figure 5).



Figure 5: Participants by sector representation (DBOC survey)



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4.4. Integrated results of the DBOC study

4.4.1. Drivers

10 drivers were identified in the online expert workshops. For enhanced readability, the drivers below are numbered and ranked according to their perceived **relevance** to the implementation and delivery of DPPs. This ranking is determined by the stakeholders participating in the survey, with D1 being the driver with the highest ranking and D10 the one with the lowest ranking²⁶:

- D1 Regulatory push and pull effects
- D2 A growing market for circular and sustainable products
- D3 Rising consumer expectations on transparency
- D4 Existing regulatory incentives for sustainability
- D5 Increased awareness about social and environmental problems
- D6 Informed decisions based on comparisons
- D7 Expectations of cost savings and economic gains
- D8 Increasing pressure on governments due to resource scarcity
- D9 High demand for user data
- D10 Existing infrastructure, IT solutions and processes

The survey results show that drivers relating to regulation and market expectations were rated particularly high in terms of their relevance. For instance, many stakeholders rate 'Increased awareness about social and environmental problems' (D5) as an important driver.

Figures 6 and 7 display the drivers sorted by relevance and awareness, respectively. The bars for each driver show the distribution of the answers from strongly disagree to strongly agree. The means and standard deviation are listed on the right side of the chart.

²⁶ The statement numbers of the drivers were slightly different in the questionnaire.





Figure 6: Drivers' relevance (DBOC survey)









The drivers identified could be grouped into five of the seven categories used in this report: regulatory and institutional, economic and market, social and cultural, technological and technical infrastructure, and knowledge and education. Within each category, the drivers are sorted according to the relevance determined in the survey. They are provided below in Table 2:

D#	Explanation	Relevance (Mean; Standard	Awareness (Mean; Standard
		deviation)	deviation)
Reg	ulatory and Institutional		
D1	Regulatory push and pull effects: New and upcoming regulations around	3.43; 0.78	2.65; 0.98
	sustainability, such as the ESPR and delegated acts, require the		
	development and implementation of DPPs, creating a regulatory push for		
	eco-innovations.		
D4	Existing regulatory incentives for sustainability: Existing taxation and	3.20; 0.92	2.33; 1.04
	regulation schemes that target sustainability goals, e.g., the right to		
	repair, can leverage the data stored on DPPs, thereby enhancing their		
	adoption.		
D8	Increasing pressure on governments due to resource scarcity: Global	2.94; 0.84	2.34; 0.92
	supply chains for resources such as rare earth metals have become less		
	reliable. Businesses are increasingly interested in legislative solutions		
	such as the DPP to secure resource flows through improved recycling and		
	other circular strategies.		
Ecor	iomic and Market		
D2	A growing market for circular and sustainable products: An emerging	3.38; 0.84	2.48; 0.95
	market for circular and sustainable products, driven by consumer demand		
	and EU regulations, is increasing the interest in DPPs. Second-hand		
	markets, buy-back and trade-in schemes are becoming more accepted.		
	The scarcity of virgin materials and increased profitability of recycling		
	further promote DPPs.		
D7	Expectations of cost savings and economic gains: Firms expect improved	2.94; 1.06	1.96; 1.02
	transparency, traceability, and resource and product flows by using DPPs,		
	leading to increased efficiency, cost savings, new revenue streams, higher		
	technology usage, and higher customer demand.		
D9	High demand for user data: Firms and e-commerce platforms have a	2.88; 1.26	2.39; 1.09
	growing interest in customer and product data. DPPs can be helpful in		
	collecting this information.		
Soci	al and Cultural		
D3	Rising consumer expectations on transparency: An increasing number of	3.24; 0.82	2.58; 1.01
	consumers expect access to the product's sustainability information when		
	making purchasing decisions. The availability of this information could		
	contribute to the acceptance and widespread use of DPPs among the		
	general public.		





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D6	Informed decisions based on comparisons: For an increasing number of consumers, a product's sustainability significantly influences their purchasing decisions. DPPs could allow for a better assessment of the environmental impact and resource consumption of products, enabling informed decisions based on robust data. For example, the transparency created by DPPs allows comparisons between similar products of different producers.	2.97; 1.06	2.43; 1.06
Tech	nological and Technical Infrastructure		
D10	Existing infrastructure, IT solutions and processes: In several industries, there are already foundations upon which the circular economy and DPPs can be built. Many products and components are serialised and have digital labels to track them in the value chain. DPP proofs of concepts have been implemented on a smaller scale. There is a high standardisation of parts and processes. Finally, many IT solutions exist that track and store product data.	2.86; 1.00	2.23; 1.00
Knov	wledge and Education		
D5	Increased awareness about social and environmental problems: There is growing awareness about child labour issues related to the mining of rare metals, human rights violations in supply chains, and the impacts of waste on the environment and human health. Both the general public and businesses acknowledge the need for solutions such as the DPP to support the transition towards a circular economy.	3.17; 0.91	2.56; 0.91

Table 2: Drivers detailed view

4.4.2. Barriers

28 barriers were identified in the online expert workshops. For enhanced readability, the barriers below are numbered and ranked according to their perceived **relevance** to the implementation and delivery of DPPs. This ranking is determined by the stakeholders participating in the survey, with B1 being the barrier with the highest ranking and B28 the one with the lowest ranking²⁷:

- B1 Lack of awareness about current developments among firms
- B2 Lack of expertise and proficiency
- B3 Complexity of the value chain
- B4 Missing data from international actors outside the EU
- B5 Lack of standards
- B6 Higher costs and limited financial resources
- B7 Navigating in a complex regulatory framework
- B8 Unclear financial benefits
- B9 Lack of willingness to provide product data
- B10 Loss of traceability during the use phase
- B11 Wide diversity of specifications and standards for single products
- B12 High complexity of the supporting IT architecture
- B13 Diverse digital readiness of the EU member states

²⁷ The statement numbers of the barriers were slightly different in the questionnaire.



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- B14 Unclear benefits for the supply chain
- B15 Lack of leadership and innovation pathway
- B16 Lack of qualified personnel
- B17 Diversity of IT systems among firms
- B18 High manpower costs and labour taxes
- B19 Bypassing compliance controls
- B20 Limited consumer access to products using DPPs
- B21 Cultural resistance and path dependency
- B22 Lack of appropriate ecosystems, business models and infrastructure
- B23 Volatile market environment and stressed organisations
- B24 High granularity required by regulation
- B25 Changing political landscape
- B26 Increasing customer power
- B27 Low consumer interest in used goods
- B28 Additional steps in sorting due to electronic data carriers

The survey results show that of the 28 barriers, those relating to lack of knowledge or data exchange along the value chain were rated particularly high in terms of their relevance. The 'Lack of awareness about current developments among firms' (B1); 'Lack of expertise and proficiency' in relation to DPPs (B2); 'The complexity of the value chain' (B3); and 'Missing data from international actors' (B4) were categorised as relevant barriers. Many stakeholders also rate the existing 'Lack of standards' as one of the main barriers (B5).

Figures 8 and 9 display the barriers sorted by relevance and awareness, respectively. The bars for each barrier show the distribution of the answers from strongly disagree to strongly agree. The means and standard deviation are listed on the right side of the chart.







Figure 8: Barriers' relevance (DBOC survey)

		E	Barriers Awareness			Mean*	SD**
в9 -	1 <mark>% 9%</mark>	20%	28%	41%	B9	3.01	1.03
B3 -	6%	20%	48%	26%	B3	2.94	0.84
B2 -	7%	23%	40%	30%	B2	2.92	0.91
В4 -	1 <mark>% 7%</mark>	21%	43%	28%	B4	2.90	0.92
B6 -	<mark>2% 9%</mark>	24%	30%	34%	B6	2.85	1.07
B1 -	1 <mark>% 11%</mark>	22%	37%	29%	B1	2.83	1.00
B5 -	2% 6%	23%	44%	24%	B5	2.81	0.96
B8 -	2 <mark>% 8%</mark>	29%	32%	29%	B8	2.79	1.01
B12 -	<mark>2% 12%</mark>	21%	40%	26%	B12	2.76	1.02
B16 -	1 <mark>% 10%</mark>	30%	40%	20%	B16	2.69	0.93
B18 -	2 <mark>% 10%</mark>	28%	41%	20%	B18	2.67	0.96
B7 -	<mark>3% 8%</mark>	30%	37%	22%	B7	2.66	1.02
B10 -	2 <mark>% 8%</mark>	32%	40%	18%	B10	2.65	0.92
B11 -	<mark>3% 8%</mark>	34%	35%	20%	B11	2.60	1.00
B17 -	2% 14%	27%	37%	20%	B17	2.60	1.01
B14 -	2 <mark>% 12%</mark>	31%	36%	20%	B14	2.60	1.00
B23 -	3% 11%	27%	42%	17%	B23	2.59	1.00
B13 -	1 <mark>% 11%</mark>	33%	41%	14%	B13	2.57	0.89
B22 -	2% 15%	31%	31%	21%	B22	2.55	1.03
B21 -	14%	36%	38%	12%	B21	2.47	0.88
B15 -	1 <mark>% 11%</mark>	43%	30%	15%	B15	2.47	0.91
B24 -	2% 14%	33%	35%	15%	B24	2.46	1.00
B19 -	4% 8%	40%	34%	14%	B19	2.45	0.97
B20 -	2% 11%	43%	31%	12%	B20	2.40	0.92
B26 -	3% 16%	36%	35%	10%	B26	2.32	0.97
B25 -	4% 12%	43%	31%	10%	B25	2.30	0.95
B27 -	4% 20%	33%	36%	7%	B27	2.23	0.99
B28 -	4% 18%	50%	24% 3%		B28	2.05	0.85
Stror	45% 40% 35% 30% 25% 20% 15% 10%	5% 0% 5% Pe	10% 15% 20% 25% 30% 35% 40% 45% 50% rcentage of Responses		y disagr	ee to 4 for S	itrongly agree





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The barriers identified could be grouped into six of the seven categories used in this report: regulatory and institutional, economic and market, social and cultural, technological and technical infrastructure, knowledge and education, and value chain and physical infrastructure. **Within each category, the barriers are sorted according to the relevance determined in the survey**. They are provided below in Table 3:

B#	Explanation	Relevance (Mean; Standard deviation)	Awareness (Mean; Standard deviation)		
Regu	gulatory and Institutional				
B5	Lack of standards: Standards are crucial to maximise the benefits of	3.38; 0.77	2.81; 0.96		
	DPPs and operationalise a robust and efficient circular economy. In				
	particular, standards are needed for data and IT systems, design and				
	spare parts, or the location of electronic tags. The current lack of				
	standards hinders the widespread adoption of DPPs.				
B7	Navigating in a complex regulatory framework: The large number of	3.18; 0.96	2.66; 1.02		
	national and international regulations create a complex environment,				
	especially for firms with cross-sectoral product portfolios, leading to				
	conflicts between data sharing and data protection activities. For				
	example, textiles with electronic data carriers such as NFC tags are				
	classified as electronic devices under the WEEE directive.				
B18	High manpower costs and labour taxes: Firms face obstacles in	2.81; 1.08	2.67; 0.96		
	implementing circular strategies due to high manpower costs and labour				
	taxes, particularly in highly manual activities with low automation levels,				
	such as repair, remanufacturing, or recycling.				
B25	Changing political landscape: European elections pose the risk that the	2.54; 1.05	2.30; 0.95		
	DPP deployment is delayed or stopped altogether.				
Econ	omic and Market				
B6	Higher costs and limited financial resources: Firms may lack the	3.19; 1.10	2.85; 1.07		
	financial resources to establish the necessary IT systems and				
	technological infrastructure (e.g., data carriers) for DPPs. Additional				
	funds for employee training and data management are needed, such as				
	data gathering, tracking, storage, maintenance, and auditing, as well as				
	correcting inaccuracies. SMEs might face constraints due to low IT				
	capabilities and financial resources, potentially transferring higher costs				
	to their customers through price increases.				
B8	Unclear financial benefits: There is a lack of estimations about the	3.10; 1.04	2.79; 1.01		
	financial benefits of implementing DPPs in the medium and long term,				
	thereby hindering a discussion about risks and benefits.				
B9	Lack of willingness to provide product data: Industries characterised by	3.02; 1.23	3.01; 1.03		
	fierce innovation and competition may be reluctant to provide or share				
	product data (e.g., product raw material composition) with third parties.				
	The demand for data transparency clashes with the need to protect				
	intellectual property and maintain a competitive advantage.				
B20	Limited consumer access to products using DPPs: Most DPP initiatives	2.77; 1.05	2.40; 0.92		
	are still in the pilot stage, and consumers have yet to experience them.				



	For example, modern batteries with DPPs are often not available for		
	consumers as a direct purchasing option, such as in the case of electric		
	vehicles and solar photovoltaic storage, where they are embedded in		
	another product.		
B22	Lack of appropriate ecosystems, business models and infrastructure:	2.74; 1.13	2.55; 1.03
	Profitable and established capacities for circularity are crucial. There is		
	potential for improving business models and ecosystems at scale as		
	pilots already exist. However, manual methods are still used for		
	dismantling in recycling settings. Batteries are still evolving, and their		
	raw material composition and construction may change in the future.		
	This lack of scale hinders the adoption of DPPs because of fewer use		
	cases for product data collection, analysis, and exchange.		
B23	Volatile market environment and stressed organisations: Amid global	2.66; 1.18	2.59; 1.00
	financial strain and economic difficulties over the past years, a systemic		
	change such as the introduction of DPPs could create resistance among		
	organisations and put acceptance at risk.		
B24	High granularity required by regulation: Equipping low-value products	2.63; 1.22	2.46; 1.00
	sold in large quantities (e.g., socks) with DPPs may be uneconomical.		
B28	Additional steps in sorting due to electronic data carriers: Using	1.87; 1.16	2.05; 0.85
	electronic data carriers could slow down industrial sorting processes and		
	create inefficiencies.		
Socia	and Cultural		
B15	Lack of leadership and innovation pathway: There are uncertainties	2.85; 0.98	2.47; 0.91
	about what entities within the business and policymaking communities		
	shall take a leadership role in conducting the large-scale deployment of		
	DPPs beyond pilots or small-scale solutions. In addition, the unclear		
	scope and vision of the DPP hinders the emergence of a concrete		
	innovation pathway.		
B21	Cultural resistance and path dependency: Initial implementation	2.76;0.94	2.47; 0.88
	difficulties and path dependency on functioning legacy systems could		
	lead to resistance against implementing DPPs. In addition, combining		
	current centralised systems with a decentralised architecture is seen as		
	a burden by firms.		
B26	Increasing customer power: Extensive transparency could catalyse	2.30; 1.18	2.32; 0.97
	campaigns against controversial business practices and misbehaviour.		
	This increased customer negotiation power could discourage firms from		
	adopting DPPs and higher transparency standards.		
B27	Low consumer interest in used goods: New products still symbolise	2.28; 1.26	2.23; 0.99
	status, and fashion trends significantly influence consumption patterns.		
	For instance, there is low consumer awareness about WEEE regulations		
	and the significance of returning used products. DPPs may be		
	superfluous if the interest in used products remains low and business		
	models do not shift towards that direction.		
Techr	ological and Technical Infrastructure		
B10	Loss of traceability during the use phase: Electronic tags may be lost,	2.96; 1.02	2.65; 0.92
	removed, or damaged for various reasons, leading to a loss of product		
	traceability. For instance, textiles often lose their QR codes because the		





			1
	labels are cut out by consumers or the printed tags fade with		
	subsequent washing cycles.		
B13	Diverse digital readiness of the EU member states: Significant	2.90; 0.95	2.57; 0.89
	differences in digital readiness among EU member states, related to		
	implementation costs and a lack of digital capabilities, may impede the		
	implementation of DPPs in certain countries.		
B17	Diversity of IT systems among firms: Differences in data architecture	2.84; 1.21	2.60; 1.01
	and IT systems among companies along the value chain hinder data		
	exchange.		
Know	ledge and Education		
B1	Lack of awareness about current developments among firms: Many	3.38; 0.77	2.83; 1.0
	firms, especially in the supply chain, are unaware of the developments		
	surrounding DPPs and lack an understanding of how they could utilise		
	them for their business. Overall, awareness of the DPP varies widely		
	between countries and industries.		
B2	Lack of expertise and proficiency: Especially among SMEs and small	3.35; 0.76	2.92; 0.91
	suppliers, the necessary IT skills to establish a DPP data architecture are		
	missing. Shortfalls in data literacy and technical proficiency in semantic		
	web technologies are common. Digital maturity is often unevenly		
	distributed within supply chains, and substantial knowledge gaps persist		
	between industry, consumers, and regulators.		
B12	High complexity of the supporting IT architecture: The complexity and	2.92; 1.21	2.76; 1.02
	length of data requirements at multiple layers for the DPP might appear		
	overwhelming or incomprehensible and drive away relevant		
	stakeholders.		
B16	Lack of qualified personnel: There is a lack of human resources in the	2.84; 1.11	2.69; 0.93
	EU due to an ageing society. Implementing DPPs requires recruiting		
	qualified experts or training employees, which may cause delays.		
Value	Chain and Physical Infrastructure		
B3	Complexity of the value chain: Multi-tiered and cross-geography value	3.22; 1.01	2.94; 0.84
	chains face challenges in collecting data for DPPs due to the multitude		
	of actors and partners involved within them. Stakeholders have varied		
	business models and data interests. SMEs might be especially vulnerable		
	in this context. This complexity implies different power relationships		
	among them and difficulties in reaching a consensus on appropriate		
	solutions. For example, dismantlers, shredders, and recyclers in the		
	automotive sector require different end-of-life data.		
B4	Missing data from international actors outside the EU: Numerous	3.22; 1.02	2.90; 0.92
	industries produce a significant portion of their products or source		
	components and raw materials outside the EU (e.g., batteries from		
	China). It remains unclear to what extent international stakeholders will		
	increase cooperation efforts with EU actors to gather the required data		
	for the DPP.		
B11	Wide diversity of specifications and standards for single products:	2.94; 1.10	2.60; 1.00
	Manufacturers face complexities and low standardisation in their		
	production cycles due to multiple individual products and components,		
	their specifications, and highly volatile assembly lines (i.e., a component		



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	used in the same model could be produced by different suppliers). This		
	leads to highly data-intensive and possibly multiple DPPs for a single		
	product. This is particularly relevant for electronics.		
B14	Unclear benefits for the supply chain: International suppliers are	2.87; 1.13	2.60; 1.0
	uncertain about how the additional efforts of collecting DPP data could		
	benefit their own business. This lowers their willingness to cooperate		
	and share data.		
B19	Bypassing compliance controls: In some industries, it is relatively easy	2.79; 1.12	2.45; 0.97
	to bypass regulatory requirements by shipping old products to third		
	countries instead of declaring them waste. To effectively introduce		
	DPPs, it will be necessary to eliminate the respective gaps in regulation.		

Table 3: Barriers detailed view

4.4.3. Opportunities

32 opportunities were identified in the online expert workshops. For enhanced readability, the opportunities below are numbered and ranked according to their perceived **relevance** to the implementation and delivery of DPPs. This ranking is determined by the stakeholders participating in the survey, with O1 being the opportunity with the highest ranking and O32 the one with the lowest ranking²⁸:

- O1 Providing information on the material composition for recycling
- O2 Increasing recovery and use of recycled materials
- O3 Increasing economic benefits from sustainable products
- O4 Simplifying maintenance and repair
- O5 Providing sorters and recyclers with valuable insights
- O6 Improving product design based on data
- 07 Limiting greenwashing and plagiarism
- O8 Reducing waste and improving resource efficiency
- O9 Creating an interoperable infrastructure for data exchange
- O10 Utilising standards for smooth DPP implementation
- O11 Enabling new business opportunities
- O12 Scaling up circularity
- O13 Educating the customer about sustainability impacts
- O14 Facilitating take-back of used products
- O15 Simplifying access to product data in real-time
- O16 Shifting towards service business models
- O17 Becoming a leader in environmental regulation
- O18 Tracking and enforcing regulations and standards
- O19 Preventing and exposing environmental, social and governance (ESG) violations
- O20 Building on existing technologies and ecosystems
- O21 Promoting cultural change towards circularity and sustainability

²⁸ The statement numbers of the opportunities were slightly different in the questionnaire.





- O22 Integrating several regulations
- O23 Reducing costs with automated data exchange
- O24 Calculating demand and supply for recyclates
- 025 Gaining insights and knowledge
- O26 Informing policymaking
- O27 Benefiting from decentralised data architecture
- O28 Learning from past initiatives
- O29 Promoting knowledge exchange and cooperation
- O30 Streamlining process capabilities
- O31 Regionalising the value chain
- O32 Monetising product data

Among the opportunities with the highest relevance, most are related to the R-strategies (i.e., reuse, repair, refurbish, remanufacture, recycling, etc.) for which DPPs are seen as a major enabler (O1, O2, O4, and O5). In addition, the potential for economic aspects such as 'Increasing economic benefits from sustainable products' (O3); 'Improving product design based on DPP data' (O6); and 'Monetising product data' (O7) received a high rating.

Figures 10 and 11 display the opportunities sorted by relevance and awareness, respectively. The bars for each opportunity show the distribution of the answers from strongly disagree to strongly agree. The means and standard deviation are listed on the right side of the chart.



Figure 10: Opportunities' relevance (DBOC survey)





01 - 019 - 03 - 02 - 07 -	2% 6% 8% 1% 7%	19% 33% 26%	48% 36%	25% 23%	01 019	2.89 2.75	0.92
019 - 03 - 02 - 07 -	8% 1 <mark>% 7%</mark>	33% 26%	36%	23%	019	2.75	0.91
O3 - O2 - O7 -	1 <mark>% 7%</mark>	26%					
O2 - O7 -			49%	17%	O3	2.73	0.86
07 -	8%	29%	45%	18%	O2	2.73	0.85
	1 <mark>% 13%</mark>	26%	39%	21%	07	2.66	0.99
013 -	2% 9%	29%	43%	17%	O13	2.64	0.93
021 -	2% 9%	31%	43%	16%	O21	2.63	0.92
08 -	3% 9%	31%	40%	18%	08	2.62	0.97
05 -	10%	29%	50%	10%	O5	2.60	0.81
04 -	3% 11%	29%	41%	16%	04	2.57	0.97
015 -	13%	34%	38%	15%	015	2.54	0.90
014 -	12%	34%	41%	13%	014	2.54	0.87
011 -	2 <mark>% 13%</mark>	32%	37%	16%	011	2.52	0.97
010 -	2 <mark>% 12%</mark>	37%	33%	17%	010	2.50	0.97
06 -	1 <mark>% 15%</mark>	34%	34%	17%	06	2.50	0.97
012 -	3% 9%	31%	47%	9%	012	2.50	0.92
017 -	<mark>3% 9%</mark>	40%	32%	15%	017	2.46	0.97
016 -	1 <mark>% 13%</mark>	38%	36%	12%	016	2.46	0.89
026 -	1 <mark>% 12% -</mark>	40%	35%	12%	026	2.46	0.89
018 -	<mark>3% 9%</mark>	41%	36%	11%	018	2.44	0.90
025 -	3% 14%	32%	41%	10%	025	2.43	0.94
020 -	1 <mark>% 12% </mark>	50%	23% 149	%	020	2.37	0.90
024 -	2 <mark>% 18%</mark>	38%	28% 15%		024	2.37	1.00
023 -	1 <mark>% 18%</mark>	39%	29% 13%	6	023	2.35	0.96
028 -	17%	46%	25% 12%	0	028	2.33	0.90
029 -	2% 17%	41%	28% 11%	6	029	2.30	0.94
09 -	5% 14%	39%	29% 12%	6	09	2.29	1.03
027 - 🕴	18%	42%	24% 14%		027	2.28	1.00
022 -	19%	39%	26% 12%		022	2.23	0.01
031 -	3% 18%	40%	33% 7	%	020	2.24	0.91
030 - 2	2% 16%	47%	31%	1%	030	2.21	1.00
032 - 5%	25%	41%	22% 8%		032	2.02	1.00

Figure 11: Opportunities' awareness (DBOC survey)

Opportunities could be grouped into all seven categories used in this report. Within each category, the opportunities are sorted according to the relevance determined in the survey. They are listed below in Table 4:

O#	Explanation	Relevance (Mean; Standard deviation)	Awareness (Mean; Standard deviation)
Regu	latory and Institutional		
010	Utilising standards for smooth DPP implementation: Implementing EU-wide standards and guidelines could drive the introduction of DPPs, offering companies clarity on expectations and obligations placed on them. This, in turn, may help them reduce implementation costs.	3.26; 0.76	2.50; 0.97
017	Becoming a leader in environmental regulation: The EU could become a role model in environmental regulation for other parts of the world, especially the global south, by adopting pioneering rules and standards. In addition, regulation on DPPs could be a gateway for further European regulation to expand standards on a global scale.	3.11; 0.88	2.46; 0.97





2 4 4 . 0 00
2.44; 0.90
2.25; 1.01
2.46: 0.89
-,
2 33.0 90
2.33, 0.30
2.73; 0.86
2.73; 0.86
2.73; 0.86
2.73; 0.86
2.73; 0.86
2.73; 0.86 2.57; 0.97
2.73; 0.86 2.57; 0.97 2.60; 0.81
2.73; 0.86 2.57; 0.97 2.60; 0.81 2.50; 0.97



07	Limiting greenwashing and plagiarism: Standardised data collection	3.32; 0.90	2.66; 0.99
	and product data disclosure could mitigate greenwashing and		
	plagiarism risks. Transparent information may support certification,		
	allowing civil society, authorities, or third-party auditors to verify		
	compliance. Intellectual property information could also be included		
	in the DPP and be easily verified when buying a product.		
011	Enabling new business opportunities: The introduction of DPPs	3.24; 0.82	2.52; 0.97
	could present numerous business opportunities and use cases. For		
	example, reducing reliance on international raw material suppliers		
	through growing secondary markets or enhancing brand reputation		
	through transparency. Value chains could become more efficient		
	through data transparency, robotic automation, and standardisation.		
	Industries may create better-paying jobs and retain know-how by		
	increasing their products' and operations' sophistication, quality, and		
	sustainability performance.		
012	Scaling up circularity: By leveraging DPP data, firms could rapidly and	3.22: 0.79	2.50: 0.92
	effectively scale up already in place individual circular strategies such	,	
	as maintenance renair or recycling as well as develop an integrated		
	approach to execute several circular strategies in parallel		
016	Shifting towards service business models: DPPs could drive the shift	3 12 0 8/	2 /6: 0 89
010	towards service business models such as rentals or leasing by	5.12, 0.04	2.40, 0.85
	anabling continuous product monitoring and take back. Consumers		
	could benefit from durable, high quality products and access to		
	could benefit from durable, high-quality products and access to		
	maintenance, repair, or replacement (e.g., in case or relocation)		
	services. Servicisation could also help firms attract younger user		
	demographics to their customer base.		0.07.4.00
024	Calculating demand and supply for recyclates: Analysing DPP data	3.00; 0.99	2.37; 1.00
	could allow multiple stakeholders to collaborate in estimating future		
	demand and supply for recyclates. Firms and recyclers could leverage		
	this information to establish long-term cooperation and supply		
	contracts.		
031	Regionalising the value chain: DPP-enabled transparency and	2.68; 1.04	2.24; 0.91
	traceability of used products could increase the proximity between		
	local and regional producers, suppliers, and recyclers, thus enabling		
	actors to compete and access domestic value chains.		
032	Monetising product data: DPP data could be monetised, for	2.43; 1.21	2.02; 1.00
	instance, through a premium access model. This could generate		
	additional revenue for firms and the emergence of new markets		
	based on data exchange.		
Socia	l and Cultural		
019	Preventing and exposing environmental, social and governance	3.09; 0.82	2.75; 0.91
	(ESG) violations: With higher data transparency, firms engaged in		
	questionable or harmful business practices related to ESG criteria		
	could be more easily exposed. The pressure created by higher		
	transparency could lead to a general decrease in such practices.		
021	Promoting cultural change towards circularity and sustainability:	3.07; 0.83	2.63; 0.92
	Implementing DPPs could enable consumers to align purchasing	,	,

...

	-		
	decisions with sustainability, fostering a potential shift away from the		
	"throwaway society". For instance, consumers could learn about the		
	environmental impact of electronic products, raise their demand for		
	second-hand products, or become temporary users instead of		
	owners under service business models.		
Tech	nological and Technical Infrastructure		
09	Creating an interoperable infrastructure for data exchange:	3.27; 0.82	2.29; 1.03
	Creating an interoperable and automated data architecture that is		
	easily accessible could create numerous opportunities for future		
	business and use cases. Firms could profit from a data-centred		
	culture and use the DPP as a single source of environmental (and		
	other product-related) information.		
020	Building on existing technologies and ecosystems: Leveraging	3.09; 0.89	2.37; 0.90
	existing technological solutions (e.g., data carriers) and industry		
	ecosystems could simplify the implementation of DPPs. For instance,		
	established data exchange systems, as seen in industries like		
	automotive, provide a solid foundation for further development.		
023	Reducing costs with automated data exchange: Using automated	3.02; 0.89	2.35; 0.96
	data exchange with DPPs along the value chain could significantly		
	reduce costs. For instance, real-time monitoring systems and digital		
	data carriers could enable data sharing with multiple customers or		
	the automation of reporting and auditing tasks.		
027	Benefiting from decentralised data architecture: A decentralised	2.99; 0.94	2.28; 1.00
	data architecture for DPPs could help firms maintain control over		
	their data. This could positively impact the acceptance and		
	willingness to invest in IT systems and computing power for DPPs.		
030	Streamlining process capabilities: An automated data architecture	2.78; 0.85	2.21; 0.82
	spanning the manufacturing cycle and the entire value chain could		
	enable business process optimisation. Firms could generate reports		
	and conduct mandatory control checks in a timely manner. As robust		
	data is available, payments and other administrative processes could		
	also be streamlined.		
Envir	onmental		
08	Reducing waste and improving resource efficiency: DPP data could	3.29; 0.81	2.62; 0.97
	help prevent resource losses, minimise waste generation, and reduce		
	raw material extraction by enabling longer product lifetimes and		
	more efficient production and take-back processes.		
Knov	vledge and Education		
01	Providing information on the material composition for recycling:	3.40; 0.79	2.89; 0.92
	DPPs could store information about the product's material		
	composition to improve recycling. For instance, in the case of textiles		
	with blended fibres, this information could be used to separate		
	fibres.		
013	Educating the customer about sustainability impacts: DPPs could	3.21; 0.80	2.64; 0.93
	empower consumers to understand the environmental impact of		
l	their products. NGOs and firms could use the DPP as a channel to		



	educate consumers about the footprint of their goods. This could		
	counteract harmful trends like fast fashion and spread knowledge		
	about sustainable behaviour.		
015	Simplifying access to product data in real-time: Implementing DPPs	3.14; 0.91	2.54; 0.90
	could provide easy access to product and process data for end		
	consumers and businesses. For example, digital product wallets or		
	exchanges on electronic devices (e.g., smartphones) could further		
	simplify access for all users, including individuals with disabilities, and		
	showcase the product's environmental impact.		
025	Gaining insights and knowledge: DPP data could aid firms in	3.00; 0.96	2.43; 0.94
	generating market knowledge and streamlining procurement by		
	offering them insights into supply chain providers, their products,		
	know-how and performance. Access to product data could allow		
	firms to analyse consumer behaviour for educational or economic		
	purposes.		
029	Promoting knowledge exchange and cooperation: The increased	2.86; 0.96	2.30; 0.94
	networking of actors along the value chain due to data exchange		
	could promote cooperation and knowledge transfer among them.		
	This could lead to the rapid spreading of sustainability know-how and		
	best practices.		
Value	e Chain and Physical Infrastructure		
02	Increasing recovery and use of recycled materials: DPPs and related	3.36; 0.70	2.73; 0.85
	technologies could facilitate material recovery at the product's end		
	of life, thus helping to scale up recycling, increasing the quality and		
	availability of recyclates, and supporting collection and sorting		
	schemes.		
014	Facilitating take-back of used products: DPPs could enhance take-	3.20; 0.73	2.54; 0.87
	back and buy-back options for used products. This aids in closing		
	circular economy loops by providing location and condition		
	information, as demonstrated in successful attempts to implement		
	this approach with less technological support, especially in the textile		
	industry (e.g., carpets).		

Table 4: Opportunities detailed view

4.4.4. Challenges

30 challenges were identified in the online expert workshops. For enhanced readability, the challenges below are numbered and ranked according to their perceived relevance to the implementation and delivery of DPPs. This ranking is determined by the stakeholders participating in the survey, with C1 being the challenge with the highest ranking and C30 the one with the lowest ranking²⁹:

- C1 Ensuring security protocols and data protection
- C2 Lacking trustworthy data and dependence on other value chain actors
- C3 Aligning relevant regulations with non-European governments

²⁹ The statement numbers of the challenges were slightly different in the questionnaire.


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- C4 Ensuring data quality
- C5 Creating a level playing field
- C6 Achieving interoperability between data models and IT systems
- C7 Lacking standardisation and guidance by the EU Commission and member states
- C8 Identifying data points
- C9 Educating consumers about relevant concepts
- C10 Missing information about materials
- C11 Satisfying users' information requirements
- C12 Changing internal processes, business models and collaboration practices
- C13 Ensuring user identification and authentication
- C14 Measuring environmental impact and footprint
- C15 Aligning internal departments
- C16 Building capacity outside the EU
- C17 Lacking clarity on data usage by regulators
- C18 Including multiple languages
- C19 Establishing a suitable data architecture
- C20 Lacking value chain infrastructure for a circular economy
- C21 Recycling is not always sustainable
- C22 Integrating multiple stakeholders
- C23 Establishing circular product design
- C24 Scaling up service business models
- C25 Extending firm accountability and liability
- C26 Increasing energy costs and footprint to scale up the IT infrastructure
- C27 Tight regulatory schedule
- C28 Lock-in issues with service providers
- C29 Including non-mandatory data by the civil society
- C30 Increasing electronic waste

Several of the challenges rated as particularly relevant are data-related: 'Ensuring security protocols and data protection' (C1); 'Lacking trustworthy data and dependence on other value chain actors' (C2); and 'Ensuring data quality' (C4). However, regulatory aspects such as 'Aligning relevant regulations with non-European governments' (C3) and 'Creating a level playing field' (C5) were also considered important factors.

Figures 12 and 13 display the challenges sorted by relevance and awareness, respectively. The bars for each challenge show the distribution of the answers from strongly disagree to strongly agree. The means and standard deviation are listed on the right side of the chart.

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Figure 12: Challenges' relevance (DBOC survey)

		Challen	ges Awareness		Mean*	SD**
C2 -	<mark>6%</mark>	22%	45%	27% C2	2.93	0.86
C1 -	2 <mark>% 6%</mark>	25%	38%	29% C1	2.86	0.96
C5 -	2 <mark>% 8%</mark>	35%	33% 23	3% C5	2.68	0.97
C9 -	<mark>2% 10%</mark>	29%	39%	20% C9	2.66	0.97
14 -	1 <mark>% 12%</mark>	30%	36% 2	1% C14	2.65	0.97
24 -	10%	34%	36% 2	C4	2.65	0.92
- 6	3% 11%	30%	33% 249	6 C6	2.65	1.04
27 -	2% 16%	22%	36% 24%	C27	2.64	1.07
8 -	3% 12%	28%	34% 23%	C18	2.61	1.07
0 -	1 <mark>% 14%</mark>	33%	30% 23%	C10	2.60	1.01
7 -	2% 11%	32%	36%	C7	2.59	0.98
20 -	1 <mark>% 10%</mark>	30%	45%	13% C20	2.59	0.88
.8 -	3% 12%	31%	39%	6% C8	2.54	0.98
3-	2% 16%	26%	41%	6% C3	2.53	0.99
9-	2% 11%	37%	34%	6 C19	2.52	0.96
3 -	4% 11%	32%	38%	5% C13	2.52	1.00
<u> </u>	8%	43%	40%	9% C25	2.50	0.77
7	1% 8%	48%	29% 15	C17	2.49	0.87
2	2% 12%	36%	40%	C12	2.45	0.90
2	2% 11%	40%	35% 12	% C22	2.44	0.91
1	2% 16%	30%	42%	0% C11	2.44	0.94
	2% 9%	49%	24% 16%	C24	2.42	0.92
	4% 16%	30%	35% 15%	C15	2.41	1.05
2	4% 12%	41%	26% 17%	C16	2.40	1.02
。]	3% 11%	45%	30% 11%	C28	2.36	0.92
2	1% 19%	37%	30% 13%	C23	2.35	0.96
1	3% 18%	44%	26%	C21	2.23	0.95
;]	4% 19%	40%	27%	C29	2.20	1.01
7]	F % 21%	30%		C26	2.10	0.97
]	5% 25%	11%	27/0 0/6	C30	1.99	0.96
50	% 45% 40% 35% 30% 25% 20% 15% 10%	5% 0% 5% 10% Percenta	15% 20% 25% 30% 35% 40% 45% 50% 55% 609 ge of Responses	<pre>* 0 for Strongly disagre</pre>	e to 4 for S	Strongly a

Figure 13: Challenges' awareness (DBOC survey)



Challenges could be grouped into all seven of the categories used in this report. **Within each category, the challenges are sorted according to the relevance determined in the survey**. They are listed below in Table 5:

C#	Explanation	Relevance (Mean; Standard deviation)	Awareness (Mean; Standard deviation)
Regul	atory and Institutional		
С3	Aligning relevant regulations with non-European governments: EU regulations need to be aligned with those of third countries due to the	3.24; 0.83	2.53; 0.99
	international nature of value and supply chains. Otherwise, foreign data privacy regulations could prohibit the exchange of data for DPPs. Currently, it's unclear how efficient cross-border collaboration will be established to harmonise data governance.		
C5	Creating a level playing field: Due to the high IT requirements and investment costs, DPPs could favour a few large companies at the expense of most small businesses, thus contributing to market imbalances. Clear definitions, rules, and requirements for participation based on a level playing field are needed for the DPP system.	3.21; 0.92	2.68; 0.97
C7	Lacking standardisation and guidance by the EU Commission and member states: Without clear guidelines, standards, and support from the EU Commission and member states, regulation could negatively impact genuine transformation. Firms might prioritise meeting legal obligations and compliance over achieving higher sustainability and circularity.	3.18; 0.92	2.59; 0.98
C16	Building capacity outside the EU: Europe's leading role in deploying DPPs pressures various governmental and non-governmental stakeholders outside the EU to collaborate and build capacity for DPP deployment. The coordination of such initiatives and the role of the EU in this context remain unclear.	3.04; 0.87	2.40; 1.02
C17	Lacking clarity on data usage by regulators: It is unclear how and whether regulators can utilise DPP data to work on standardisations or to conduct checks on companies, as these checks are primarily based on self-reporting.	3.02; 0.91	2.49; 0.87
C22	Integrating multiple stakeholders: Currently, there is a strong focus on implementing the DPP for car batteries. This needs to be expanded to the whole battery industry. Narrow perspectives like these should be avoided from the outset for other product categories, such as textiles and electronics.	2.95; 0.92	2.44; 0.91
C27	Tight regulatory schedule: The time pressure for the transition to DPPs poses significant challenges for firms, with some perceiving the transition period as too short.	2.74; 1.22	2.64; 1.07
C29	Including non-mandatory data by the civil society: Consumers, NGOs, and civil society institutions may request the addition and generation of data on specific DPPs. However, their role and the extent to which	2.69; 1.05	2.20; 1.01

	they may add data to a DPP are not yet well defined.		
Econo	mic and Market		
C15	Aligning internal departments: Additional data requirements for the DPP involve aligning several departments at the firm level, such as CSR, procurement, marketing, IT, and finance. In companies, this alignment is often very low or, in some cases, non-existent.	3.05; 1.04	2.41; 1.05
C23	Establishing circular product design: The deployment of DPPs may not inherently contribute to sustainability or the circular economy, as these outcomes depend on product design considerations. For example, reducing glued connections in a product could enable better recycling, but this and other properties, such as repairability, are independent of DPPs.	2.93; 1.04	2.35; 0.96
C24	Scaling up service business models: Service business models remain rare and challenging to implement. This is particularly difficult for component manufacturers, OEMs, and SMEs due to financial constraints related to long-term capital requirements or value chain dependencies (e.g., leasing car batteries when the car is sold). Due to these challenges, DPPs might not automatically contribute to higher servitisation and resource savings.	2.79; 1.07	2.42; 0.92
Social	and Cultural		
C11	Satisfying users' information requirements: Attractiveness and ease of use are relevant factors to consider in the deployment of DPPs for the general public. Therefore, a balance between sufficient information density and easy comprehension must be ensured. DPP data must not be too superficial, as this would not provide any real added value compared to current labels and certifications.	3.11; 0.83	2.44; 0.94
C18	Including multiple languages: The DPP must be accessible and usable in multiple languages for widespread acceptance.	3.00; 1.08	2.61; 1.07
Techn	ological and Technical Infrastructure		
C1	Ensuring security protocols and data protection: Sharing product information could lead to unauthorised use of intellectual property (IP) rights, counterfeit, or hacking issues. Security and privacy protocols need to be implemented to prevent such misuse.	3.32; 0.87	2.86; 0.96
C4	Ensuring data quality: Automated procedures are essential for auditing the quality of DPP information, especially considering the large number of actors in the value chain and possible duplicates. A gradual implementation of the DPP shall ensure compliance with current standards and regulations (e.g., REACH regulation and SCIP database).	3.21; 0.80	2.65; 0.92
C6	Achieving interoperability between data models and IT systems: To facilitate global and interoperable DPPs, it's crucial to establish overarching data models, ontologies, and technology standards, which are currently missing. For example, integrating the DPP with existing product tracking systems could be difficult without well-established interoperability.	3.19; 0.94	2.65; 1.04



	different stakeholders may pose organisational, technical, and financial		
	challenges. In particular, civil society actors may need access to specific		
	information to monitor and verify the DPP data or may deny access to		
	their private data.		
C19	Establishing a suitable data architecture: The amount of data required	2.98; 1.07	2.52; 0.96
	for DPPs makes creating systems that automate data management and		
	storage necessary. The architecture for the DPP needs to evolve,		
	follow the changes to the product over time, and allow permanent		
	exchange between companies. It is unclear whether decentralised or		
	centralised data storage and management is better suited for this.		
C28	Lock-in issues with service providers: Firms facing challenges in	2.73; 0.98	2.36; 0.92
	collecting and organising the extensive data required for DPPs may		
	turn to external IT service suppliers, resulting in power imbalances due		
	to lock-in issues.		
Enviro	onmental		
C14	Measuring environmental impact and footprint: There is a lack of	3.08; 1.01	2.65; 0.97
	frameworks to consistently and comparably assess the product's		
	environmental impact. This is also due to different perspectives on		
	sustainability. As a result, capturing appropriate information through		
	DPPs could be challenging.		
C21	Recycling is not always sustainable: The DPP may overemphasise	2.96; 1.02	2.23; 0.95
	recycling, which can be energy-intensive. Thus, the deployment of the		
	DPP shall focus on all circular strategies for promoting sustainable		
	business practices.		
C26	Increasing energy costs and footprint to scale up the IT	2.74; 1.14	2.10; 0.97
	infrastructure: Significant energy resources may be needed to store		
	and manage the data to scale up DPPs. Energy calculations should be		
	undertaken and incorporated into the planning process as early as		
	possible to reduce the carbon footprint of the DPPs.		
C30	Increasing electronic waste: Due to regulatory changes and the	2.32; 1.18	1.99; 0.96
	introduction of DPPs, the necessary electronic tags, such as QR codes		
	or RFID chips, may increase the amount of electronic and plastic		
	waste.		
Know	ledge and Education		
C8	Identifying data points: To advance circularity and share product data	3.16; 0.84	2.54; 0.98
	through DPPs with ecosystem actors, the relevant data points, such as		
	technical specifications or material composition, need to be identified		
	and agreed upon for each product model and category.		
C9	Educating consumers about relevant concepts: DPP-related concepts	3.14; 1.01	2.66; 0.97
	and tools need to be explained to consumers to increase their		
	awareness about DPPs.		
C10	Missing information about materials: Companies might not have	3.12; 1.01	2.60; 1.01
	clarity about the materials used in their products and what data should		
	be collected about them in the DPP.		
C12	Changing internal processes, business models and collaboration	3.08; 0.86	2.45; 0.90
	practices: Silo-thinking and cultural inertia could hinder the necessary		
	collaboration, practices, and network structures (e.g., across		



	companies, industries, and supply chains) to build efficient circular		
	business models and ecosystems for DPPs.		
Value	Chain and Physical Infrastructure		
C2	Lacking trustworthy data and dependence on other value chain	3.27; 0.84	2.93; 0.86
	actors: Collecting appropriate data for the DPP along the value chain is		
	challenging. There may be a lack of trust in the data provided and a		
	lack of capabilities for accurate data collection among suppliers.		
C20	Lacking value chain infrastructure for a circular economy: The lack of	2.97; 0.80	2.59; 0.88
	a comprehensive value chain infrastructure hinders the adoption of a		
	circular economy at a large scale. Issues include low spare parts		
	production, inadequate disposal practices, insufficient collection points		
	for take-back, low industrialisation of circular activities, and unequal		
	infrastructure within the EU. Building up an effective circular economy		
	requires investments in physical infrastructure, potentially delaying		
	DPP implementation or rendering them unsuitable for some circular		
	use cases.		
C25	Extending firm accountability and liability: Upcoming regulations may	2.77; 0.88	2.50; 0.77
	extend the accountability and liability of producing firms beyond the		
	product's sale. This poses challenges for component suppliers such as		
	car battery manufacturers as it remains unclear how they can take		
	back their products after a transfer of ownership of the car.		

Table 5: Challenges detailed view





5. Recommendations for policy, business and IT

5.1. Recommendations: Objective

The objective of this second study is to identify recommendations for policymakers, businesses in the concerned value chains, and IT firms. Policymakers will receive recommendations regarding further necessities for the implementation and operation of the DPP and its underlying systems. Businesses and IT firms will receive recommendations on implementation, functionalities, future development, collaboration, technologies, business models, and other relevant topics related to DPPs.

The recommendations were identified and developed following a three-stage Delphi study in which experts from the CIRPASS partners and registered CIRPASS stakeholder groups participated. Therefore, they are not the outcome of the individual opinions of the authors but rather the product of an empirical methodology based on expert consultation. However, they are also subject to the current state and timing of DPP regulation and the evolution of the DPP system. They are not to be seen as exhaustive. As pointed out above, they complement the recommendations and roadmaps presented in other CIRPASS reports.

5.2. Method: Delphi Study

To create timely and target group-specific recommendations in the dynamic environment of the emerging DPP and DPP system, the development of recommendations was based on a Delphi study³⁰. Through a Delphi study, the opinions of a panel of experts are gathered in several phases or rounds to achieve consensus on the topic under study. Recommendations were developed for policymakers, businesses, and IT firms. In tune with the method, we aimed at collecting ideas for recommendations and reaching consensus in three rounds on 1) the content of the recommendations, 2) the perceived contribution of the DPP to the circular economy, and 3) the priority level for policymakers of the respective recommendations.

The general structure of the surveys was similar for the three rounds. Before starting, participants were directed to the introductory page of the respective survey. They were informed about the study objective and context. Informed consent was also obtained from all participants before the survey started by informing them that their data would be treated according to GDPR and the CIRPASS privacy policy. In accordance with common standards of research ethics, participation in the survey was voluntary; that is, there were no mandatory content-related questions, allowing participants to answer questions as they preferred and withdraw at any time. Consequently, there is a slight variance in the number of answers between survey questions and the overall number of participants. However, no pattern of non-response could be observed. Therefore, we were able to use all available answers for our analyses.

Further, participants were asked to answer three mandatory questions to gather statistical information about participation based on categories defined by the CIRPASS project. These categories included the stakeholder group, the industry they belong to, and the country of their operations. The

³⁰ See Fitch et al. 2001





study was structured in three rounds, each with its respective objectives. Each round of the survey is described in further detail below.

5.2.1. Delphi survey: Round 1

The goal of this round was to gather recommendations for policymakers, businesses, and IT firms through open-ended questions.

To guide the participants through the first part of the questionnaire about policy instruments and initiatives, we developed a framework that included six policy categories from the Better Regulation Toolbox of the European Commission³¹. We used a specific question and provided examples for each category to inspire the participants. All questions included the three goals for DPPs proposed by the European Commission: circularity, sustainability, and legal compliance. We used the following six policy categories and their respective questions and exemplary sentences:

- 1. Economic instruments
 - What market-based instruments could be used by policymakers so that DPPs contribute to the goals (circularity, sustainability, legal compliance) proposed by the European Commission?
 - Usual examples of economic instruments include taxes, charges, fees, fines, penalties, liability and compensation schemes, subsidies and incentives, labelling schemes, and tradable permit schemes.
- 2. Education and information instruments
 - What education and information instruments could be used by policymakers so that DPPs contribute to the goals (circularity, sustainability, legal compliance) proposed by the European Commission?
 - Usual examples of education and information instruments include information and publicity campaigns, training and guidelines (e.g., circular economy skills, DPP technologies), disclosure requirements, and standardised testing or rating systems.
- 3. Legally binding policy instruments
 - What legally binding policy instruments could be used by policymakers so that DPPs contribute to the goals (circularity, sustainability, legal compliance) proposed by the European Commission?
 - Usual examples of legally binding policy instruments include regulations (e.g., ESPR), directives (e.g., CSRD, Right to Repair directive), and decisions.
- 4. Soft policy instruments
 - What soft policy instruments could be used by policymakers so that DPPs contribute to the goals (circularity, sustainability, legal compliance) proposed by the European Commission?
 - Usual examples of soft policy instruments include recommendations, technical standards, voluntary bottom-up initiatives (self-regulation), and legislation-induced co-regulation.
- 5. Other policy instruments and voluntary initiatives

³¹ See European Commission 2023



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- What other instruments or initiatives could be used by policymakers so that DPPs contribute to the goals (circularity, sustainability, legal compliance) proposed by the European Commission?
- Usual examples of other policy instruments and voluntary initiatives include regulatory sandboxes (e.g., Artificial Intelligence Act), and public frameworks/measures (e.g., green public procurement, public-private partnerships).
- 6. General recommendations for policymakers
 - What further recommendations would you give policymakers so that DPPs contribute to the goals (circularity, sustainability, legal compliance) proposed by the European Commission?
 - For instance, your recommendations could refer to implementation, functionalities, future development, collaboration, technologies, business models, or other relevant topics related to DPPs.

To identify other relevant policy instruments and initiatives, we examined the current literature on policy design to formulate relevant questions for the different categories described above³² (see Figure 14 below for an example). Each category had five types of questions oriented towards different aspects of policy design:

- 1. What is the goal? What problem should it alleviate/solve?
- 2. What is the specific instrument/initiative?
- 3. How can we check that the instrument/initiative "x" achieves the goal?
- 4. What is the target population/stakeholder group?
- 5. Who should implement it?

	What is the goal? What problem should it alleviate/solve?	What is the specific instrument/initiative?	How can we check that the instrument/ initiative "x" achieves the goal?	What is the target population / stakeholder group?	Who should implement it?
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2	11		11		
3			11		
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Figure 14: Exemplary question of the policy section of round 1

To guide participants through the second part of the questionnaire, which focused on businesses and IT firms, we developed open-ended questions about recommendations. These were structured

³² See Birkland 2020



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similarly to those in the previous section, and included the following two categories with their respective questions and exemplary sentences:

- 1. Recommendations for businesses
 - What recommendations would you give businesses so that DPPs contribute to the goals (circularity, sustainability, legal compliance) proposed by the European Commission?
 - For instance, your recommendations could refer to implementation, functionalities, future development, collaboration, technologies, business models, or other relevant topics related to DPPs.
- 2. Recommendations for IT firms
 - What recommendations would you give IT firms and IT service providers so that DPPs contribute to the goals (circularity, sustainability, legal compliance) proposed by the European Commission?
 - For instance, your recommendations could refer to implementation, functionalities, future development, collaboration, technologies, business models, or other relevant topics related to DPPs.

This survey was sent to 805³³ registered CIRPASS stakeholders and 112 staff members of the CIRPASS partners. It was conducted in December 2023. We selected a broad base of experts to gather knowledge from different roles, environments, and perspectives, and to enrich the survey results. During this round, 32 participants provided 435 answers to the survey. These were aggregated and translated into 62 recommendations.

5.2.2. Delphi survey: Round 2

The goal of this round was to seek consensus on the content of an initial set of recommendations obtained from the first round. For each of the 62 recommendations, participants were asked to rate their agreement on a five-point Likert scale ranging from 0 = "strongly disagree" to 4 = "strongly agree" (see Figure 15 for an example).

In addition, they could offer suggestions to improve each recommendation further. The categories 'Soft policy instruments' and 'Other policy instruments and voluntary initiatives' from round 1 were merged due to the similarities in the statements collected. Finally, participants could propose new recommendations that were missing from the list. Consequently, the following eight categories were used in this round. The number next to each category indicates the number of questions (/recommendations) included:

- 1. Economic instruments (7)
- 2. Education and information instruments (5)
- 3. Legally binding policy instruments (14)
- 4. Voluntary initiatives and soft policy instruments (7)
- 5. General recommendations for policymakers (5)
- 6. Recommendations for businesses (12)
- 7. Recommendations for IT firms (12)

³³ Please note that the number of registered stakeholders increased during the project duration.





8. An open-ended field for additional or new recommendations for policymakers, businesses, and IT firms

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Do you agree with this recommendation	0	0	0	0	0

Figure 15: Exemplary question of the policy section of round 2

The second survey was sent to 857 registered CIRPASS stakeholders and 112 staff members of the CIRPASS partners. It was conducted in February 2024. Due to the low response rate of the first round (only 32 participants), we sent this survey again to all CIRPASS partners and registered CIRPASS stakeholders. A total of 87 participants answered the survey. During this round, 42 additional suggestions for policymakers, businesses, and IT firms were made by the participants in the open-ended section. These were aggregated and used to write new recommendations (see Tables 6, 7 and 8 below). A final list of 67 recommendations was generated for this round.

5.2.3. Delphi survey: Round 3

The goal of this round was to seek final consensus on the content, the perceived contribution of the DPP to the circular economy, and the priority level for policymakers of a final list of recommendations generated after analysing the feedback from the second round.

Similar to the second round, the category 'Voluntary initiatives and soft policy instruments' was renamed to 'soft policy instruments' following expert advice due to the lack of voluntary initiatives in the final list of statements. Thus, the following seven categories were used in this round. The number next to each category indicates the total number of questions included:

- 1. Economic instruments (7)
- 2. Education and information instruments (5)
- 3. Legally binding policy instruments (12)
- 4. Soft policy instruments (9)
- 5. General recommendations for policymakers (9)
- 6. Recommendations for businesses (4)
- 7. Recommendations for IT firms (4)

The number of recommendations for each category differs from the list of the previous round for the following reasons: First, two recommendations were moved from the 'Legally binding policy instruments' category to the 'Soft policy instruments' category. Second, the 'General recommendations for policymakers' category contains new statements. Finally, the last two





categories only included recommendations that were improved or achieved low consensus in the previous round. We explain this in more detail below.

Recommendations for this survey were separated into three types according to their consensus values and the qualitative suggestions for improvement obtained in the second round. Consensus was calculated using the average value of the Likert scale and was set at 70% (equivalent to 2.8 on the Likert scale). This approach aligns with standard practices in the Delphi method³⁴. Below, we provide the definitions of the different groups.

- Group 1: These recommendations achieved high consensus in the second round (mean value above 2.8). Their description was not modified or improved.
- Group 2: These recommendations achieved low consensus in the second round (mean value below 2.8). Their description was improved using recurring qualitative suggestions written by the participants.
- Group 3: These recommendations achieved high consensus in the second round (mean value above 2.8). However, participants added qualitative suggestions that did not align with the current description or proposed improvements to the respective recommendation. Thus, their description was improved, but we kept the recommendation's inherent logic.

For each policy recommendation in group 1, participants were asked to rate their perception of the perceived contribution of the DPP to the circular economy and the priority level for policymakers on a five-point Likert scale ranging from 0 = "strongly disagree" to 4 = "strongly agree" (see Figure 16 for an example). In addition, for policy recommendations in groups 2 and 3, participants were asked to rate their agreement on the same five-point Likert scale with the aim of reaching a consensus (see Figure 17 for an example).

l6. Fund open-source solutions:							
ind open-source solutions, prototypes, and methodologies related to DPPs.							
	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree		
R106 significantly contributes to the Circular Economy	0	0	0	0	0		
R106 should be a high priority for policymakers	0	0	0	0	0		

Figure 16: Exemplary question of the policy section of round 3 (group 1)

 Increase fines for misuse: ease fines for fraudulent economic operators that misus gedly sustainable products, and counterfeits. 	e or alter DPP data	(in alignme	nt with the	Green C	laims Directive
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Do you agree with the improved recommendation R104?	0	0	0	0	0
R104 significantly contributes to the Circular Economy	0	0	0	0	0
R104 should be a high priority for policymakers	0	0	0	0	0

Figure 17: Exemplary question of the policy section of round 3 (group 2 or 3)

³⁴ See Diamond et al. 2014



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Regarding recommendations for businesses and IT firms, we only asked the participants to rate their agreement with the statements in groups 2 and 3 on the same five-point Likert scale. We did not consider the perceived contribution of the DPP to the circular economy nor the priority level for policymakers due to the length and complexity of the survey.

This survey was sent to the 94 individual participants who responded to the first and/or second rounds and gave us their Email addresses for further contact. It was conducted in March 2024. A total of 39 participants answered the survey.

5.3. Demographic results of the Delphi study

In this section, we show the results obtained from the Delphi study. Participation fluctuated over the course of the study. 32, 87, and 39 participants took part in the survey in the first, second, and third rounds, respectively.

While the number of participants varied between rounds, their distribution among industries remained similar. That is, while IT & Digital, Textiles, Electronics, as well as Cross-sectoral remained among the most represented, only a few participants were from Plastics & Composites and Batteries sectors. In addition, there was a substantial number of participants from other industries (see Table 6).

Round & Date	IT & Digital	Textiles	Electronics	Cross-sectoral	Plastics & Composites	Batteries	Other	Sum
1 December 2023	22% (N = 7)	25% (N = 8)	18% (N = 6)	16% (N = 5)	<1% (N = 1)	<1% (N = 1)	13% (N = 4)	32
2 February 2024	18% (N = 16)	18% (N = 16)	17% (N = 15)	20% (N = 17)	<1% (N = 1)	<1% (N = 2)	23% (N = 20)	87
3 March 2024	21% (N = 8)	15% (N = 6)	21% (N = 8)	23% (N = 9)	- (N = 0)	<1% (N = 2)	15% (N = 6)	39

Table 6: Industry distribution of the participants



5.3.1. Delphi participants: Round 1

32 stakeholders participated in the first round. Figure 18 shows that stakeholders from 11 different EU countries participated in the first survey; Germany is the most represented, with 7 participants (22%). In addition, the same number with global operations participated (22%).



Figure 18: Participants by location of firm's activities (Delphi survey round 1)

As seen in Figure 19, a wide range of stakeholder groups participated. 44% of the participants are technical solution providers or manufacturers. No stakeholders implementing the R-Strategies of the circular economy, such as remanufacturers or recyclers, participated.



Figure 19: Participants by stakeholder group (Delphi survey round 1)





5.3.2. Delphi participants: Round 2

87 stakeholders participated in round 2, the highest number of participants in this study. Figure 20 shows that stakeholders with operations in 12 different EU countries participated. Germany, again, is the most represented, with 28 participants (32%).



Figure 20: Participants by location of firm's activities (Delphi survey round 2)

As seen in Figure 21, technical solution providers (17) and manufacturers of finished products (13) comprise again the largest group of participants (34%) in the second round.



Figure 21: Participants by stakeholder group (Delphi survey round 2)





5.3.3. Delphi participants: Round 3

39 stakeholders participated in the third round. As seen in Figure 22, stakeholders from 11 different EU countries participated. Germany is again the most represented, with 7 participants (18%). The relatively high number of participants with global operations suggests rising interest in the DPP from outside Europe.



Figure 22: Participants by location of firm's activities (Delphi study round 3)

Figure 23 shows the stakeholder groups of the third round. The distribution is similar to that of the previous two rounds. Technical solution providers are the group with the highest participation (28%), followed by manufacturers of finished products (13%) and research institutes (13%).



Figure 23: Participants by stakeholder group (Delphi study round 3)



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5.4. Integrated results of the Delphi study

5.4.1. Recommendations for Policymakers

The resulting recommendations are ranked and listed according to the **perceived contribution of the DPP to the circular economy**. These values were obtained during the last round of the Delphi study, where 58 out of 67 recommendations achieved an overall agreement of more than 70% – equivalent to 2.8 on the Likert scale – regarding their perceived contribution of the DPP to the circular economy. In this respect, the top ten recommendations are:

- R301 Ensure policy coherence,
- R501 Advocate for transparency, sustainability and circularity,
- R201 Support training and educational programmes,
- R302 Define technical vocabularies and ontologies,
- R101 Fund innovation projects,
- R401 Promote stakeholder collaboration
- R202 Showcase DPP data usage and best practices,
- R502 Ensure practical applications and innovations,
- R303 Mandate cyber security measures, and
- R304 Digitise labels and markings.

Figure 24 shows the detailed results for each recommendation (contribution of the DPP to the CE) using a five-point Likert scale ranging from 0 = "strongly disagree" to 4 = "strongly agree", the mean value, and the standard deviation.



Figure 24: Recommendations for policymakers (contribution to the circular economy)





Furthermore, the resulting recommendations are ranked and listed according to their perceived priority level for policymakers. These values were obtained during the last round of the Delphi study, where 55 out of 67 recommendations achieved an overall agreement level of more than 70% – equivalent to 2.8 on the Likert scale – regarding their perceived priority level for policymakers. In this respect, the top ten recommendations are:

- R301 Ensure policy coherence
- R303 Mandate cyber security measures,
- R302 Define technical vocabularies and ontologies,
- R401 Promote stakeholder collaboration,
- R307 Set a timeline for DPP implementation across sectors,
- R501 Advocate for transparency, sustainability, and circularity,
- R506 Create a level playing field,
- R101 Fund innovation projects,
- R204 Establish public-private collaboration, and
- R105 Support SMEs financially.

Figure 25 shows the detailed results for each recommendation (priority level for policymakers) using a five-point Likert scale ranging from 0 = "strongly disagree" to 4 = "strongly agree", the mean value, and the standard deviation.



Figure 25: Recommendations for policymakers (priority level for policy)





Finally, the resulting recommendations are ranked and listed according to the overall agreement on their content. These values were obtained during the second and third rounds of the Delphi study, where 61 out of 67 recommendations achieved an overall agreement level of more than 70% – equivalent to 2.8 on the Likert scale – regarding their content. In this respect, the top ten recommendations are:

- R303 Mandate cyber security measures,
- R301 Ensure policy coherence,
- R305 Define data requirements for the DPP,
- R501 Advocate for transparency, sustainability, and circularity,
- R302 Define technical vocabularies and ontologies,
- R202 Showcase DPP data usage and best practices,
- R507 Standardise business-related DPP terminology,
- R201 Support training and educational programmes,
- R503 Seek stakeholder engagement and feedback, and
- R401 Promote stakeholder collaboration.

Figure 26 shows the detailed results for each recommendation (consensus) using a five-point Likert scale ranging from 0 = "strongly disagree" to 4 = "strongly agree", the mean value, and the standard deviation.



Figure 26: Recommendations for policymakers (consensus)





As explained in the method section, the recommendations were categorised based on the Better Regulation Toolbox of the European Commission. The resulting recommendations, their respective categories, and index numbers are listed below and **ranked according to the perceived contribution of the DPP to the circular economy** (Table 7):

- R101-R107: Economic instruments,
- R201-R205: Education and information instruments,
- R301-R312: Legally binding policy instruments,
- R401-R409: Soft policy instruments, and
- R501-R512: General recommendations for policymakers.

R#	Explanation	Contribution to the Circular Economy (Mean; Standard deviation)	Priority level for policymake rs (Mean; Standard deviation)	Consensus (Mean; Standard deviation; Delphi Round*)
Econon	nic Instruments			
R101	Fund innovation projects: Fund innovation projects on physical infrastructure for the circular economy, e.g., end-of-life collection and processing and DPP-based circular business models and ecosystems. This could facilitate the implementation of DPPs and the development of sector-specific solutions.	3.31; 0.72	3.17; 0.75	3.17; 0.62; 3
R102	Fund open-source solutions: Fund open-source solutions, prototypes, and methodologies related to DPPs.	3.16; 0.87	2.97; 0.94	3.18; 0.82; 2
R103	Fund DPP research: Allocate funding for research focused on technologies, interoperability, and innovative applications of DPPs in various industries. Focus on unexplored opportunities such as new products and services, circular business models, ecosystem development, and innovations related to DPP data.	3.11; 0.75	2.89; 0.93	3.11; 0.71; 3
R104	Increase fines for misuse: Increase fines for fraudulent economic operators that misuse or alter DPP data (in alignment with the Green Claims Directive) to combat greenwashing, allegedly sustainable products, and counterfeits.	3.08; 0.77	3.14; 0.90	3.17; 0.81; 3
R105	Support SME's financially: Support SMEs through subsidies, loans with favourable rates, or other instruments (e.g., vouchers) to allow them access to DPP-related services such as training, support, or DPP-as-a-service offers. This could encourage SMEs to adopt DPPs and circular business models.	3.06; 0.84	3.14; 0.91	3.14; 0.95; 2
R106	Provide fiscal incentives: Provide tax reductions or fiscal incentives to encourage circular business practices adopting DPPs. For instance, introduce taxation considering the	2.74; 0.96	2.48; 1.00	2.68; 0.88; 3



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	environmental impact of products using DPP data (i.e., eco-			
	modulated taxes), decrease taxes on circular services such as			
	repair when DPP data is used or updated, and shift taxes from			
	labour to resources using DPP data (e.g., Ex'Tax).			
R107	Introduce funding for DPP solutions for SMEs: Introduce	2.63; 1.11	2.47; 1.24	2.83; 1.01; 3
	funding schemes or grants for DPP-related software solutions			
	directed at SMEs, such as DPP-as-a-service, product data			
	management, or product life cycle management solutions.			
Educati	ion and Information Instruments			
R201	Support training and educational programmes: Support	3.35; 0.68	3.05; 0.97	3.36; 0.64; 2
	training and educational programmes for the workforce,			
	economic operators (particularly SMEs), and consumers about			
	topics related to DPPs. These topics may include circular			
	economy principles, standards, interoperability, legal			
	requirements, benefits, and general usage of DPPs. These			
	programmes could be implemented through online resources,			
	training and workshop programmes, or higher education			
	courses.			
R202	Showcase DPP data usage and best practices: Showcase how	3.31; 0.77	3.03; 0.84	3.36; 0.67; 3
	DPP data can improve the success of circular economy			
	practices and sustainable business models. Develop			
	guidelines with best practices and highlight efficient			
	implementation pathways of DPPs.			
R203	Initiate information campaigns: Initiate information	3.18; 0.73	3.13; 0.84	3.18; 0.73; 3
	campaigns to raise awareness on both circular economy			
	principles and DPPs' usage. They could also empower			
	economic operators and consumers to make informed			
	decisions regarding product sustainability and circularity.			
R204	Establish public-private collaboration: Establish collaboration	3.16; 0.72	3.16; 0.82	3.11; 0.76; 3
	mechanisms between legislators and the industry, such as			
	public-private partnerships, round tables, or knowledge-			
	sharing platforms to support the transition towards DPPs.			
	These mechanisms shall include all relevant stakeholders of a			
	circular value chain.			
R205	Create support centres: Create regional DPP support centres	2.81; 0.82	2.72; 0.94	2.92; 0.81; 3
	or hubs to help economic operators, especially SMEs, with the			
	implementation of DPPs.			
Legally	Binding Policy Instruments	1	1	ł
R301	Ensure policy coherence: Ensure policy coherence and reduce	3.45; 0.76	3.57; 0.69	3.48; 0.92: 2
	duplication of efforts by economic operators, for instance, by	,	,	, ,
	aligning data protection rules and necessary data exchange			
	for DPPs. Some data requirements are already fulfilled by			
	existing databases (e.g., EPREL, SCIP).			
R302	Define technical vocabularies and ontologies: Define cross-	3.34: 0.67	3.34: 0.71	3.40; 0.87: 2
	sectoral technical vocabularies and ontologies, that is, rich	- ,	· ·, ··· -	_,, _
	metadata models, exchange protocols, interfaces, and			
	standardised information systems across product groups.			
•				



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	actors, and sectors. Also, existing data-sharing technologies			
	and databases should be included. This ensures			
	interoperability, easy access to integrating the DPP, and a			
	smooth information exchange for the DPP in global value			
	chains.			
R303	Mandate cyber security measures: Ensure cyber security	3.29; 0.93	3.45; 0.86	3.50; 0.77; 2
	measures are in place to protect confidential business			
	information and intellectual property, building trust in the			
	system's reliability and integrity.			
R304	Digitise labels and markings: Replace certain labels,	3.28; 0.78	3.11; 0.80	3.31; 0.95; 3
	information, and markings with digital ones in the DPP,			
	keeping the most important ones. Digitise, for instance,			
	manuals and sustainability certificates to reduce paper			
	documentation and waste.			
R305	Define data requirements for the DPP: Define mandatory and	3.24; 0.98	3.14; 1.00	3.41; 0.80; 2
	non-mandatory data requirements for the DPP at different			
	levels (model, batch, or item level), with the mandatory			
	adhering to the data minimisation principle (i.e., limit			
	collection to only relevant and necessary data to accomplish			
	the purposes of the DPP). This could reduce the burden on			
	economic operators and enhance DPP usability.			
R306	Allow regular updates to the DPP: Allow regular updates to	3.2; 0.76	2.91; 0.95	3.12; 0.89; 2
	the DPP to reflect changes to the product status and			
	ownership throughout its life cycle. Set clear guidelines			
	regarding what economic operators shall make these updates			
	(e.g., batteries may belong to a leasing company, whereas the			
	electric vehicle belongs to the final customer).			
R307	Set a timeline for DPP implementation across sectors: Set a	3.19; 0.98	3.28; 0.94	3.24; 0.89; 2
	timeline for the rollout of DPPs across different sectors			
	(through delegated acts) to uphold the goals outlined in the			
	European Green Deal. Effective implementation requires the			
	adoption of the Green Claims Directive and the			
	implementation of DPPs by the public sector.			
R308	Grant regulatory flexibility for technologies: Grant regulatory	3.19; 0.89	3.14; 0.99	3.22; 0.95; 2
	flexibility for technologies and specifications related to the			
	DPP, e.g., QR codes, RFID chips, or other approaches. This			
	could enable market actors to find the most innovative and			
	appropriate solution for their sector.			
R309	Align standards with international initiatives: Align DPP	3.16; 0.92	3.11; 0.98	3.16; 1.00; 2
	standardisation efforts with relevant international initiatives.			
	Exemplary initiatives include the Digital Product Conformity			
	Certificate Exchange (DPCCE), Building Information Modelling			
	(BIM), and trade and sustainable development chapters of			
	international treaties. This could enhance interoperability,			
	facilitate digital end-to-end processes in the value chain, and			
	help European countries stay strong players in a global			
	market.			





R310	Allow access to use phase data: Allow economic operators to	2.84; 0.93	2.64; 1.02	2.81; 0.81; 3
	access dynamic use phase data on the DPP (e.g., battery			
	management system data), while ensuring compliance with			
	data privacy regulations and IP protection. This could improve			
	product design, reduce the need for repairs, and minimise			
	waste.			
R311	Introduce mandatory eco-labelling: Introduce mandatory	2.59: 1.08	2.41: 1.10	2.71: 0.97: 3
	eco-labelling schemes based on DPP data that build upon or			,,, _
	streamline existing certification efforts. This could facilitate			
	product sustainability comparisons and enhance consumer			
	awareness			
R312	Grant sufficient time to implement DPPs: Establish a	2 46.1 1	2 62.1 01	2 81.0 81.3
1012	transitional period for the first sectors implementing DPPs	2.40, 1.1	2.02, 1.01	2.01, 0.01, 5
	after regulation and standardisation have entered into force			
	These sectors could face challenges, such as low automation			
	of and of life processing and everal low digital maturity of			
	or end-or-me processing and overall low digital maturity of			
Soft Po	licy Instruments		-	
R401	Promote stakeholder collaboration: Promote stakeholder	3.31; 0.63	3.31; 0.72	3.32; 0.72; 2
	collaboration (e.g., cross-sector alliances) to create a			
	consistent approach to circularity, sustainability, and DPP-			
	related software solutions, as well as share knowledge and			
	best practices on DPPs.			
R402	Promote investments in digital infrastructure: Promote	3.17; 0.86	3.06; 0.91	3.07; 0.82; 2
	investments in digital infrastructure (e.g., identification			
	systems, data storage and exchange, interfaces) among			
	economic operators to support the implementation of DPPs			
	at scale.			
R403	Incorporate quality assurance: Incorporate quality assurance	3.03; 0.81	2.86; 0.90	2.97; 0.87; 2
	processes, digital tools and certificates to measure and			
	standardise data quality in the DPP.			
R404	Strengthen green public procurement: Use green public	3.00; 0.92	2.68; 0.98	3.00; 0.73; 3
	procurement (GPP) to prioritise firms and SMEs using DPP			
	software solutions, drive sustainable demand for products			
	with active DPPs, and showcase best practices. Enhance these			
	practices and prevent greenwashing through progressive GPP			
	targets.			
R405	Encourage the inclusion of information about take-back	2.71; 1.00	2.62; 1.04	2.71; 1.09; 3
	schemes: Encourage the inclusion of information about			
	product take-back schemes (e.g., deposit refund) into DPPs to			
	boost circularity, sustainability, reverse logistics, and			
	extended producer responsibility (EPR).			
R406	Develop platforms to aggregate DPP data: Develop platforms	2.67; 1.17	2.42; 1.34	2.92; 1.05; 3
	and dashboards to aggregate publicly available DPP data to			
	track circulating products and materials, automate			
	compliance checks, or improve the efficiency of public			
	oversight processes. DDP-based platforms could			
	automatically collect and aggregate data already available in			
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	DPPs, avoiding additional bureaucracy for economic actors			
	and facilitating the activities of public entities.			
R407	Encourage primary data collection: Encourage primary data	2.64; 0.96	2.45; 1.09	2.64; 1.03; 3
	collection by economic operators instead of delegation to			
	external certification experts to prevent vendor lock-in effects			
	and the creation of power imbalances.			
R408	Commission an agency for circularity and sustainability data:	2.49; 1.07	2.14; 1.22	2.49; 1.07; 3
	Commission an agency to monitor product flows throughout			
	their entire life cycle using publicly available DPP data. The			
	agency could monitor safety and environmental concerns of			
	waste management, collection rates of second-life products,			
	and measure sustainability impacts. They could generate			
	statistical information for research purposes and increase the			
	overall transparency of the circular economy.			
R409	Create recognition systems: Create recognition systems and	2.41; 1.08	2.30; 1.16	2.59; 0.96; 3
	sector-specific awards for pioneering economic operators			
	that exceed regulatory requirements in implementing DPPs			
	for circularity, sustainability, and legal compliance.			
Genera	al Recommendations for Policymakers			
R501	Advocate for transparency, sustainability, and circularity:	3.37; 0.55	3.27; 0.76	3.41; 0.61; 3
	Prioritise the fundamental principles of DPPs – transparency,			
	sustainability, and circularity – and ensure these values			
	remain central in a form-follows-function approach.			
R502	Ensure practical applications and innovations: Ensure that	3.29; 0.63	3.09; 0.78	3.29; 0.67; 3
	DPPs have practical applications that increase economic			
	performance and generate product, service, and business			
	model innovations. The DPP should not just be a data			
	collection effort for compliance purposes.			
R503	Seek stakeholder engagement and feedback: Establish	3.08; 0.66	3.10; 0.79	3.35; 0.71; 2
	mechanisms for continuous stakeholder engagement,			
	including businesses, consumers, technology providers, and			
	environmental organisations. Seek feedback on DPP			
	implementation, address concerns, and improve policies			
	based on real-world experiences.			
R504	Use DPP data to measure the circular economy: Use DPP	3.06; 0.92	2.91; 1.06	3.12; 0.98; 3
	data to measure the circular economy. Define necessary KPIs			
	to measure product and resource circularity (e.g., resource			
	consumption, use of recyclates, employed R-strategies), and			
	include those data points into DPPs to enable a data-driven			
	evaluation.			
R505	Support sustainability reporting: Support sustainability	3.03; 0.88	2.92; 1.09	3.27; 0.84; 2
	reporting and compliance based on DPP data for economic			
	operators. Simplify and promote transparency in			
	sustainability reporting using the DPP.			



R506	Create a level playing field: Ensure that the introduction of	3.03; 0.97	3.20; 0.99	3.22; 0.90; 3
	DPPs does not create power imbalances to the detriment of			
	SMEs. The ESPR and delegated acts shall contribute to a level			
	playing field.			
R507	Standardise business-related DPP terminology: Standardise	3.00; 0.73	2.95; 0.86	3.36; 0.58; 3
	business-related DPP terminology (e.g., stakeholder			
	categories and types, traceability in the DPP context) and use			
	it consistently to enable clear communication and avoid			
	stakeholder confusion.			
R508	Ensure a gradual knowledge-building process: Ensure a	2.97; 0.65	2.89; 0.90	3.06; 0.67; 3
	gradual knowledge-building process about the DPP among			
	economic actors and policymakers. Support regulatory			
	sandboxes, living labs, and hubs for the DPP. Conduct impact			
	assessments on circularity, sustainability, and legal			
	compliance to evaluate the DPP. This could prioritise data			
	quality and the usability of the DPP while promoting			
	innovation.			
R509	Build an energy-efficient system: Design the DPP system and	2.97; 0.91	3.06; 0.94	3.17; 0.74; 3
	infrastructure as energy and resource-efficient as possible,			
	with special attention to data transmission and data carriers			
	at end of life.			
*The co	nsensus threshold was achieved (or not achieved) on the second "2" or	r third round "3	"	

Table 7: Recommendations for Policymakers

5.4.2. Recommendations for Businesses

The resulting recommendations are ranked and listed according to the overall **agreement on their content**. These values were obtained during the second and third rounds of the Delphi study, where 12 out of 13 recommendations achieved an overall agreement of more than 70% – equivalent to 2.8 on the Likert scale – regarding their content. In this respect, the top five recommendations are:

- R601 Implement data security and privacy measures,
- R602 Map data requirements to stakeholders,
- R603 Deploy pilot projects,
- R604 Improve sustainability practices, and
- R605 Engage and share data with the customer.

Figure 27 shows the detailed results for each recommendation using a five-point Likert scale ranging from 0 = "strongly disagree" to 4 = "strongly agree", the mean value, and the standard deviation.





Figure 27: Recommendations for businesses ranked according to their consensus on content³⁵

In Table 8, the recommendations are numbered and ranked according to the overall agreement on their content:

R#	Explanation	Consensus (Mean; Standard Deviation; Delphi Round*)
R601	Implement data security and privacy measures: Implement high data security	3.48; 0.78; 2
	and privacy measures to protect sensitive information during the deployment of	
	DPPs. This could build consumer trust and boost adoption.	
R602	Map data requirements to stakeholders: Map data requirements of the DPP to	3.44; 0.66; 3
	internal and external stakeholders to prepare for the implementation of DPPs,	
	plan efficient data collection and exchange, and identify potential challenges.	
R603	Deploy pilot projects: Deploy pilot projects with specific products to test the	3.36; 0.62; 2
	DPP before full-scale implementation. Use these initiatives to identify	
	challenges, refine processes, and ensure a smooth integration of DPPs in the	
	business.	

³⁵ Consensus was achieved in the second and third round. For further details, please see Table 8



R604	Improve sustainability practices: Use the detailed information within DPPs to	3.36; 0.62; 2
	improve sustainability practices, such as optimising resource use, enhancing	
	product design for longevity, and facilitating recycling.	
R605	Engage and share data with the customer: Develop strategies to engage and	3.26; 0.71; 2
	share data with the customer before and after a product's sale. For instance,	
	educating customers about DPPs, their products' environmental and social	
	impacts, and how they can access DPP data to make purchasing decisions. Share	
	product data to verify green claims and foster trust and brand reputation.	
R606	Develop a long-term vision and strategy: Develop a long-term vision and	3.24; 0.9; 3
	sustainability strategy involving the deployment of DPPs, circular business	
	models, and innovative business practices (e.g., product-as-a-service, leasing,	
	and rentals) to create new revenue streams and address untapped	
	opportunities.	
R607	Train staff on DPP and circularity: Train staff on skills related to the	3.23; 0.66; 2
	implementation and utilisation of DPPs, sustainability, circularity, and	
	compliance to support the interaction of the DPP with these goals.	
R608	Invest in digital technologies: Invest in interoperable, adaptable IT solutions	3.18; 0.81; 2
	and automation to prepare for the deployment of DPPs. This includes leading	
	the digital transformation of the supply chain, investing in standardised data	
	management, storage, and analysis solutions, as well as testing emerging	
	technologies such as AI, the IoT, or blockchain.	
R609	Leverage data for sustainability reporting: Leverage DPP data to enhance	3.12; 0.77; 2
	sustainability reporting and demonstrate the commitment to circularity and	
	environmental responsibility.	
R610	Foster collaboration with stakeholders: Foster collaboration with multiple	3.09; 0.81; 2
	stakeholders to ensure a seamless integration of the DPP across the value chain.	
	Businesses can collaborate with the supply chain to ensure data is accurate, up-	
	to-date, and compliant with DPP requirements. They can join industry	
	associations or run projects with research organisations to share knowledge,	
	develop common approaches, and advocate for supportive policies. Finally, they	
	can partner with start-ups and technology providers to access cutting-edge DPP	
	solutions and accelerate implementation.	
R611	Establish data quality checks: Establish internal processes to review and	3.09; 0.93; 3
	manage DPP data quality. Implement validation mechanisms and regularly audit	
	the information to maintain a high level of trustworthiness. Consider external	
	partners or independent actors that might change the product without updating	
	the DPP.	
R612	Develop risk management protocols: Develop risk management protocols to	2.99; 0.79; 2
	ensure compliance with evolving regulations related to DPPs. Stay informed	
	about legal requirements and adapt DPP practices accordingly to mitigate legal	
	and reputational risks.	
R613	Develop a unified IT system (new): Develop a unified, interoperable IT system	2.75; 1.23; 3
	for the DPP to avoid creating isolated platforms. This system should be capable	
	of accommodating various DPPs under a single framework, promoting	





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	integration and seamless communication between different sectors and	
	product categories.	
'The cor	nsensus threshold was achieved (or not achieved) on the second "2" or third round "3".	

Table 8: Recommendations for Businesses

5.4.3. Recommendations for IT firms

The resulting recommendations are ranked and listed according to the overall **agreement on their content**. These values were obtained during the second and third rounds of the Delphi study, where 11 out of 12 recommendations achieved an overall agreement level of more than 70% – equivalent to 2.8 on the Likert scale – regarding their content. In this respect, the top five recommendations are:

- R701 Design user-friendly platforms,
- R702 Prioritise robust data privacy and security measures,
- R703 Involve users in product development,
- R704 Avoid vendor lock-in issues, and
- R705 Build up know-how.

Figure 28 shows the detailed results for each recommendation using a five-point Likert scale ranging from 0 = "strongly disagree" to 4 = "strongly agree", the mean value, and the standard deviation.



Figure 28: Recommendations for IT firms ranked according to their consensus on content³⁶

³⁶ Consensus was achieved in the second and third round. For further details, please see Table 9





In Table 9, the recommendations are numbered and ranked according to the overall agreement on their content:

R#	Explanation	Consensus (Mean; Standard Deviation; Delphi Round*)
R701	Design user-friendly platforms: Design user-friendly interfaces and platforms to facilitate a low-effort adoption and widespread usage of DPPs by businesses and consumers. Platforms should allow easy creation, management, and utilisation of DPPs.	3.47; 0.66; 2
R702	Prioritise robust data privacy and security measures: Prioritise robust data privacy and security measures in DPP development and data management solutions. Implement encryption, secure authentication, and access controls to safeguard sensitive product information and ensure the integrity of the DPP.	3.46; 0.76; 2
R703	Involve users in product development: Involve users as early as possible in the development of IT solutions for DPPs.	3.27; 0.81; 2
R704	Avoid vendor lock-in issues: Offer interoperable DPP solutions and neglect vendor lock-in practices to comply with the requirements of the DPP regulation.	3.23; 0.9; 2
R705	Build up know-how: Build up know-how on relevant technologies and architectures involved in DPP developments (e.g., semantic web, knowledge graph, RFID technologies, SPARQL queries) to support economic operators with the implementation of DPPs.	3.23; 0.61; 2
R706	Launch pilot projects on new technologies: Launch pilot programs to explore the potential of emerging technologies, such as artificial intelligence and the Internet of Things, to enhance the functionality and effectiveness of DPPs.	3.19; 0.73; 2
R707	Use visualisation and storytelling: Explore data visualisation and storytelling techniques to communicate the benefits of DPPs and circular practices to a wider audience.	3.13; 0.75; 2
R708	Develop open-source solutions: Contribute to the development of open- source DPP solutions and common frameworks (e.g., ontologies) to promote collaboration, support circularity, and aim at wider adoption of DPPs across the ecosystem.	3.11; 0.87; 2
R709	Explore the use of different technologies: Explore the use of different technologies for the DPP and evaluate their potential for different business cases. For instance, explore the use of blockchain to improve traceability, transparency, and data security.	3.00; 0.87; 3
R710	Integrate different data confidentiality approaches: Integrate different confidentiality approaches for data collection depending on the level of security needs (e.g., simpler and resource-efficient measures for moderate security needs versus more complex ones for higher security needs).	2.97; 0.89; 3





R711	Leverage AI and data analytics: Develop data analytics solutions (e.g., artificial	2.88; 0.91; 3	
	intelligence) tailored to extract valuable insights from DPP data. Customer		
	firms could use insights for informed decision-making on product circularity,		
	sustainability, efficiency, and social impact.		
R712	Develop IoT-based solutions: Develop Internet of Things-based (IoT) solutions	2.71; 0.91; 3	
	that allow firms to regularly collect product data (e.g., status, performance,		
	use), exchange information with the product (if possible), and enrich their		
	DPPs.		
*The consensus threshold was achieved (or not achieved) on the second "2" or third round "3"			

Table 9: Recommendations for IT Firms

5.4.4. Recommendations with low consensus

After the third round of the study, 8 recommendations out of 67 remain with low consensus. This means they did not exceed the agreement threshold of 2.80 on average. With regards to recommendations for policymakers, these include:

- R106 Provide fiscal incentives (mean = 2.68),
- R311 Introduce mandatory eco-labelling (mean = 2.71),
- R405 Encourage the inclusion of information about take-back schemes (mean = 2.71),
- R407 Encourage primary data collection (mean = 2.64),
- R408 Commission an agency for circularity and sustainability data (mean = 2.49), and
- R409 Create recognition systems (mean = 2.59).

With regards to businesses and IT firms, these include:

- R613 Develop a unified IT system (mean = 2.75), and
- R712 Develop IoT-based solutions (mean = 2.71).

Among the feedback received in the second round, numerous comments focused on the recommendations with low consensus, and these topics were rather controversial amongst the participants. In general, the recommendations for policymakers that did not achieve consensus also achieved lower agreement levels for their contribution to the circular economy and their priority level for policymakers.



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6. Main Takeaways and Future Work

DPPs are envisioned to significantly enhance the digitalisation of sustainable business models and the circular economy. Firstly, DPPs could foster the implementation of circular strategies of maintenance, repair, reuse, remanufacturing, and recycling within industries, circular ecosystems, and supplier networks. For instance, ecosystem actors could utilise DPPs to achieve higher proximity to their customers during and before the execution of circular activities, improve product design for circularity, or provide relevant product data to remanufacturers and recyclers. Moreover, the reach of DPPs could extend beyond industry boundaries, allowing for the exchange of materials and components between different sectors. Secondly, collaboration and data availability through DPPs could facilitate new ways of sustainable value creation in a smart circular economy. Data from DPPs could empower firms to create new products and services based on data analytics or sustainability information. Endconsumers could make sustainable purchasing decisions informed by DPP data, while authorities and policymakers could promote a sustainable European economy and streamline customs and market surveillance. Finally, although our work provides reasonable evidence of the relevance of DPPs for different stakeholder groups, creating a level playing field for them is essential. This should include funding for research, open-source solutions, and SMEs, as well as education, training, and support services.

6.1. DBOCs: Main takeaways

The DBOCs identified in the study cover a wide range of topics, including education and training, circular strategies, standards, international supply and value chains, policy and regulation, business models, and ecosystems, among others. This variety provides insights for different stakeholders and underscores the multidimensional nature of introducing DPPs. Policymakers can harness these findings to develop targeted policies based on the DBOCs, while businesses and IT firms can leverage these insights to tackle the implementation of DPPs.

Although the demographic results of the DBOC study indicate that not all stakeholder groups potentially affected by DPPs are represented, the participating stakeholders exhibit high knowledge and awareness of DPPs. As mentioned earlier, their contributions to the empirical results are significant, marked by a wide variety of comments and insights.

As the mean values of the survey show, the perceived relevance of the DBOCs to the implementation and delivery of DPPs demonstrates a high overall degree of consensus. These findings provide empirical support for the significance of the identified DBOCs for the DPP. In addition, the relevance scores for most DBOCs are higher than their awareness scores. This suggests that considerable efforts in communication, education, and information are required concerning DPPs within the EU, specifically for businesses and economic operators, as they will be mandated to introduce DPPs into the market.

Although the overall number of **drivers** is low compared to barriers, opportunities, and challenges, we suggest they highlight two main aspects that can work as catalysts for the development of DPPs. First, they reflect evolving market expectations for DPP-enabled sustainable and circular products/services. Second, they emphasise the importance of regulatory changes and the effect of a strong regulatory framework in driving and enforcing DPP development. The following drivers support this perspective:



'Regulatory push and pull effect's (D1); 'A growing market for circular and sustainable products' (D2); 'Rising consumer expectations on transparency' (D3); 'Existing regulatory incentives for sustainability' (D4); and 'Increased awareness about social and environmental problems' (D5). Finally, we suggest that these two overarching themes are mutually reinforcing. While some market drivers are already relevant, DPPs are at a very early stage of development, and their introduction into the market is primarily influenced by regulatory changes. As the DPP system matures, market expectations and economic incentives could further drive the introduction of DPPs.

The **barriers** identified in the study reflect the overall low maturity of the field and the uncertainties felt among stakeholders in multiple dimensions. In particular, they underscore knowledge and resource constraints: 'Lack of awareness about current developments among firms' (B1); 'Lack of expertise and proficiency' (B2); and 'Higher costs and limited financial resources' (B6). They also portray market and cultural dynamics: 'Missing data from international actors outside the EU' (B4); 'Unclear financial benefits' (B8); and 'Lack of willingness to provide product data' (B9). Finally, they reveal the complexity of different systems such as value chains, the IT architecture, and the regulatory framework: 'Complexity of the value chain' (B3); 'Lack of standards' (B5); 'Wide diversity of specifications and standards for single products' (B11); and 'High complexity of the supporting IT architecture' (B12). Overall, the barriers suggest the need for improved communication, regulatory clarity, and reliable standards for the DPP introduction into the market.

The **opportunities** illustrate how the DPP could enable the circular economy, sustainable practices, and resource efficiency: 'Providing information on the material composition for recycling' (O1); 'Increasing recovery and use of recycled materials' (O2); 'Simplifying maintenance and repair (O4); and 'Providing sorters and recyclers with valuable insights' (O5). Additionally, they highlight likely business benefits related to data and technology integration: 'Increasing economic benefits from sustainable products' (O3); 'Creating an interoperable infrastructure for data exchange' (O9); and 'Simplifying access to product data in real-time' (O15). Finally, they underscore chances for compliance and governance: 'Limiting greenwashing and plagiarism' (O7) and 'Tracking and enforcing regulations and standards' (O18). Overall, these observations support the hypothesis that the DPP is an important vehicle for enhancing and strengthening the European twin green and digital transition.

Challenges provide insights into the difficulties expected in deploying DPPs in the coming years. First, stakeholders are particularly concerned with data management and the quality of the DPP system when collaborating with and relying on other actors: 'Ensuring security protocols and data protection' (C1); 'Lacking trustworthy data and dependence on other value chain actors' (C2); 'Ensuring data quality' (C4); and 'Achieving interoperability between data models and IT systems (C6)'. Second, they address the need for alignment of regulations and standards: 'Aligning relevant regulations with non-European governments' (C3); 'Lacking standardisation and guidance by the EU Commission and member states' (C7); and 'Lacking clarity on data usage by regulators' (C17). Finally, they highlight the difficulties of creating a sound environment for DPP development: 'Creating a level playing field' (C5); 'Educating consumers about relevant concepts' (C9); 'Changing internal processes, business models, and collaboration practices' (C12); and 'Aligning internal departments' (C15). Overall, these insights suggest that creating and enforcing clear rules and standards, as well as a transparent and interoperable system, will be crucial to instil trust in the DPP system and ensure the success of DPPs in the market.



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6.2. Recommendations: Main takeaways

Significant alignment exists among the topics identified in the DBOC analysis and the Delphi study on recommendations. The participants of both studies resemble the whole group of CIRPASS stakeholders. Although there is high diversity among this group, their underlying concerns and insights into the DPP were similar. For example, the recommendations address several previously identified short- and long-term barriers and challenges for the DPP. This suggests that stakeholders are aware of the necessary actions to overcome such obstacles. Likewise, the consensus data for the content of the recommendations, the perceived contribution of the DPP to the circular economy, and the priority level for policymakers showed uniformity. This suggests a general consensus on the relative importance of the topics identified and assessed in the study. The recommendations aim to fulfil the objectives of contributing to the circular economy, sustainability, and transparency, as well as drive digitalisation and the implementation of DPPs.

Regarding the demographic data, stakeholders from the IT and manufacturing industries have a high participation rate in this research. This indicates the high interest of these stakeholders in relation to DPPs and contrasts with the lower participation of other stakeholder groups such as consumers, circular economy operators, or civil society organisations. This shows similarities with the awareness values of the DBOC study. We suggest that the lack of involvement is not related to lower interest levels but low awareness and knowledge about the DPP. These findings again highlight the need for communication, education, and information efforts.

Similar to the DBOCs, the recommendations span a wide variety of topics, yet some overarching themes arise regarding the implementation and delivery of DPPs. First, regarding **economic** instruments, key themes include funding for research, innovation, open-source solutions, and SMEs: 'Fund innovation projects' (R101); 'Fund open-source solutions' (R102); 'Fund DPP research' (R103) 'Support SME's financially' (R105). Increasing penalties is also relevant: 'Increase fines for misuse' (R104).

Second, regarding **education and information**, focal points relate to supporting training, education, and information campaigns, as well as creating guidelines with best practices: 'Support training and educational programmes' (R201) and 'Initiate information campaigns' (R203). Additionally, supporting collaboration mechanisms between private and public organisations is seen as relevant: 'Establish public-private collaboration' (R204).

Third, **legally binding policy** instruments should emphasise policy coherence, alignment of standards and data exchange, and security measures to ensure interoperability across sectors and trust in the DPP system: 'Ensure policy coherence' (R301); 'Define technical vocabularies and ontologies' (R302); and 'Align standards with international initiatives' (R309). Moreover, clear definitions regarding a timeline, data requirements for the DPP, and policy changes are needed: 'Define data requirements for the DPP implementation across sectors' (R307).

Fourth, with regards to **soft policy** instruments, policymakers could promote investments and collaboration among stakeholders, standardise data quality assurance, and drive DPP adoption through green public procurement: 'Promote stakeholder collaboration' (R401); 'Promote investments in digital infrastructure' (R402); 'Incorporate quality assurance' (R403); and 'Strengthen green public procurement' (R404).



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Finally, **general recommendations** for policymakers underscore that transparency, sustainability, and circularity should remain central in the development of DPPs: 'Advocate for transparency, sustainability and circularity' (R501). Moreover, tangible applications for the DPP and stakeholder engagement for policy improvements should be pursued: 'Ensure practical applications and innovations' (R502) and 'Seek stakeholder engagement and feedback' (R503). Measuring circular flows, using DPP data for reporting, standardising business terminology, and ensuring knowledge building are also relevant measures: 'Use DPP data to measure the circular economy' (R504); 'Support sustainability reporting' (R505); 'Standardise business-related DPP terminology' (R507); and 'Ensure a gradual knowledge-building process' (R508).

Businesses should deploy pilot projects and engage with internal and external stakeholders to map their requirements and prepare for the implementation of DPPs: 'Map data requirements to stakeholders' (R602); 'Deploy pilot projects' (R603); and 'Foster collaboration with stakeholders (R610). In addition, protecting customer data is key to generating trust in the DPP: 'Implement data security and privacy measures' (R601). Finally, adapting the strategy and business practices towards sustainability arises as relevant measures to benefit from DPPs: 'Improve sustainability practices' (R604) and 'Develop a long-term vision and strategy' (R606).

IT firms shall build know-how and launch pilot projects to explore the potential of the DPP: 'Build up know-how' (R705) and 'Launch pilot projects on new technologies' (R706). In addition, they should focus on collaborating with users to design user-friendly and secure applications: 'Design user-friendly platforms (R701); 'Prioritise robust data privacy and security measures' (R702); and 'Involve users in product development' (R703). Finally, using open-source solutions and avoiding vendor lock-in is crucial to ensure interoperability of the DPP system: 'Avoid vendor lock-in issues' (R704) and 'Develop open-source solutions' (R708).

Overall, policymakers should prioritise circularity and sustainability when designing DPP-relevant regulations to maintain the focus of the DPP as an enabler of the circular economy. They should ensure the building of knowledge, alignment and participation of stakeholders, and a level playing field, with a particular focus on SMEs. Furthermore, funding for implementation and research should be considered. Businesses and IT firms should prioritise launching pilot projects and collaborating with stakeholders along the value chain to prepare for the deployment of DPPs. Although these insights are not exhaustive, they summarise the main learnings and findings of this study.

6.3. Further research and implementation work

Since DPPs are under development and the first DPPs mandated by EU regulation, namely the battery passports, are set to come into effect in 2027, our findings represent a snapshot of the state-of-theart on DPPs. DBOCs and recommendations for action are expected to evolve as the implementation process of the DPP system and DPPs unfolds. Further research and implementation work will be required to align expectations and continue developing this emerging field towards maturity.

Firstly, one interesting observation is that current DPP development in the EU is already receiving high interest beyond EU borders. For instance, participants with global operations are one of the largest groups in all Delphi surveys. Therefore, further internationalisation and collaboration efforts are needed. Ideally, DPPs should be interoperable with similar endeavours outside of the EU. It is crucial that international standardisation organisations adopt current standardisation efforts related to the





DPP's underlying technical infrastructure and business activities. This is key to enabling data sharing across international borders. In addition, pilot projects that embrace large international supplier networks should start to align all relevant ecosystem actors that gather DPP data. This is vital because most supply chains do not end at EU borders; thus, circularity should not be seen solely as an EU internal concern. Hence, adopting a global perspective could lead to spillover effects and ensure a point of no return for the worldwide implementation of DPPs.

Secondly, regulation and technological developments operate at different speeds. Future work and research should consider investments in technological developments and the use of newer technologies such as distributed ledgers, the Internet of Things, or Artificial Intelligence in the context of the DPP. Pilot programs should incorporate emerging digital tools and technical infrastructure to explore their potential to enhance the functionality and effectiveness of DPPs.

Thirdly, it is essential that all data relevant to the circular economy is available during the introduction of DPPs across different sectors. For example, DPPs should include mandatory or required proofs of quality, like EU declarations of product conformity. This inclusion would provide additional utility to DPP users and support the circular economy by improving information quality and reducing the paperwork burden for products and materials.

Fourthly, given the novelty of the topic and tight regulatory timelines, consistently providing updates on DPP developments to various stakeholder groups is highly relevant. Educational and informational campaigns are crucial to raise awareness about the latest DPP regulatory and implementation developments. In addition, research and communication about best practices and new business models are needed to uncover more opportunities for the circular economy.

Fifthly, reoccurring comments on recommendations with low consensus in the second round criticised, for instance, whether some recommendations disproportionately favour large companies. The urgency of action regarding climate change was also highlighted when assessing recommendations on transitional periods for the implementation of DPPs. Moreover, specific aspects of DPP design, such as implementing dynamic use phase data or take-back schemes, were frequently discussed. These debates illustrate that some areas are still controversial and require further study and consensus.

Finally, it was interesting to see that the results of both DBOC and recommendations studies did not significantly differ across industries, namely cross-sectoral, batteries, electronics, or textiles DPPs. We therefore suggest that this alignment of perspectives is due to the early phase of the DPP's introduction. However, this may change considerably when the ESPR delegated acts become public, the DPP system matures, and the first experiences with DPP implementation are reported. Thus, research on DBOCs and ensuing recommendations for action should be regularly performed during the forthcoming phases of DPP development.





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