Digital Product Passport Implementation: Key Factors in Circular Economy of Textiles
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The Digital Product Passport (DPP) is a technological proposal for a digital policy tool that gathers data on the value chain, sustainability, raw materials, and safety of products across several sectors. The DPP might also gather data on how products are used, maintained, recycled, and repurposed. This transparency aims to support the circular economy transition, promote sustainable production, open up new business opportunities for economic actors, assist authorities in ensuring compliance, and support consumers and end users in making sustainable decisions.

The DPP concept has started to gain high attention recently and a multitude of activities by research organizations, policymakers, and businesses are in progress. However, there is a lack of industry-specific research about what kind of effects the DPP implementation would have on the textile value chains that have been identified to be very complex, global, and heterogeneous. This study aims to identify the perceptions and key factors in the DPP implementation specific to the Finnish textile industry. Secondly, it provides a brief overlook of the current status of the DPP development in the EU. To explore the perceptions and key factors in the DPP implementation eight businesses of different sizes and business models were interviewed. Prior to the interviews, a comprehensive literature review was conducted to compare the findings with previous findings of the academic research.

As a result, the study finds that successful DPP implementation by EU policymakers, which considers the business point of view, could lead to a competitive advantage for Finnish textile companies. The perception of the DPP is positive and the expectations towards the increased transparency are high as the DPP is seen as a valuable element to contributing to the Green Transition. Organizational IT skills are considered to be sufficient for the DPP implementation, yet concerns about the financial resources and time constraints especially within SME companies were emphasized. Although businesses face versatile challenges in the implementation process, the readiness and willingness of the Finnish textile industry can be an important aspect of the successful DPP implementation.

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1 Introduction

This chapter introduces the background and motivation for the thesis. Secondly, the aim of the study, research questions, and thesis structure are reviewed.
1.1 Thesis motivation and background

The circular economy is a concept that is becoming more and more prominent on the agendas of both industry and policymakers. This is demonstrated, for instance, by the European Union’s recently released Circular Economy Action Plan (CEAP) and a growing body of research that demonstrates the circular economy is becoming more significant for enterprises. (Walden et al., 2021) The textile industry is still in the early stages of adopting circular economy practices. Although, there are already textile enterprises established on circular economy ideas that prioritize long-term sustainability. (Luoma et al., 2022)

More and more end-of-life products are being collected, recycled, or remanufactured, yet data about products is rarely shared between stakeholders. This could include product data such as material flows, how to disassemble products, or whether they contain dangerous substances. Secondly, manufacturers receive limited information on how their products are handled at the end of their lives and what issues arise during recycling. Moreover, users are unaware of which products are made in a way that has a little negative impact on the environment, as well as if they are recyclable. (Plociennik et al., 2022)

Additionally, consumers now want to make more informed purchases since they are increasingly aware of the social and ecological concerns associated with the textile business and do not want to support such activities. For these reasons, new laws and regulations are needed to improve the transparency of the globalized and dispersed textile supply chains. (Ospital et al., 2022)

In other words, reliable, up-to-date, and accessible data is a key enabler of a well-functioning circular economy. In the textile industry, there is a pressing demand for product data and value chain information for textile tracking and traceability, as well as to improve material processing and recycling. Data and information are even more important in a circular economy since they allow us to plan and create more sustainable textile systems while also enabling improved product recycling. (Kauppila et al., 2022)

To boost the development of reliable product data the European Commission has proposed the creation of Digital Product Passports (DPPs) (European Commission, 2022a). DPPs are projected to play a critical role in accelerating the transition to a circular economy by facilitating the exchange of information on product sustainability metrics. DPPs, in general, could be critical to enabling new circular economy business models and carbon reduction strategies, as well as social compliance reporting. A generally applicable DPP approach, on the other hand, remains to be established. (CISL, 2022)
1.2 Study objective

Despite the increased interest in the Digital Product Passport offered by the European Commission’s proposal in March 2022, there are only limited studies about the perceptions, and how companies see the upcoming regulation. Especially in the textile sector, there is not yet a comprehensive understanding, of how DPP implementation would affect companies operating in the textile value chain. Solita (2022) recommends that different kinds of feasibility studies and economic impact assessments would be carried out to find out the DPP implementation effect on textile sector companies and deep dive into practical limitations that occur specifically in this industry.

To fill this gap in the existing literature, this thesis aims to identify the perceptions of the industry and study what are the key factors in DPP implementation for the Finnish textile industry.

To achieve these objectives two specific research questions are posed:

1. What kind of perceptions do textile industry enterprises have on the implementation of DPP?

2. What kinds of impacts the implementation of DPP would have on the current operations of textile industry enterprises?

By interviewing individual companies that are of different sizes, have a distinct customer base, and operate in different phases of the textile value chain, the thesis aims to create a holistic picture that represents better the views of the Finnish textile industry.

1.3 Empirical context

This thesis was commissioned by Finnish Textile & Fashion, the central organization for textile, clothing, and fashion companies in Finland. The thesis continues the work started by Finnish Textile & Fashion and Technology Industries of Finland in the Spring 2022, where a general DPP concept was created and piloted with batteries and textiles. This thesis focuses specifically on DPP implementation in the textile industry.

1.4 Thesis structure

There are six chapters in this thesis. The reader was given a brief overview of the research themes in the introduction chapter, which also included the research questions. The next section in the thesis, chapter two, will go further into the analysis of previous research and discuss recent findings as well as concepts and theories associated with the key research areas. The research method and methodologies used in the empirical research for this thesis are presented in chapter three. It provides an overview of the research design, data collection and analysis, and lastly, a conclusion that assesses the research methodologies used and addresses ethical implications. Next, the findings of the empirical study will be presented in chapter four. After that, the discussion chapter gives answers to the research questions and contextualizes the findings within the framework of previous research. The conclusions chapter wraps up by summarizing the thesis, outlining the implications of the findings, and making recommendations for possible future studies.
2 Literature review

This chapter presents a theoretical framework for the thesis. Firstly, the Digital Product Passport will be introduced. In the first part of the chapter, the thesis looks into the background of the DPP in terms of regulation and explains the main benefits and challenges recognized. Additionally, the technical aspect of the DPP is briefly discussed.

In the second part of the chapter, the thesis discusses how the digital product passport is addressed in the circular textile industry context. In the chapter, industry-specific DPP implementation factors are considered to deepen the understanding of the characteristics defining the textile industry.
Digital technologies offer a significant chance to expand the circular economy and offer the ideal solutions to advance it further, since, they enable the creation and processing of data and information necessary for circular business models and the complex requirements of circular supply chains. In order to develop and scale the circular economy, higher levels of transparency and information are needed. Thus, information shortages need to be solved. (Berg et al., 2020)

Moreover, DPPs can also accelerate the dual green and digital transitions as part of EU efforts to achieve effective climate action and sustainable economies. (CISL, 2022) DPPs are thought to be crucial components in establishing a circular economy, which is a major element of the "Green Deal" and the "Twin Transition" strategy of the European Union that is why DPPs are a significant component of current circular economy regulation activities. (Jansen et al., 2022)

As said, the EU has highlighted the need for a low-carbon transition and a circular economy with the help of the Digital Product Passport. It is intended to provide information on a product’s composition, origin, repair, and disassembly options, as well as how to handle it when its life is ended. Regarding the DPP’s final layout and execution, there are a number of unsolved concerns. For instance, the DPP needs to be integrated into a long-established regime with various information requirements. (Adisom et al., 2022)

In figure 1, a general concept for DPP created by Solita (2022) is introduced where product data of different actors in different phases of the value chain is gathered into a DPP. The following sub-chapters will look further into the background of the DPP. It is necessary to explore objectives, regulation basis, and technical details to gain a better understanding of the subject.
2.1.1 What is a Digital Product Passport?

The concept of the Digital Product Passport is broad and multiple definitions have been given. Jansen et al. (2022) have identified 76 current research, corporate, and policy activities regarding the DPP. They add that only a few DPP activities have been placed in practice. In this part of the thesis, the various definitions will be discussed to gain a better understanding of the concept.

Adisorn et al. (2021) define The Digital Product Passport (DPP) as a concept of policy instrument, preliminarily designed to compile product-related information in digital format to serve as a foundation for more circular products. CISL (2022) adds that for instance, a product’s origin, composition, and potential for repair and disassembly, as well as information on how the various parts can be recycled or disposed of at end of life, would all be covered by the DPP. Jansen et al. (2022) define the DPP followingly to combine the previous definitions mentioned:

“a set of data summarising a product’s components, materials, chemical substances, and/or information on reparability, replacement parts, and proper disposal. The data originates from all phases of the product life cycle and can be used for various purposes in all these phases (design, manufacture, use, disposal).”

Currently, product-related data is rarely shared between stakeholders, and for instance, manufacturers have limited access to inspect how their products are processed in the end-of-life phase. Additionally, users of the products lack information about the environmental impact of the product and the possibility to recycle products. (Plociennik et al., 2022a)

The required data provided by DPP could be utilized to more efficiently identify, track, and manage resources along a product’s complex value chain, promote the improvement of sustainability performance, and ultimately support consumers’ sustainable purchasing decisions (Deloitte, 2022).

In the future, the proposal for Ecodesign for Sustainable Products Regulation suggests that the DPP will be required for all products covered by a delegated act that will be identified later on in the regulation process. Dedicated priority areas include batteries, textiles, ICT, structures, and toys, but DPP will eventually apply to all physical goods. There are several commercial DPP solutions and technical sub-solutions accessible right now, but there isn’t a fully developed and implemented solution yet. (Saari et al., 2022)

An important observation is that DPP use cases vary between industries leading to different demands. In terms of information content, procurement, and design, an organization dealing with DPPs for the construction sector, for instance, has different requirements than one using a DPP for the textile or automotive industries. It is also feasible to design the DPP in many ways for various sectors or businesses thanks to the large range of technologies that are currently available. (Jansen et al., 2022)

In light of the COVID-19 outbreak, the Russian invasion of Ukraine, and the cost-of-living crisis, it is essential that we rebuild our economic and corporate structures while simultaneously addressing the massive quantity of material emissions. In order to accomplish this goal, Digital Product Passports (DPPs) may be particularly vital. (CISL, 2022)
2.1.2 Expected benefits

Various benefits for DPPs have been identified. Plocien-
ik, et al. (2022b) identified common goals for multiple
DPP concepts in their study:

- ensure that all stakeholders in the product lifecycle
can access and share product-related data
- improve collaboration in the value chain
- foster transparency and traceability of products,
  materials, components
- enable compliance checking and facilitate certifica-
tion procedures
- enable tracking of critical materials/substances
- improve circularity of products in terms of the R
  strategies
- allow to benchmark different products
- track progress in the development of sustainable
  products

The benefits vary between different users of the DPP.
Saari et al. (2022) collected benefits for different actors
in the value chain more detailed followingly:

- Designers will be more equipped to incorporate
  middle- and end-of-life feedback into product
design (for example, increasing a product’s
  recyclability or maintainability).
- The ability of manufacturers to gather comprehen-
sive information on the product life cycle and use
  it for a variety of purposes, such as traceability for
  warranty claims and recalls, will improve.
- Providers of maintenance and repair services may
  profit from in-depth technical data, background
  knowledge, and spare parts data to deliver better
  services.
- Access to vital information about components will
  help remanufacturers.
- Information on dangerous or valuable materials
  will be useful to recyclers.
- To encourage environmentally responsible purcha-
sing decisions and product handling, end consu-
mers will be informed about many aspects of the
  product (such as spare parts, the product’s CO2
  footprint, allergens, etc.).

Additionally, according to Guth-Orlowski (2021) the
ability to be used as an audit tool and a compliance
tool are the two major advantages of the digital product
passport for the public authorities: As a compliance
tool, the DPP can be used to implement the legal requi-
rements for the products. Using the DPP as an auditing
tool can provide details on the components used and
the manufacturing conditions if compliance with a
regulation needs to be audited. Audits can be harmo-
nized and minimized with the help of a digital product
passport. It is feasible to electronically verify whether
an audit was completed. (Guth-Orlowski, 2021)
The expenses of implementation will significantly affect the net benefits of DPP. A product passport will boost the macroeconomic productivity of the European economy, paving the way for the establishment of a circular economy through an effective data-based approach. (Deloitte, 2022)

2.1.3 Concerns

Regarding the DPP’s functionality and content, or more specifically, what data it must have and what data it may include, there are still some unanswered questions. (GCE, 2022) Determining what details a DPP can or should contain over the course of a product’s lifetime, including repairs and usage, will be a significant challenge. All product-specific data should ideally be included in a DPP, but from a systems perspective, full implementation may be challenging in practice. (CISL 2022)

Another difficulty is data storage because there are concerns about how the data will be handled and kept. The issue of transparency and how company confidentiality will be upheld are both crucial. (GCE, 2022) If industries want to adopt the idea, concerns about private company information and IP security must be resolved (Walden, 2021)

Additionally, the selection of the data to be included will have an impact on the DPP’s goal, whether it is to serve as a mechanism for disclosure or a tool for systemic change that aims to address problems that cannot be quantified (such as environmental footprint), for instance, by including social sustainability data. (GCE, 2022)

According to CISL (2022) social sustainability data, such as avoiding employing child labor farther up the value chain, are not addressed in the current proposals for DPPs. At the moment, only a direct value chain company monitors this at the production site. For some stakeholders, these data sets may be able to offer insightful information on the materials’ or products’ overall environmental and social sustainability footprint. Others countered that a significant barrier to its inclusion in an early draft of a DPP is still the extremely limited availability of such social sustainability information. (CISL, 2022)
2.1.4 Background

Several policy frameworks and legislative initiatives from the European Commission have mentioned or recommended the development of DPP throughout the years. Figure 2 adapted from CISL (2022) and concludes the relevant EU initiatives on a timeline to create a clearer picture of the regulation background.

Before regulators identified DPPs as a potential answer, a number of institutions had already observed and investigated the potential mechanisms through which DPP could promote a circular economy (Deloitte, 2022).

Initial negotiations on a DPP were started by the European Resource Efficiency Platform in 2014 (EREP, 2014) with an emphasis on the recycling of materials during production. Following that, the circular economy and product sustainability have become hot political themes. The European Green Deal eclipsed the introduction of a DPP in 2019. (CISL, 2022) The DPP could be a crucial tool in confirming production and compliance with the required standards. (CISL, 2022)

To help consumers make better purchasing decisions, the EU Consumer Agenda 2020 (European Commission, 2020b) was created. The agenda especially refers to a DPP’s function as an instructional tool that enables product comparisons by evaluating their carbon footprints and broader environmental impacts. DPPs may therefore be a vital tool for combating the problem of greenwashing. (CISL, 2022)
A call to develop at least three DPP prototypes, complete with data requirements and system designs, was released by the EC under its Digital Europe Programme in 2021. Its goal is to get everything set up for the gradual deployment of at least three DPPs in the key value chains of electronics, batteries, and at least one other key value chain from the list provided by the Circular Economy Action Plan, which includes information and communication technology, textiles, furniture, and high-impact intermediary products like steel, cement, and chemicals. (CISL, 2022)

In March 2022, European Commission proposed the Ecodesign for Sustainable Products Regulation (ESPR) (European Commission, 2022a), which is intended to establish a common framework for product design, labeling, and reporting criteria that would help reduce the harmful environmental effects of products across their entire lifecycles and enhance the efficiency of the internal market. (Solita, 2022) It expands on the Ecodesign Directive that covers energy-related products, as part of the Circular Economy Package. The ESPR’s primary regulatory component, the Digital Product Passport, will improve the traceability of products and their individual components. Taking into account their environmental impact, this will give customers and manufacturers the knowledge they need to make better decisions. (CISL, 2022)

Performance and information are the two requirement categories that the ESPR prioritizes. How items should be designed regarding energy efficiency, recyclability, durability, waste generation, and environmental footprint is determined by the performance criteria. The information requirements highlight specifics contributing to product performance and address how the information should be provided along with the product in manuals, labeling, and product passports. The ESPR will specify both general and product-specific guidelines regarding the details that need to be included in the digital product passport. Rules for interoperability, accessibility, data points, and roles and responsibilities for maintaining the data in the digital product passport belong to the general requirements. (Solita, 2022)

Every product containing substances of concern that are being brought to the EU market will be required to have a DPP, according to the current proposal. The ESPR provides only limited information on the DPP system’s technical requirements. The current proposal offers a central register that will, at the very least, include a unique identifier for each product, item series, or batch, but it is not specified what other data must be included in a DPP. (Plociennik et al., 2022a)

Additionally, Strategy for Sustainable and Circular Textiles mentions DPP as one of the specific measures that are included in the strategy actions (European Commission, 2022b). Moreover to the EU Textile Strategy and ESPR, in the future, the Waste Framework Directive (WFD) (European Commission, 2022c) revision can be relevant to the textile industry from the DPP point of view. (Solita, 2022)

The Commission will probably implement a general basic design for DPPs that is applicable to the majority of materials and products, along with sectoral modulations to tailor the design to the core components of various product groups. (CISL. 2022)
2.1.5 Technical solutions and implementation

The proposal of the commission suggests that:

“To ensure that the product passport is flexible, agile and market-driven and evolving in line with business models, markets and innovation it should be based on a decentralized data system, set up and maintained by economic operators.” (European Commission, 2022a)

The difference between centralized and decentralized data storage can be defined as followingly: centralized data storage system might be a single computer or server with a single owner. Decentralized data storage systems can be found in clouds with numerous server owners, all of which store the same data. Data can be saved in spreadsheets, ERP, PLM, and PO systems and software, among other formats, in both centralized and decentralized systems. (Cura et al., 2022)

The suggestion to set up DPP based on a decentralized approach is widely supported and considered to be the best option available (Solita, 2022; Orgalim, 2022; CISL, 2022) According to Solita (2022) the decentralized approach includes the following advantages over centralized one:

- Data is created where it was first created, so it is always accurate and up to date.
- More data can be created and connected to the product passport if needed
- Data entries may be updated or removed.
- Identification of information providers; control of access to data by producers over sharing volume and visibility;
- There is no single organization that owns or controls the digital product passport system.
- The actors can freely choose the tools as long as the tools adhere to open standards, and the tools and systems for regulating data are not restricted to any vendors or systems.

Guth-Orlowski (2021) discusses the proposed decentralized implementation of the DPP and sheds light on what technicalities decentralized solutions are based on. Standardized solutions already exist provided by World Wide Web Consortium (W3C) (Guth-Orlowski, 2021). The decentralized DPP approach should be based on decentralized identifiers, verifiable credentials, and verifiable presentations. (Solita, 2022).

A wide range of objects and entities can be identified using a decentralized identifier (DID), which is a unique identifier. A DID is assigned to each product that has a digital product passport. Companies and other participants who provide information for the product passport also have DIDs. DIDs are documents that can be stored in a variety of places, including web servers and blockchains. (Solita, 2022)

Verifiable credentials are claims that one decentralized identity makes about another decentralized identification. A raw materials manufacturer, for example, can utilize a credential to make claims about his product (Guth-Orlowski, 2021). By using keys available from DIDs, a third party can examine the digital signatures of the party making the claim and the product about which the claim has been made to confirm that it is accurate. (Solita, 2022)

Verified presentations are information clusters made from a collection of verifiable credentials. In this way, several different data sheets, claims, and other pieces of information can be merged into a single, verifiable presentation that incorporates metadata, the information, and digital signatures serving as proof of validity. (Solita, 2022)
The DPP as envisioned by current circular economy-related research and political policies can be achieved through the use of decentralized identities and verifiable credentials. (Berg et al., 2022)

According to Jansen et al. (2022) to access the DPP or sort products, unique identification is necessary for industries like the textile industry, batteries and electronic devices, consumer goods, and construction. The technologies used in this context range from conventional Quick Response codes (QR codes) to Near Field Communication (NFC) and other technologies, like digital watermarking technologies. It is also becoming more common to employ blockchain technology to store data in a purpose-driven, incorruptible, decentralized manner. (Jansen et al., 2022)

Multiple sources discuss that the implementation should be done in phases. Instead of aiming to develop everything perfectly from the start, DPP implementation should start small and swiftly with assessments and pilots. The need of creating adaptable and future-proof systems must be taken into account. (CISL, 2022)

Additionally, it is impossible to create a system that satisfies every need without incorporating shorter feedback loops into the implementation process because the needs and requirements of various economic actors and stakeholders for the Digital Product Passport are so versatile depending on the value chain stage, industry, product category, and other factors. To make sure actors can manage the changes to their business and production processes, a phased implementation is required. (Solita, 2022)

From the company perspective CISL (2022) listed some of the points that should be considered for a successful DPP implementation:

- To guarantee that the additional requirements are reasonable and will support the circular economy, new DPPs should only be imposed after an impact assessment and cost/benefit analysis have been completed
- Each piece of information for a DPP should be based on a clear scope and a specific user benefit throughout the product life cycle in order for it to be relevant and appropriate for its intended usage
- To prevent overlap or duplication of effort, existing international and EU initiatives, techniques, and stakeholders involved in the harmonization of product data and standards should be leveraged
- In order to ensure transparency as the default along the value chain without violating legitimate confidentiality concerns, mandatory product information in DPPs should balance the various levels of data access and data protection considerations
- Instead of taking a one-size-fits-all approach, every detailed information in DPPs should be product group specific to be credible and comparable
2.2 DPP in the textile industry

The fast fashion business model-based manufacturing and consumption that currently characterize the global textile and apparel industry are having serious negative effects on the environment and society. Consumers, businesses, regulators, and politicians demand greater transparency coupled with traceability information, particularly on product origin, product composition, and production processes. (Cura et al., 2022)

However, there are many challenges in providing transparency to the industry. Cura et al. (2022) highlight six topics concerning textile-industry-specific themes over the connection of circular economy and digitalization to provide transparency:

a. Although highly complex data systems like blockchain can track the lifecycle of a product, they can be energy-intensive.

b. While enhancing understanding, data embedded in clothing and textiles might also obstruct recyclability. E.g. metal data carriers (such as RFID tags and NFC chips) inserted in fibers and yarn may interfere with recycling processes.

c. Open lifecycle data can help businesses with their sustainability initiatives, but they face the danger of losing their competitive edge.

d. Customers can gain from data sharing by receiving personalized products. Data privacy is a concern, and personalization may not necessarily lead to decreased consumption.

e. Consumers care about sustainability yet are price sensitive in purchasing decisions.

f. Traceability technologies already exist, and have been used in a number of pilot projects, and are being adopted by certain businesses, yet they are difficult to make profitable.

Another challenge discussed by Alves et al. (2022) is associated with the tracking of individual products versus product batches in the value chain. Depending on the product batch, a value chain activity may not involve the full batch. For instance, only a portion of a batch of yarn may be sold, transported, or utilized as input to create a batch of fabric. (Alves et al., 2022)

Additionally, there is no way to distinguish one shirt from another when the final consumer delivers it for recycling. The garment carries the batch code from a batch made many years ago. As a result, each value chain action on a product batch must specify the amount (such as the number of shirts, cotton weight, or yarn length) that it affects. (Alves et al., 2022)

Moreover, the creation of a Digital Product Passport for textile items is a possibility to inform consumers as well as to enhance communication along the entire value chain, including that which occurs after purchase, in order to promote a greater circular economy. A dynamic interaction between brands, manufacturers, customers, and NGOs could result from the digitalization of the entire supply chain from raw materials to consumers. (Ospital et al., 2022)
2.2.1 Data in the textile value chain

This sub-chapter will discuss the status and possibilities of data related to the circular economy of textiles. As discussed in the earlier part of the chapter new circular business models are needed to slow and close the resource loops (Bocken et al., 2016). According to Luoma et al. (2021), More effective data utilization can be a key enabler and driver of the circular economy, and innovative examples of data-driven circular business models are already developing. These include performance contracts, sharing models, and online marketplaces for resources and waste streams. (Luoma et al., 2022) and Cura et al., (2022) agree that the interrelation between circular economy and the application of cutting-edge technologies to business operations is imminent. However, very few studies have looked especially at the role of digitalization and data for the textile-related circular economy, despite the fact that the intersection between circular economy and digitalization has recently gained more study attention (Luoma et al., 2022).

It is important to define what is meant by circular economy data. Luoma et al., (2022) define it as followingly:

“Circular-economy data consist of a body of data on diverse aspects of product and service life cycles and more system-level value-network data that can provide knowledge for development toward a circular economy.”

According to Heikkilä et al. (2021), the product information that is the most valuable in the textile circular economy includes:

- evidence on sustainability and responsibility
- evidence on quality and durability
- evidence on safety (clean, free of harmful chemicals)
- fitting and comfortability
- condition (of product and material)
- use, care and recycling instructions
- exact material content
- user experiences and product history (may include many kind of information
- availability (used products and recycled materials).

According to Kauppila et al. (2022), textile sector product data and value chain information are urgently needed for textile tracking and traceability as well as to enhance material processing and recycling.

Currently, there is no systematic collection of circular textile data and gathering the information required for systemic knowledge and planning of circular textiles is difficult as the availability of data linked to textile flow is constrained to some waste-related statistics. (Kauppila et al., 2022)

Secondly, Cura et al., (2022) argue that the data that is available from the textile supply chain is often stored and managed in conventional systems that might be outdated and inefficient.
The difficulties in tracking and tracing raw materials and finished goods of the textile value chain are mostly caused by conventional data management and sharing, the large number of value chain activities, along with the absence of unified data standards. (Cura et al., 2022)

2.2.2 DPP implementation in the textile industry

In the modern textile business, data storage is frequently production-related and is not intended to gather and retain data, such as sustainability data. Furthermore, most sustainability data management technology solutions are incompatible with these platforms. (Cura et al., 2022) Although, in the study by Luoma et al., (2022) the stance of textile experts towards digital identities such as the DPP was seemingly positive as most experts desired that by 2035, 73% of the number of textiles produced globally should be digitally identified with solutions such as DPP. This implies that willingness for DPP implementation exists, yet the implementation might cause difficulties.

Secondly, verification of the data included in the DPP divides opinions. The deployment of external verification in the textile industry faces a number of difficulties even though it is generally regarded as a good way to ensure data quality and consistency. Lead times could be lengthened by a third-party evaluation. Additionally, third-party evaluations can raise expenses for textile businesses and have a detrimental effect on their ability to compete, particularly for SMEs. (Solita, 2022)

The textile industry presents an intriguing empirical environment for evaluating the DPP concept because of the complexity and global scale of its value chains, which can also help to clarify whether the concept can be applied to other types of goods. (Solita, 2022)

As for the Finnish textile industry, DPP might be a useful tool. According to a roadmap published by Kamppuri et al. (2022), Finland will be a frontrunner in the sustainable and knowledge-based textile sector by 2035. Future environmental claims for textile products should be based on life cycle assessment calculations, in accordance with the PEF approach shaped by European Commission. The DPP is being created to ensure the accessibility of product-related information throughout the product life cycle. (Saari et al., 2022)

There already exist multiple development projects, traceability platforms, and DPP standard initiatives in the textile industry context. A more detailed look at few examples can be seen in figure 3 on page 20.
<table>
<thead>
<tr>
<th>Initiative</th>
<th>Country</th>
<th>Description</th>
<th>Technologies</th>
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<tr>
<td><strong>Development Projects</strong></td>
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| CIRPASS                                        | Europe (funded by European Commission) | Lays the foundation for the DPPs’ gradual deployment and piloting. The first focus is on three priority areas: the electric and electronics, battery, and textile industries, while establishing the basis for a cross-sectoral DPP based on shared rules, principles, taxonomy, and standards. | • Cross-sectoral definition and description of the DPP  
• Cross-sectoral product data model for the DPP  
• Open DPP data exchange protocol  
• Building stakeholder consensus on key data for circularity  
• Developing use cases and roadmaps for piloting, deployment |
| DPP Concept by Finnish Textile & Fashion and Technology Industries of Finland | Finland                     | DPP concept that serves different industries and promotes the green transition focusing on textiles and batteries. | • The study defines a concept, data architecture and technical approach that meets the needs of companies, developing regulation, and stakeholder expectations.  
• Technical solutions are designed to be generally applicable to use in different categories of products |
| Produktinformation 4.0                        | Germany                     | The goal is to create a concept for sharing product information so that you can use it to determine the legal criteria you need to create DPP and accomplish your circular economy goals. | Creation of a demonstration website (front-end) that meets the actors’ data interface requirements |
| **Traceability Platforms**                     |                             |                                                                              |                                                                              |
| TrueTwins                                      | Denmark                     | Creation of an ecosystem where brands, customers, suppliers, and service providers may collaborate to co-write a product’s story through the provision of a distributed, trusted digital ID platform for brands. | • Blockchain technology  
• Digital ID platform  
• NFC or QR code  
• Smartphone App + Website |
| Textile Genesis                                | Hong Kong                   | Utilizing blockchain technology to monitor and confirm the use of sustainable fibers from source to finished product. | GS1 framework combined with blockchain |
| Threadcounts                                    | Germany                     | The development of product traceability to highlight a company's efforts in sustainable textile sourcing and value chain analysis. | • Blockchain  
• Tracking through QR codes, invisible/visible fluorescent substances, synthetic DNA and microbiome analysis |
| EON Product Cloud                              | USA                         | A decentralized platform that allows businesses and customers to exchange digital product data by leveraging the garments’ Digital ID | Connected to Circular Product Data Protocol  
Washable QR codes, NFC and RFID |
| **DPP Standard Initiatives**                   |                             |                                                                              |                                                                              |
| EON Circular Product Data Protocol              | USA                         | The global identification system for apparel products in the circular economy, enabling resellers and recyclers to access, identify and share essential product and material information. | • QR Code  
• NFC  
• RFID  
• Smartphone App  
• Cloud Platform |
| circularityID* Open Data Standard              | Germany                     | Intended for use in the fashion industry to store, label and identify digital product data for powering circular practices. | • Automatic data recognition in sorting systems (e.g., QR codes)  
• Open Data Standard (with the purpose of joining forces with other initiatives that seek to achieve the same objectives within circular economy) |
| Global Textile Schema                          | Germany                     | Standardized industry language and basic technology for the automated exchange of essential data along textile supply chains. | Suppliers provide their data via a standardized catalogue from PDM, PLM, PIM, or ERP systems. |

* Figure 3 own recreation from Plociennik et al., (2022b) and Jansen et al., (2022)
3 Methodology

The research framework, data collection, and analytic strategies used in this study, as well as the research design and methodology, are introduced in this chapter.

Additionally, the chapter offers a research assessment and discusses key ethical problems relating to this study. The chapter wraps up with a brief overview of the companies interviewed.

This research is a qualitative exploratory multiple-case study, that collects empirical data from industry experts by interviewing company representatives and compares it to previous findings from the academic literature.
3.1 Literature review

At first, a thorough literature review was made to give a sufficient understanding of previous research on the subject and create a relevant theoretical background for the thesis. The first subchapter aimed to understand what kind of different approaches for the DPP exists and what kind of perceptions and expectations there are for the DPP implementation. In the second subchapter, the goal was to understand the textile industry-specific characteristics that shape the DPP implementation compared to other industries.

3.2 Data collection

In order to gather the responses to the "what kind" questions, semi-structured interviews were used in this thesis. This interview method was useful as a pre-planned template of the questions on the DPP and circular textile industry and directed the interviews in the appropriate direction while allowing the possibility to ask extra questions. To choose the participants purposive sampling was used.

Purposive sampling refers to the deliberate selection of a participant based on the background knowledge of the researched subject. Simply said, a researcher decides what information is essential to obtain before looking for sources willing and able to provide it based on their expertise or experience. (Etikan et al., 2016)
To produce results that are applicable to many sorts of textile companies, the decision to analyze multiple case companies was made. The goal of the empirical study was to find a holistic view of DPP from the Finnish textile industry, hence the case companies included SMEs and large companies that vary in terms of business models, customer segments, and value chains. The unifying factor throughout all the case companies was the sustainability-minded approaches to their way of doing business, to collect insightful data on the subject. Overall, eight companies were interviewed for this thesis.

3.3 Data analysis

After the collection of data by organizing semi-structured interviews, the data was analyzed by conducting a thematic analysis. In the analysis, all the data from the eight case company interviews were compared to identify similarities and differences to formulate themes to summarize the findings from the empirical study.

3.4 Research evaluation & ethical concerns

As mentioned earlier this thesis was commissioned by Finnish Textile & Fashion, the central organization for textile, clothing, and fashion companies in Finland. Being employed by the commissioner might influence in posing biases over the researched subject as the researcher had prior knowledge of the subject before conducting this research.

Secondly, CE and existing CE literature were the primary points for this research. To establish a feasible research scope, potential contributions from other research fields that might be relevant to the subject were not taken into account.

Thirdly, this study includes references from both academic and grey literature as the number of previous studies is limited due to the novelty of the DPP concept. However, the researcher strived to ensure the authenticity of the used research literature by evaluating the used references one by one.

3.5. Case company overview

All of the interviewees were employees of Finnish textile companies. The goal of the study was to collect insightful data from diverse companies acting in different phases of the textile value chain. This required that interviewed individuals had prior knowledge of the product sustainability and current status of the transparency and traceability in the textile value chain.

The interviewed companies were all sustainability-oriented and had already established circular economy activities in different ways. The individuals interviewed were either working in the sustainability department in management or in representative roles of the company or were the founding members of the companies.

The interviewed companies acted in different stages of the value chain. Five of the companies interviewed were operating in the consumer fashion sector, one in the repair sector, one in the circular textile fiber business, and one in the workwear apparel sector.
4 Findings

This chapter presents findings from the interviews. It is divided into two parts to analyze separately the two research questions posed. In the first sub-chapter, a deep dive into the perceptions of the case companies is made.

Secondly, the next sub-chapter assesses the impact on the current operations of the case companies.
4.1 Perceptions on the DPP

The results implicate that all the interviewees had at least heard about Digital Product Passport before. However, the result might be affected by the purposive sampling method that was used in the selection of participants to collect rich data about the subject. At this point, the knowledge about the concept was considered to be perfunctory, yet the basic principles were identified. The primary resource for knowledge was the employer’s association and different media reports. Few participants had already developed their own traceability system that can be considered relatively similar to the DPP concept described in this study. This was not known by the researcher prior to the interviews and it strengthens the image of readiness to adopt the upcoming DPP concept within the case companies.

Overall, the perception towards DPP implementation can be seen as surprisingly positive as all of the case companies had a positive stance on the effect that DPP could bring to their companies and for the industry as a whole. All of the companies agreed that the DPP in the best-case scenario would be a crucial tool to improve the environmental sustainability of the industry and push the transition from a linear economy to a circular economy.

“Reliable product data have an essential role in enabling circular economy in the textile industry. Many of the current bottlenecks of the circular loop could be solved by collecting, organizing, and clarifying the digital product information in an easy-to-use format.”
- Interviewee 4

The case companies expressed that with comparable and reliable sustainability data offered by DPP, communicating it to customers would be easier leading to brand benefits. Secondly, evaluating the sustainability of their value chain operations would be eased by DPP implementation. All of the case companies feel that different regulation is needed to make the textile industry more sustainable and circular. The DPP was seen as an important tool to enable compliance with the regulation. Thirdly, many interviewees felt that common ground rules are needed for the industry to increase sustainability, and requiring a DPP for the products would be a desirable trend for the upcoming years.

“If implemented properly Digital Product Passport would be a positive thing for us and the textile industry as a certain type of regulation and common ground rules are needed”.
- Interviewee 3

The readiness to comply with upcoming product sustainability regulations was perceived as sufficient, yet this evoked plenty of discussions. In the best-case scenario, the upcoming EU initiative would lead to a competitive advantage in the Finnish textile industry. However, different concerns were expressed regarding the increasing workload, especially in the SMEs, who fear that collecting and organizing data to comply with incoming regulations in the EU will result in a social sustainability issue inside their own organization as insufficient time resources will lead to fatigue among personnel.

Secondly, setting ambitious product sustainability targets by the EU was seen as a good thing by most of the case companies. However, there were opinions that the regulation should stay within reasonable limits to not penalize the companies already operating sustainably by complicating their processes that would lead to competitiveness issues.
There was a consensus regarding the preconditions of DPP implementation. The DPP should be implemented in a reasonable manner, that would not be an administrative burden that increases costs and workload. To avoid this, the DPP interface should be easy-to-use for different stakeholders, from producers to consumers. Secondly, the integration into other product data systems should be possible to implement in an easy way. There were also discussions about whether DPP could replace existing product registries and be a resource-saving solution after the successful implementation. Thirdly, the case companies expressed the need for harmonized calculation methods and data standards, in order to make the data truly comparable with other actors.

All of the interviewees felt that in the long run DPP requirement would lead to a positive impact in their respective companies and in the industry as a whole compared to a voluntary-based approach, where companies could gain a competitive advantage by providing traceable and transparent sustainability information voluntarily. However, companies felt that requiring a DPP is a two-way street in the textile industry. Ultimately, irresponsible actors, whose operations are socially and environmentally on unsustainable basis could be eliminated.

"If irresponsible clothing brands would be required to show their value chain operations with the DPP requirement, this would be beneficial for us as we are already doing so".  
- Interviewee 2

Yet, at the same time, all the case companies expressed their worry about the SME sector, where insufficient resources regarding information systems, data collection, and technical abilities can create major issues in operations. This could lead to breaking the information flow in the value chain and causing difficulties to collect information into the DPP.

Additionally, a common concern was the competitiveness of Finnish textile companies. If the DPP requirements are not concerning companies operating outside of the EU, yet selling their products in the same market, DPP might have a cost-increasing impact that could result in decreased competitiveness caused by the regulation. Secondly, actors outside of the EU might circumvent the information requirements demanded by EU economic actors which would lead to complications in collecting the required information from the value chain actors.

Another concern raised in interviews related to the changing business environment that creates new sustainability requirements causing costs for companies that reflect in increased product prices is that it might lead to decreased possibilities for low-income households to consume sustainable products. This decreases the environmental impact, hence it is important to carefully consider what requirements are necessary and what are not.
4.1.1 The role of product sustainability data

The case companies identified digital product sustainability data as a key factor in the future of their sustainability work. At the moment, the collection of the sustainability data varied between case companies, and multiple respondents stated that the need for the data exists, yet the utilization at the moment is insufficient compared to the future usage possibilities.

“The data about product sustainability is a crucial component in our future plans. At the moment we utilize it to some extent, yet we recognize the significant possibilities that it could have on our core business operations in the near future. The hindering factors are the scarce time and cost resources.”
- Interviewee 7

Another consensus among the interviewees was that currently, the issues in utilizing product sustainability data are the data collected from the value chain actors and the fragmentation of the data as it is managed in various different information systems. DPP was seen as a possible solution for this as it could connect the sustainability data in a single information system and require value chain actors to provide the necessary information facilitating more effective data collection.

Interviewed startup companies expressed their worry about the proposed information requirements in the upcoming EU regulation as they have discovered that collecting specific sustainability data from their product might be time-consuming and prevent personnel to focus on the development work and other core business activities. Companies called for reasonableness in placing the information requirements. However, opposite opinions from the SME sector occurred as some companies expressed that requirements such as the DPP and ecodesign requirements proposed in the ESPR proposal will have a big role in boosting the transition to a circular economy and lead to competitive advantage as multiple case companies already had a business models based on circular economy. Thus, requiring ambitious information and performance requirements are necessary to enable real change and add value in building a circular economy ecosystem in the textile industry.

“Digital product passport might be a significant factor to circular economy development and thus in our business operations. The objectives should be ambitious to have a real impact on CE development. If DPP execution is closer to digital care label the development is not sufficient enough”.
- Interviewee 7

Secondly, another observation from the interviewees was that companies naturally collect plenty of other data from their value chain, and this limits the possibility to focus only on collecting sustainability data. However, multiple interviewees expressed that the importance of sustainability data for core business operations is increasing constantly and believed that upcoming sustainability regulations will boost this trend. Additionally, investments in digitalization in form of new information systems and strategic changes were expressed to act as drivers in boosting data collection that includes sustainability data.

The case companies agreed that sustainability data should be the source for making understandable sustainability claims in reporting and stakeholder communication and harmonized calculation standards would be welcomed to compare product sustainability between companies. DPP and ESPR as a whole could be important in enabling this development.
4.1.2 Included product data

There were plenty of different opinions on what data should be included in the DPP as the development of the concept in terms of specific product information included is in the initial phase. Secondly, operating in different sectors in the heterogeneous industry affected the data needs of the case companies as for instance work wear company’s data needs vary from consumer clothing brand’s individual needs.

As the DPP’s information requirements for the textile industry are waiting for the specific details from the upcoming delegated act, it was challenging for companies to have a clear opinion on what specific product data should be included in the DPP and what should not. One common concern was the definition of products as textile value chains consist of multiple sub-products such as fibers and fabrics before the finalized product. There were questions about how granular the DPP concept will be. In other words, case companies called for a clear definition of what is meant by a product in the textile industry value chain.

Multiple respondents hoped for a material-oriented mindset in defining the information requirements for DPP. This means that the origin of materials, all the processing phases, and their locations from fiber to a finished product would be included.

All of the case companies believed that building different user interfaces with access control would be a solid foundation for building the data architecture for the DPP. Different stakeholders are interested in the different product information for instance consumers might not have sufficient understanding of the chemical structure of the product and thus it would be irrelevant in supporting purchasing decision-making. However, for the recycler chemical substances and material structure might be the key information in their operations. Secondly, to have a bigger impact, consumers should be able to understand provided information and case companies expressed the need for visualized and easy-to-use user interfaces for consumers.

Another advantage of creating multilevel user interfaces with different access rights could protect sensitive business information and trade rights. However, interviewees noted that different access rights might affect negatively the creation of more transparent and traceable textile supply chains if the status quo in limited information sharing is possible to maintain under the upcoming information requirements of the DPP.

Many of the case companies called for social sustainability data to be included in the DPP, yet they felt that this could be added later on in the development of the DPP. They felt that for the consumers this would be a good addition in supporting purchasing decision-making. Many of the case companies considered the simplicity and visualization of the DPP user interface for consumers to be a key element in the effectiveness of DPP to have a real impact on consumer behavior.

Overall, the case companies’ views on the product data that should be included in the DPP were in line with Heikkilä et al. (2021) findings of the most valuable product information in the textile circular economy (chapter 2.1.2).
4.2 The impacts on the operations

Based on the interviews, case companies' abilities to implement Digital Product Passport varies by the field they operate in within the textile and fashion industry. For instance, in the workwear sector, there are already existing solutions to collect product data digitally and this is also part of existing EU regulation for some product groups. For instance, some of the products of the interviewed workwear company are under EU medical devices regulation and it enters the product-specific data in the EUDAMED database. This process is fairly similar to the proposed DPP implementation and the usage of RFID tags in other products of the company as well makes the preconditions for implementing a Digital Product Passport relatively favorable.

“...For us operating in the workwear sector, the implementation of Digital Product Passport is a great thing and relatively easy to implement as we have a comprehensive understanding of our value chain. Even though we have thousands of different products in our product range, the cycle is much longer compared to the consumer fashion market, where this might not be as easy process”.

-Interviewee 1

According to the interviews for the consumer fashion brands, the implementation might be more difficult, yet the Finnish companies feel that this will not be an impossible task. The opinions about the difficulty of DPP implementation varied between different-sized companies, whose revenue, amount of products and a number of clothing collections differ from each other to some extent. For larger companies, modification to the upcoming DPP implementation might require considerably more time and costs compared to the SME sector, where implementation issues arise from different aspects. As larger companies might have difficulties integrating their information systems into the DPP infrastructure, SMEs might lack product information systems such as ERP. Consequently, all the case companies called for implementation support from the European Commission and feel that the implementation cannot be the burden of industry alone.

All the case companies supported that DPP implementation should be done in phases to mitigate the negative effect on the current operations. Collecting existing data on the sustainability of the products is considered to be a reasonable starting point instead of focusing on gathering new sustainability information right away.

Integration into existing enterprise systems was considered to be a key factor as many of the interviewed companies were taking into account the development of the DPP in designing new product information systems. Those who did not have sufficient systems felt that DPP would be beneficial to tackle the issue of fragmented data management practices currently used.
The decentralized approach to the data architecture of DPP did not arouse resistance among the case companies as many of the interviewees felt that to have a bigger impact it would be adequate for DPP to be more than a supplement EU centralized database.

Overall, the impacts on the current operations varied among the respondents as the companies are in different stages regarding digitalization and the collection of product sustainability data. However, the common view was that even though DPP implementation might cause momentary issues in the operations, in the long-run, it would be beneficial for all of the case companies.

4.2.1 Implementation effects on resources

Looking into the sufficiency of current resources and how case companies perceive the additional allocation of resources, the case companies appeared to be in a relatively adequate position to implement DPP as they looked favorably toward the upcoming implementation process. However, all of the case companies identified that workload will increase and cost allocation for the DPP implementation is inevitable.

Many of the interviewees highlighted that even though DPP implementation in their respective companies is considered possible to carry out only with minor additional resources, for micro-sized companies and newcomers the mandatory DPP implementation might appear unfair. Companies expressed concern over technical know-how and systems within these companies as the lack of resources to hire consultants and invest in information systems in implementing the DPP might cause serious problems in their operations.

All of the case companies agreed that the IT skills of the personnel are sufficient to implement DPP as proposed by the European Commission. Instead, the consensus among the respondents where that implementation would require time and money as some of the case companies emphasized their employees were already overworked and some expressed the need to invest in new product information systems.

All the companies highlighted that at the moment it is difficult to estimate the impacts on resources as it will depend a lot on the finalized manner of the DPP implementation. Only one of the companies indicated that DPP implementation would likely lead to new hires, yet multiple case companies expressed the need for external consultation in the implementation process that will increase costs temporarily.

Multiple case companies perceived that some investments in technical operations such as system development or data management practices will be necessary, yet they expressed that this will eventually be done even without the proposed DPP implementation.

The interviewed startups expressed their worry over the current financial resource sufficiency, yet with the financial support provided to implement the DPP they believed that it will not be an impossible task for their respective company, as the interviewed startups operated already in a data-oriented way.

Overall, the case companies felt that the DPP implementation would not cause significant damage to the current operations, and most of the case companies expressed that in the best-case scenario implementing DPP would be beneficial for the current operations. However, this requires financial aid provided for the companies.
This chapter compares the findings of the empirical study to the findings of previous research. The perceptions of the textile industry are first discussed in subchapter 5.1, and then the effects on current operations are addressed in subchapter 5.2.
5.1 Discussion on perceptions

The aim of the first research question was to find out how textile industry enterprises view the mandatory DPP requirement proposed by the EU Commission in March 2022 as part of the ESPR proposal. Overall, the case companies had a positive approach toward the DPP implementation and identified multiple benefits that it would bring to their company and to the textile industry as a whole.

The benefits that were recognized in this study were similar to the findings of Plociennik et al. (2022), CISL (2022), and Solita (2022). The textile industry enterprises consider the DPP to be a key enabler of the circular economy by providing standardized and reliable product information leading to the opening of the current bottlenecks recognized in the circular economy of textiles such as the recycling of the products. Secondly, DPP could lead to a better comparison of competitor products and thus in communicating the company’s sustainability efforts more efficiently to customers.

However, to achieve the expected benefits the case companies called for clear definitions for different textile products as there were questions regarding the product definitions as the textile value chain consists of many different “product” phases before the finalized product. This supports the findings of Solita (2022) and Walden et al. (2021), who recognized the same issues in their studies.

Secondly, harmonized calculation methods and data standards were identified as key factors to make the DPP implementation successful and avoid duplicate efforts to other EU regulations. This also supports the findings by CISL (2022) and Solita (2022).

Thirdly, as discussed for instance by Cura et al. (2022) and Adisorn et al. (2021) although there is sustainability data available to some extent from the value chain, it is usually fragmented and in a variety of formats. This study supports previous findings as multiple case companies struggled with the same issues and there were also difficulties to gather validated data from the tier 2 and tier 3 actors of the value chain. Additionally, all the case companies considered sustainability data to be a key enabler and driver of their circular economy activities in the future supporting the findings of Luoma et al. (2021).

Regarding the pre-conditions for the DPP implementation, the study finds that DPP should be built on a decentralized solution with differentiated access control to provide relevant product data to the different needs of the actors. Moreover, confidential business information could be protected with this kind of solution as discussed by Adisorn et al. (2021). Secondly, the study finds that the implementation should be done in phases as proposed by CISL (2022) and Solita (2022), starting by gathering existing product data for the DPP. Later on, the case companies called for social sustainability to be included discussed by CISL (2022) and Saari et al. (2022).
5.2 Discussion on impacts

The aim of the second research question was to find out how DPP implementation would affect the current operations of textile industry companies. The findings of the study identified that the impact on current operations varies by the size of the company, the complexity of the value chain in terms of the number of processes as well as the level of digitalization and data utilization practices. Cura et al. (2022) noted that operating with a large number of different products requires an even greater number of processes during the value chain. Identifying every step in these processes might be challenging and might create a barrier to moving towards a more transparent and circular chain. (Cura et al., 2022)

However, Finnish textile companies interviewed expressed a positive approach toward the DPP implementation. Overall, companies thought that at first DPP implementation might cause additional resource allocation due to increased workload and increased IT costs, yet this would be temporary if the DPP implementation would go as planned. Some of the companies raised concerns over the fact that this might not be a quick and easy process and that investing in external consultation is nearly inevitable. Yet, in the long run, all the case companies felt that this would be beneficial for their operations and not an impossible project to carry out. Solita (2022) found similar results that especially SMEs might face financial difficulties implementing DPP.

One of the main findings of the study regarding the impact on operations is that textile industry companies interviewed thought that current IT skills are considered to be sufficient and that this upcoming initiative would not lead to major recruitment initiatives for new experts. Although the implementation would affect increasingly the workload of current personnel, concerns were expressed about fatigue issues, especially in SME companies. However, this finding needs future research as the sample size is relatively small.

A consensus among the companies was that financial support is needed to successfully implement the DPP. A common concern was that without financial support the new information requirements that DPP entails, may flow to prices of the products and lead to competitiveness issues. Also, the interviewees agreed that the EU should maintain the business perspective in the future development of the upcoming regulation as supported by CISL (2022) findings.
The primary conclusions and theoretical contributions of this study are outlined in this chapter. The implications for management are also provided.

The chapter closes by outlining the study's shortcomings and offering ideas for additional research.
6.1 Main findings

The thesis looked into important aspects of DPP implementation in the Finnish textile sector. The goal was to identify elements that are thought to play a crucial role in the successful implementation of the DPP.

According to Luoma et al., (2022) circular economy data in the textile industry can be categorized into five main themes. 1) Availability of circular economy data 2) sharing of circular economy data 3) use of circular economy data in business decision-making 4) connection to new business models and 5) circular economy’s impacts on the environment. The results of this study support the idea that in the best-case scenario Digital Product Passport can be a key enabler for all of these themes.

By enabling product data to be available and shared between all of the stakeholders in the textile value chain such as raw material providers, material suppliers, producers, end-users, service providers, and recyclers, DPP could boost the transition to the circular economy. Secondly, data provided in DPP could be utilized to support strategic and operative decision-making, thus leading to novel circular economy business model development and increasing the share of textile industry enterprises investing in the deployment of these models. Consequently, this could lead to a positive environmental impact.

However, there are key factors that textile industry considers to be essential for successful DPP implementation:

- Clear definitions of the textile products and required data that should be included in the DPP
- Harmonized data formats and calculation methods to provide reliable and comparable product data
- Decentralized data solution with differentiated access control to provide relevant information for the different needs of the actors and protect the confidential business information
- DPP should be easy-to-use for different actors from raw material providers to recyclers
- The implementation should be done in phases to start with simple and accessible product information and broaden the scope later on in future phases

Overall, the Finnish textile industry companies interviewed agreed on the positive effects that the DPP could provide, yet the capabilities of SMEs to implement the DPP raised concerns as the financial and human resources might turn out to be insufficient. The companies called for financial aid for implementing the DPP successfully.
6.2 Managerial implications

The benefits recognized in this study that support the findings of previous research indicate that DPP might have a key position in enabling the creation of reliable circular economy data that could be utilized to provide value chain transparency and a more sustainable textile industry overall. Although temporary implementation might increase costs and workload, according to case companies, in the long run, DPP could lead to practical benefits that might have an influence on developing new business models and optimizing the current value chain operations in the textile industry. However, this will require succeeding in regulatory work in terms of clear definitions and harmonized standards that will not create an excessive burden on businesses.

Moreover, DPP might enable a possibility to improve sustainability communication as reliable product data could be offered in a user-friendly format to customers.

To have a big impact and receive acceptance from the industries DPP should be an easy-to-use solution developed in cooperation with businesses. According to the case companies, the Finnish textile industry has sufficient prerequisites to implement DPP successfully, yet attention to supporting especially SMEs resource-wise is crucial. Overall, the DPP is seen as a vital tool in reforming the current textile industry to move towards circularity.

The prerequisites of the textile industry companies to implement DPP varies depending on e.g. size, digital maturity, and the complexity of the supply chain. However, if the proposed regulation will come into effect, it is vital for companies to prepare for the chance to gain an advantage over the proposed mandatory regulation.

The DPP could offer companies incentives to place emphasis on the proper collection of sustainability data. All the case companies already collected sustainability data in various formats and amounts, yet many were considering the future development of the DPP regulation to carry out information system purchases and development to be coherent with the upcoming regulation.
6.3 Future research

The findings of this study were overall in line with previous findings of the scarce research that is novel by nature as the development of the DPP concept is fairly new. Thus, key factors need to be studied in more detailed before moving forward with the proposed DPP approach.

The key factors that need more research include e.g.:
- definition of clear product categories for textile products
- specific data standards for textiles
- Defining the desirable information needs that should be included in the passport
- Practical case studies of the actual implementation process and data needs occurring in the development phase specific to the textile industry

Secondly, the sample size of the study was relatively small and all the companies interviewed represented Finnish textile companies. As the purposive sampling method was used to collect more insightful data, this might have had an effect on the perception of the DPP as all the companies interviewed were sustainability-oriented. Diverse opinions might appear in the textile industries of other countries.

Although, the majority of the interviewed companies were startups and SMEs, the emphasis of this study was the concerns about the impact of the DPP on their business. More studies should focus on this sector.

On the other hand, larger companies might have better capabilities to implement the DPP, yet they face distinct challenges in terms of e.g. larger product volumes and more complex supply chain networks. These should be also looked into in future research.

The context of this study is the textile sector, which limits the generalizability of the conclusions to other industries. Secondly, there are fewer opportunities to generalize the findings on a broad scale due to the small number of case companies examined—only eight in total.

More comparable research, particularly ones that focus on the practical implementation of the Digital Product Passport, is required to strengthen the validity of the results reached in this study and advance knowledge in the area.
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This theme has attracted increased attention around the textile industry throughout this year and I am astonished by how much I have learned in this short time as I have been able to pick up new skills by e.g. participating in the DPP development work as well as giving presentations and interviews.

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Personally, I hope that I could continue to work with these intriguing themes in the future and pursue my willingness to have an influence on providing a desirable future for the people close to me and of course our planet.

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