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# Digital Product Passports:

## Exploring Product information and its role in fostering the Circular Economy

Master thesis 15 HEC, course INFM10 in Information Systems

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# Digital Product Passports: Exploring Product information and its role in fostering the Circular Economy

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ABSTRACT (MAX. 200 WORDS):

The Circular Economy (CE) came into existence due to the increasing environmental concerns produced by the legacy linear economy which consumes too many resources and generates a lot of waste. The CE is initiated on the ideas of reducing, reusing, and recycling resources by utilising the product information. Thus, this study investigates the product information which is to be carried by Digital Product Passport (DPP) and its role in enabling the CE by utilising the knowledge management theoretical framework. Following a qualitative approach, by conducting semi-structured interviews with seven participants primarily in the retail sector. This research study analysis shows that DPPs are a fantastic digital tool to modernize and digitalize product information, which gets enriched when the product moves across various stages in the CE. Further to this, this study identifies the perceived benefits and challenges which an organisation can foresee while adopting DPPs. We conclude that DPP helps industry toward more circularity, there are numerous challenges highlighted by this study for adoption to be further scope for research in finding the solutions to overcome these for smoother implementation of DPPs.

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*Abhishansa Sharma & Sunitha Kopparapu*

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## List of Abbreviations

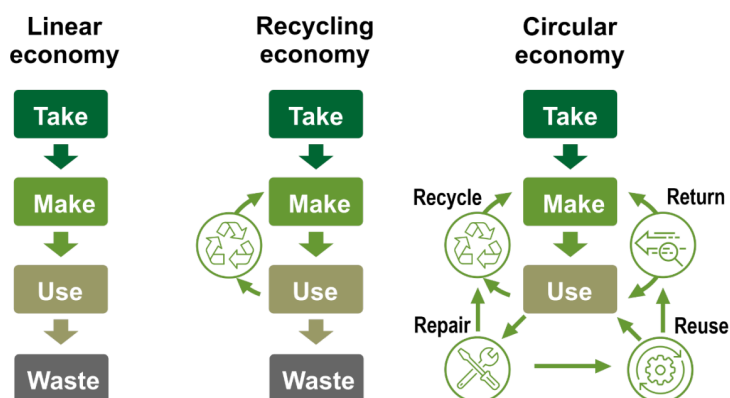
1. Building Information Modeling (BIM)
2. Circular Economy (CE)
3. Circular Economy Action Plan (CEAP)
4. Digital Product Passport (DPP)
5. Ecodesign for Sustainable Product Regulation (ESPR)
6. Electric Vehicle Battery (EVB)
7. Energy and Carbon Management Systems (ECMS)
8. European Commission (EC)
9. European Union (EU)
10. Extended Producer Responsibility (EPR)
11. Information System (IS)
12. International Material Data System (IMDS)
13. Internet of Things (IoT)
14. Knowledge Management (KM)
15. Life Cycle Assessment (LCA)
16. Near Field Communication (NFC)
17. Product Life Cycle (PLC)
18. Quick Response (QR)
19. Radio Frequency Identification Device (RFID)
20. Research and Development (R&D)
21. Supply Chain Management (SCM)

# 1 Introduction

## 1.1 Background

Meadows and the Club of Rome (Meadows, 1974) issued a caution about the finiteness of resources in 1972 as resources directly affect the ecosystem, they must be handled with prudence in order to protect people and support their economies. According to Saari, Heilala, Heikkilä, Kääriäinen, Pulkkinen & Rantala (2022), One of the factors contributing to biodiversity loss is the use of resources and goods, which also impacts ecosystem functioning and has global socioeconomic implications. Resource scarcity is and will remain an important problem so by managing resources properly and for a long time, businesses may support national industries and make a substantial contribution (Schrödl & Simkin, 2014). Sustainable development, popularised in the Brundtland Commission Report published by the International Commission on Environment and Development in 1987, is described as development that satisfies current demands without jeopardizing the capacity of future generations to satisfy their own needs (Chen, Boudreau & Watson, 2008). Due to the absence of a complete and integrated perspective of products' physical life cycles in today's linear economy leads to unsustainable product design and use (Geissdoerfer, Savaget, Bocken & Hultink, 2017; Mayer, Haas, Wiedenhofer, Krausmann, Nuss & Blengini, 2019).

The idea of a CE is one alternative to the linear economy which will enable us to move towards Sustainable development practices that are getting traction in business, politics, and academics (Schöggel, Stumpf & Baumgartner, 2020). Material movements in a CE are expected to retain their greatest value for as long as possible and to travel in circles within the economy to reduce waste, pollution and negative environmental effects (Kirchherr, Reike & Hekkert, 2017). Figure 1 shows how the linear economy generates more waste after the Use phase and in Recycling economy, certain goods or materials are recycled when a product reaches the end of its useful life, but everything may be utilized throughout several R cycles (Repair, Reuse, Recycle and Return) in the perfect CE, which results in zero waste production (Saari et al., 2022).



**Figure 1. Representation of Waste elimination when moving from Linear to Circular Economy (Saari et al., 2022)**

To transition from a linear to a CE, everyone engaged must have transparent knowledge about the composition of goods and resource usage throughout the complete product life cycle and value chain in the shape of digital data (Kouhizadeh, Zhu & Sarkis, 2020). According to Saari et al. (2022), while transitioning to sustainability and CE, product-related data must be managed more intelligently across the product life cycle, from manufacture to use, reuse, and recycling. All participants throughout the value chain do not currently have access to the majority of this information, despite it being there someplace. The loss of this data entails lost value for businesses and the broader economy, fewer educated customers and authorities, less efficient procedures throughout the product's life cycle, lost functionality for users, and adverse environmental effects from hasty replacement (Saari et al., 2022). According to Antikainen, Uusitalo & Kivikytö-Reponen (2018), digital solutions can provide real-time information about a product's availability, position, state, and monitor the journeys of products, components, and materials, and safely store the resulting data. The European Commission is working on establishing sustainability principles and other appropriate ways to regulate multiple aspects of product life cycles as part of its CEAP (EU Commission, 2020), with the aim of enhancing product resilience, usability, upgradeability, and ability to be repaired as well as managing the presence of dangerous substances in items and raising their energy and resource effectiveness. Embracing the prospect of product information's digitalization, comprising tools like Digital Product Passports, watermarks and tagging, is one of the Action Plan's primary elements (European Commission, 2020). According to Antikainen et al. (2018), it is commonly acknowledged that digitalization plays a key role in enabling CE. Digital technology adoption and the proliferation of linked things have the potential to minimize resource use and promote circular systems.

The lifespan of a product, from its creation to its end of life, can be tracked using the digital product passport and this information helps in making decisions on how to decrease waste, improve product sustainability, and establish a circular economy (Walden, Steinbrecher & Marinkovic, 2021). Companies may find opportunities to cut waste, boost efficiency, and develop more sustainable products by tracking the lifespan of a product (Walden et al., 2021). Digitalization makes it possible to optimize product life cycles and provides transparent access to data about goods' resource use, which accelerates the transition to the CE and also enables using fewer resources more effectively (Antikainen et al., 2018).

Moreover, the digital product passport may be used to inform customers about a product's components, manufacturing methods, environmental effects, and more. Consumers may use this information to make better-informed decisions about the things they buy, and businesses can use it to produce more green products (Walden et al., 2021). The incorporation of digital intelligence opens doors for the distribution of information, ownership, structure, and many levels of customization. This enables more meaningful and long-lasting connections with consumers and end users (Antikainen et al., 2018).

## 1.2 Problem

As highlighted by Götz, Berg, Jansen, Adisorn, Cembrero, Markkanen & Chowdhury (2022), the lack of standardised protocols within the present linear economy makes it difficult to access much of the product's information. In reality, the majority of the data necessary to enable a circular economy is lost at various points along the supply chain, beginning with the producer and distributor. Zeiss, Ixmeier, Recker & Kranz (2021) emphasises that by prolonging product life cycles, digitalization has enabled business model changes that have

enhanced product utilization during the in-use stage and therefore reduced waste. As enhanced resource usage necessitates integrating material flows with information flows to enable coordination amongst diverse actor networks, establishing a Circular Economy is largely an issue of effective information provision and use.

The Digital product passports would particularly come as a user-friendly system on the capabilities and requirements of the product or material with reference to a circular economy that is resource efficient. Thus, for increased resource efficacy and efficiency, the development of a fully operational digital circular economy information system must be viewed as a critical prerequisite (Götz et al., 2022).

The study of Information Systems has illustrated in the past how the material, social, and informational domains can be connected by utilizing technical artifacts for information capture, analyzing, transferring, and representation (Zeiss et al., 2021). However, when looking at the literature, there is a lack of IS research about the Digital product passports' contribution towards Circular Economy. Organizations must have adequate information and expertise in order to understand how DPPs are successful at several phases, including design, manufacture, distribution, and consumption.

Throughout the years, IS research has established a large number of ideas and frameworks. Knowledge Management (KM), as stated by Alavi and Leidner (2001), is the process of generating, disseminating, and utilizing knowledge to further organizational goals. The IS theory of Knowledge management well suits the knowledge requirement aspect of our study, as a digital product passport is to be viewed as a knowledge management process that enables retailers and manufacturers to gather and manage crucial data on the products they offer, including details on the goods' environmental effects and possibilities for reuse, refurbishing, or recycling.

### 1.3 Research Question

The scientific literature on DPPs provides a lack of understanding about the product information to be carried by DPP and its role when the product moves across various stages in a circular economy. These insights are very crucial for any organization to implement the required digital technologies to support capturing information in DPPs and adhere to EU policies. According to the EC, the actor in this context Retailers who put the product on the market in the European Union (EU) is lawfully accountable for gathering, giving, and updating the necessary DPP information (Beanland, 2023). To get a holistic view of DPPs and gain a better understanding of this research topic, the stakeholders, in this case, retailers who fall under Distribution stage of Circular Economy (European Recycling Platform, 2017), would be primarily interviewed with the aim of getting an answer to the following research question:

*What product information does the digital product passport carry in the life cycles of products, and what is its role in enabling a circular economy?*

## 1.4 Purpose

The purpose of this study is to explore the product information which is to be carried by DPP and the role it plays at various phases of the product life cycle in a circular economy. As DPPs are at very early stages of evolution, the knowledge gained through this study may serve as a foundation for companies in achieving a better understanding of DPP and its role while implementing the digital technologies required to support capturing the information in the DPPs.

## 1.5 Delimitation

With the introduction of DPPs, many stakeholders, such as raw material suppliers, manufacturing suppliers, distributors, retailers, consumers, recyclers, etc., in the value chain are directly affected. As DPPs are at an early stage of implementation, the scope of this thesis is to understand what product information DPP carries and the role it plays in facilitating the circular economy, where products move across all the above-mentioned stakeholders. Primarily retailers will be interviewed to gather insights, as they are required to produce DPPs while adhering to EU policies for selling the products in EU markets.

There are still a number of unanswered questions regarding the structure and operation of DPPs. The conceptual design, potential regulatory implications, data infrastructure, and potential integration with other comparable systems under development have been the current areas of study (Adisorn, Tholen & Götz, 2021; Donetskaya & Gatchin, 2021). And there is still no widely agreed definition of DPP, despite the fact that many publications connected to this offer insight (Pagoropoulos, Pigosso & McAloone, 2017). Hence, we do not investigate what kind of digital technologies are being developed, but rather, our focus will be on the information that DPPs carry during the product life cycle and how that information would contribute to the circular economy. This perspective can be viewed by interviewing people such as sustainability stewards, specialists, and sustainability leaders, Digital product leaders and managers who would be responsible for enabling DPPs at retailer organizations. This will give us insight into DPPs and how they would become integral parts of the circular economy.



## 2 Theoretical Background

The theoretical background section covers the concepts of Circular Economy and its phases, the benefits of Circular economy, and the enablers and inhibitors towards Circular Economy. It also covers theories revolving around Digital Product Passports (DPPs), the benefits and challenges in the implementation of DPPs, and information on piloted digital product passports which demonstrates prior outcomes achieved in the battery and construction industries respectively. Furthermore, this study's contribution towards Information Systems (IS) is being discussed, and lastly the theoretical framework of knowledge management utilized for this research is being elaborated.

### 2.1 Circular Economy

#### *2.1.1 Definition and Significance of Circular Economy*

Since the late 1970s, the idea of the circular economy has been gaining popularity. A number of authors, including Andersen (2007), Ghisellini, Cialani & Ulgiati (2016), Su, Heshmati, Geng & Yu (2013) and Pearce & Turner (1989) are responsible for introducing the idea of Circular Economy (Geissdoerfer et al., 2017). In their research, they examine the linear and open-ended aspects of modern economic systems by detailing how natural resources have an impact on the economy by functioning as outlets for outputs in the form of waste and by also providing inputs for production and consumption. As a result of Boulding's (1966), description of the world as a closed and circular system with a finite capacity for assimilation, the author deduced that the economy and the environment should cohabit in harmony.

According to Geissdoerfer et al, (2017) with an emphasis on industrial economics, Stahel and Reday (1976) developed various aspects of the circular economy. They developed a loop economy idea to explain industrial waste minimization, local employment creation, resource efficiency, and digitalization of the industrial economy methods. Geissdoerfer et al, (2017) further add that according to Stahel (1982), offering utilization of commodities rather than possession of them is the most applicable sustainable business approach for a loop economy. This approach enables enterprises to make money without externalizing costs and hazards related to waste. As highlighted by Geissdoerfer et al. (2017), the Circular Economy as it is currently comprehended today as well as its useful applications to economic institutions and industrial activities, have developed to embrace new elements and contributions from a range of ideas that all share the principle of closed loops.

The idea of a circular economy has its philosophical foundations from a multidisciplinary viewpoint, drawing on many perspectives from fields including ecology, engineering, economy, business, and design (Prieto-Sandoval, Jaca & Ormazabal, 2018). Andersen (2007) highlights that industrial ecology anticipates a kind of material synergy between organizations and production methods that would otherwise be extremely divergent. By creating intricate connections like those in well-known industrial cooperation projects, industrial ecology emphasizes the advantages of reusing leftover waste materials and by-products. In a broader sense, it encourages resource conservation as well as utilizing greener technology (Jacobsen, 2006; Andersen, 2007).

The definition of Circular Economy as mentioned by Merli, Preziosi & Acampora (2018) is dynamic and encompasses a wide range of ideas and concepts developed over the past few decades, including "regenerative design" (Lyle, 1994), "Cradle-to-Cradle" (Braungart, McDonough & Bollinger, 2007), "performance economy" (Stahel, 2008), and "industrial ecology" (Erkman, 1997). The notion of CE was developed with the understanding that economic expansion results in environmental deterioration and overuse of natural resources, which lowers the biosphere's potential to replenish (Merli et al., 2018). The Ellen MacArthur Foundation provided the most well-known definition of the Circular Economy, defining it as "*an industrial economy that is restorative or regenerative by intention and design.*" (MacArthur, 2013; Geissdoerfer et al., 2017). The circular flow of resources and the utilization of raw materials and energy across various phases constitute the foundation of the circular economy (Yuan, Bi & Moriguchi, 2006; Geissdoerfer et al., 2017).

In a novel way, the circular economy emphasizes the worth of high-value and high-quality material cycles and illustrates the synergies between sustainable production and the sharing economy that result in a more sustainable production paradigm (Korhonen, Honkasalo & Seppälä, 2018). Seroka-Stolka & Ociepa-Kubicka (2019) highlight that the premise of balanced consumption and production is key to the significance of a circular economy. The closing of economic system loops is anticipated to result in reduced levels of natural resource usage, lower levels of environmental contamination, and fewer capital and energy requirements for the extraction and processing of recycled materials.

### *2.1.2 Phases/Stages of Circular Economy*

The Circular Economy is typically described as a cycle of resource extraction and transformation, distribution, consumption, and restoration of products and materials (Prieto-Sandoval et al., 2018; Park, Sarkis & Wu, 2010; Stahel, 2016). In order to turn environmental resources into goods and amenities, organizations must first obtain them. Consumers use the goods or services in the market once they are distributed to them by companies or to customers at points of sale. The Circular Economy model now suggests that products be recovered in order to close the loop further. The significance of innovation at this point is in order to recover and enhance used materials through industrial or environmental processing as opposed to discarding or wasting them (Stahel, 2016; Prieto-Sandoval et al., 2018).

The essential stages involved in a circular economy model starts from the Raw materials, Design, Production, Remanufacturing, Distribution, Consumption, Collection, and Recycling (European Commission, 2014), these phases offer chances to reduce waste and environmentally damaging emissions, as well as to lower costs and dependency on natural resources. The stages are connected because materials can be employed in a cascading manner, such as when the industry trades byproducts, items are reconditioned or remanufactured, or customers select product-service systems. In order for the system to operate as efficiently as possible, the goal is to minimize the use of resources that leave the cycle.

Tóth Szita (2017) emphasizes while describing the tenets of the circular economy that in order to maximize resource extraction, goods, components, and materials must be circulated in order to optimize their presence in the life cycle of the product. This implies that remanufacturing, refurbishment, and maintenance are meticulously planned in order to keep materials as much as feasible as an element of economical procedures. Moreover, by

replacing or lowering the toxic compounds, harmful substances can be eliminated and adverse externalities can be minimized. The circular economy paradigm is built on closing off unrestrained economic flows. According to the Ellen MacArthur Foundation (2015), in a circular economy, trash is equivalent to nutrients, diversity is a valuable quality, energy must be obtained from sustainable sources, and pricing must be realistic.

According to Stahel (2016), business models for the circular economy are divided into two broad categories, firstly, those that encourage reuse and prolong product life through repairing, remanufacturing, enhancements, and retrofits. Secondly, those that recycle the materials from used products to create resources that are 'as good as new'. Research is essential to make old products as good as new during the Innovation phase. Water, energy, and natural elements are introduced to the manufacturing process at the Extracted Resources phase. Reusing items during the production process reduces the requirement to create original versions from the start. At the time of sale, ownership changes hands from the maker to the consumer at the Distribution step. Additionally, either the purchaser-owner-customer of the item or the fleet management who keeps ownership but offers the goods as a service controls the Usage and Consumption stage.

### *2.1.3 Benefits of Circular Economy*

An economic foundation becomes closer to the circular economy concept and becomes more lucrative while becoming environmentally friendly the more it recycles and reuses its effluent. It is meant to demonstrate how the circular economy would benefit society in an industrial setting. Advantages include utilizing the environment as a storage space for persistence. (Andersen and Jørgensen, 1997; Lancaster, 2002; Sariatli, 2017). As stated in a comparative study by Sariatli (2017), MacArthur (2013) raised several important points revolving around Circular Economy. Based on modeling the implementation of the tenets of the circular economy, a comprehensive list of significant benefits can be identified initially that implement the circular design in technical market segments and obtaining access to better and less expensive materials as well as limiting or eliminating the use of depleting materials in industrial processes (Sariatli, 2017). Moreover, a number of industries have already seen the value of performance-based business models. In this regard, mastering the reverse material flow cycle provides enterprises with a competitive edge, and CE creates more work opportunities by fostering knowledge in problems including law, mechanics, operations, or cross-sectoral issues.

As the principles of the circular economy are extremely scalable (MacArthur, 2013), CE will stimulate economic growth and draw in investment funds. As a result, adopting the characteristics of CE in the R&D phase of operation promotes advancement in materials research and results in the creation of components of a higher standard and greater durability.

Recycling, waste avoidance, and eco-design measures presently help the EU avoid using between 6 and 12 percent less material overall, including fossil fuels (European Environment Agency, 2016; Kumar, Sezersan, Garza-Reyes, Gonzalez, & Al-Shboul, 2019). The research as stated by European Environment Agency (2016) also estimates that the adoption of CE techniques in the production of complex durable products with moderate life expectancies will result in net material cost reductions of \$340–630 billion annually in the EU alone, or around 12-23 percent of the present resource input prices in these industries. Sariatli (2017) claims that the waste removal from the value chain offers the quantitative advantages of lowering systemic and direct material costs as well as reducing reliance on resources.

Organizations get functional and strategic value from the circular economy. It implies that the economy may save billions of dollars by lowering the amount of material input required.

#### *2.1.4 Enablers and Inhibitors towards adoption of Circular Economy*

The pace of a more thorough transition toward the CE will rely on whether decision-makers in enterprises feel that doing so would increase competitiveness, even though governmental grants or mandated legislation can facilitate some degree of transition. Several factors, seen from the viewpoint of a company, might encourage and reward the adoption of circularity-related activities (Scheepens, Vogtländer & Brezet, 2016; Masi, Day and Godsell, 2017).

As indicated by Houston, Briguglio, Casazza & Spiteri (2019) in their study, a fundamental enabler of the circular economy is the standardization of criteria throughout the product life cycle. Sustainability can be tracked throughout the value chain due to product standards and computations like Life Cycle Assessment (LCA) on a product's potential effect and environmental factors. In reality, the production and eventual disposal of commodities can be evaluated through the use of specific guidelines. In support of circular models, this evaluation makes it easier to find suppliers for a firm's supply chain that are socially accountable (Houston et al., 2019). They further highlight that innovative networks, alliances, and collaboration between stakeholders and competition are other driving forces behind a circular economy. Organizations that work together to transform an industry have a significant influence on the value chain and help society move toward a circular economy. In addition, collaboration may spur suppliers to develop, leading to circular concept design. De Mattos and De Albuquerque (2018) agree that collaboration acts as an enabler to the circular economy and in addition indicate that in order to develop a vast circular network, chains, and sectors must work well collaboratively. Determining the degree of accessibility, expertise, and knowledge that participants must exchange with one another as well as the creation of a technical infrastructure is essential from the standpoint of cooperation.

Talking about the challenges leading to inhibition, Kumar et al. (2019) highlights several forms of economic and environmental barriers to the adoption of a Circular Economy. Liu and Bai (2014) claim that CE is an expensive procedure that demands a substantial initial expenditure (Kumar et al., 2019). Nevertheless, it doesn't pay off instantly, rather, it has a long term economical payoff. Companies avoid implementing CE while being eager to do so because banks and governments do not provide adequate financial support mechanisms or tax incentives embedded into the budgetary systems (Geng and Doberstein, 2008; Liu and Bai, 2014; Kumar et al., 2019). Masi et al. (2017) also agrees with this challenge as he states that a major obstacle for businesses is the need to make sizable upfront investments to incorporate CE practices, particularly cleaner manufacturing technologies and industrial synergy material exchange infrastructure.

Additionally, CE encounters a number of environmental challenges since there are insufficient environmental management services and programs offered by government entities and research institutions, and those that are already in place are often ineffective (Geng and Doberstein, 2008; Govindan and Hasanagic, 2018; Kumar et al., 2019). There is inadequate technology used in landfilling and combustion. These practices thus result in significant environmental damages that are irreversible (Gregson, Crang, Fuller & Holmes, 2015; Kumar, Sezersan, Garza-Reyes, Gonzalez & Al-Shboul, 2019). To encourage garbage recovery, many governments do not even offer enough tax rebates and subsidies. In the end, enterprises

engaged in remanufacturing are compelled to employ natural materials since the number of resources recovered is insufficient to fulfill their need.

Furthermore, regarding informational inhibitors (Sarkis and Zhu, 2008; Masi et al., 2017), there is a significant absence of environmental information release mechanisms that would make pertinent information public, direct future policy initiatives, and impose compliance penalties. The importance of information exchange for businesses is also emphasized when Masi et al. (2017) highlight that information exchange is very necessary to maximize results for reduction, reusing, and recycling. Businesses and governments should use information sharing platforms to "discover more ecologically and economically effective methods to coordinate and utilize their assets." (Su et al., 2013; Masi et al., 2017).

### *2.1.5 Digitalization as an Enabler in Circular Economy*

Due to the development of transparency and expertise in products and assets, such as information of the location, condition, and accessibility of assets, digitalization is considered as one of the facilitators of the Circular Economy (MacArthur, 2013; Bocken, De Pauw, Bakker & Van Der Grinten, 2016; Antikainen et al., 2018). Digitalization can accelerate the shift to a circular economy that is more sustainable. Further Antikainen et al. (2018) highlight that digitalization makes it possible for businesses to run operations more effectively, reduce waste, encourage product longevity, and lower transaction expenses. As a result, digitalization helps to slow down the material loop and shrink the loop with greater resource efficiency, which supports business models for the circular economy.

Moreover, interaction, cooperation, and co-creation with stakeholders, including customers, are made simpler and more effective by digitalization. Moreno and Charnley (2016) agree with the statement that it is frequently acknowledged how digitalization plays a key role in enabling CE. Digital technology adoption and the proliferation of linked products have the potential to minimize resource consumption and promote circular systems (Antikainen et al., 2018).

Digital Solutions like the Internet of Things (IoT) and online marketplaces are also allowing service based business models like products as a service (PaaS), where customers buy the required services instead of merely the tools or goods. Consumers who can pay for the use of items can make better use of resources (Hedberg and Šipka, 2021). By reducing the need for people to possess goods, leasing and sharing also lessen the requirement for ongoing manufacturing. To facilitate tracking of information of products, technologies including databases, barcodes, and RFIDs are currently in use. For instance, SCIP is a database (Friege, Zeschmar-Lahl, Kummer & Wagner, 2021) maintained by the European Chemical Agency that contains details on compounds that are extremely concerning in various goods. It intends to make sure that this information is accessible to recyclers and other waste management professionals throughout the life cycle of a product. TagItSmart (Krčo, van Kranenburg, Lončar, Ziouvelou & McGroarty, 2019; Hedberg and Šipka, 2021) has created smart tags that enable all relevant parties from manufacturers to customers and recyclers to monitor products and give supplemental information by means of QR codes, such as directions on how and where to recycle things.



## 2.2 Digital Product Passport

### 2.2.1 Definition and Significance of DPP

A “Digital Product Passport” (DPP), according to the European Commission (EC), is a set of product specific data that could be electronically retrieved using a data carrier to register, analyze, and distribute product related details across distribution network enterprises, government agencies, and customers (Götz et al., 2022). A product's origin, composition, and potential for repair and disassembly, as well as information on how the various parts may be recycled or disposed of at the end of their useful lives, would all be covered by the DPP (Götz et al., 2022). According to Ducuing and Reich (2023), Digital product passport provides trustworthy information of the full value chain, including specifications of the materials used and particular supply networks involved from suppliers to manufacturers, distributors, and customers or users; as well as technical facts to promote the reuse or recycling of materials and to boost their residual value. A new comprehensive definition of DPP by the Wuppertal Institute describes it as a data collection that lists the parts, materials, and chemical compounds in a product as well as details on reparability, replacement parts, and directions for correct disposal (Walden et al., 2021). According to Walden et al. (2021) the information found in the DPP, as defined by them, is gathered at every stage of the life cycle of the product and may be utilized to improve design, manufacture, usage, and disposal. A DPP should include information for environmental and social impact assessments of a product's manufacture, usage, and transformation phases in addition to information about the product's components and their origins. The data may then be utilized to develop business models for the circular economy (Jansen, Meisen, Plociennik, Berg, Pomp & Windholz, 2023).

### 2.2.2 Potential Digital technologies and Data to manage DPP

According to Beanland (2023), EC is currently drafting a regulation on DPPs with final approval expected in 2024 and implementation for the first product groups in 2026/7. The EU DPP is a first-of-its-kind regulatory circularity tool. However, many elements in the EU DPP across scope (product groups, company size, application level), tech (data storage, data carrier, and access/security) and data (data requirements and governance) remain open with different levels of maturity (Beanland, 2023). Figure 2 shows the various digital technologies and the data governance aspects which would help organizations to look for options while capturing DPP and be compliant to regulations based on the information gathered from the literature review as mentioned below:

- Technology perspective:
  - Data storage: The EC intends to allow businesses to keep DPP data in their chosen storage method as this enables businesses to combine DPP storage with current systems, it requires substantial investments in the design and implementation of supporting IT infrastructure. According to Beanland (2023), both centralized and decentralized data storage options are available and decentralized solutions like the blockchain provide less benefits but enable more data security, transparency, and traceability.
  - Data carrier: The EC will establish broad data carrier guidelines as well as a list of recommended data carriers for each product category. According to Beanland (2023), the EC prefers QR codes in its current plan for the Battery

Regulation because they are comparatively inexpensive, robust, and already widely used. Moving forward, each designated act for a particular product group is anticipated to include a list of approved data carriers that is open to change as newer data carrier technologies might develop. For a product to be able to connect to a DPP, a data carrier (such a QR code) must be physically present on the product at the very least by including a list of the data carriers and distinctive product IDs (Götz et al., 2022).

→ Data access: According to Beanland (2023), the EC intends to distinguish data access based on interest group, but specifics have yet to be determined and differentiated access provides each stakeholder with the info they need to make choices at the granularity level they require. Deployment of digital threads to offer improved data access and perception (Voulgaridis, Lagkas, Angelopoulos, Boulogeorgos, Argyriou & Sarigiannidis, 2023). Hence, regulating data access, anonymity, and protection is equally important (Götz et al., 2022).

- Data perspective:

→ Data requirements: Data requirements could be standardized across sectors to allow businesses to plan early and reduce uncertainty, but this could restrict their usefulness in particular product groups (Beanland, 2023).

→ Data governance: The EC intends to use DPPs at the item, batch, or product model level, as determined by each product category but EC does not have any proposal to govern so the options to use as No assurance, Limited assurance or Reasonable assurance (Beanland, 2023).

→ Data collection: Digital technologies play a crucial role in Digital CE applications like DPPs, particularly when it comes to data exploitation while taking into account data gathering and analysis for effective passport production. The use of digital threads enables to connect many data sources across the period of a product's lifecycle (Voulgaridis et al., 2023). IoT sensors allow data to be transmitted through Bluetooth, Near Field Communication (NFC), or QR codes (Beanland, 2023).

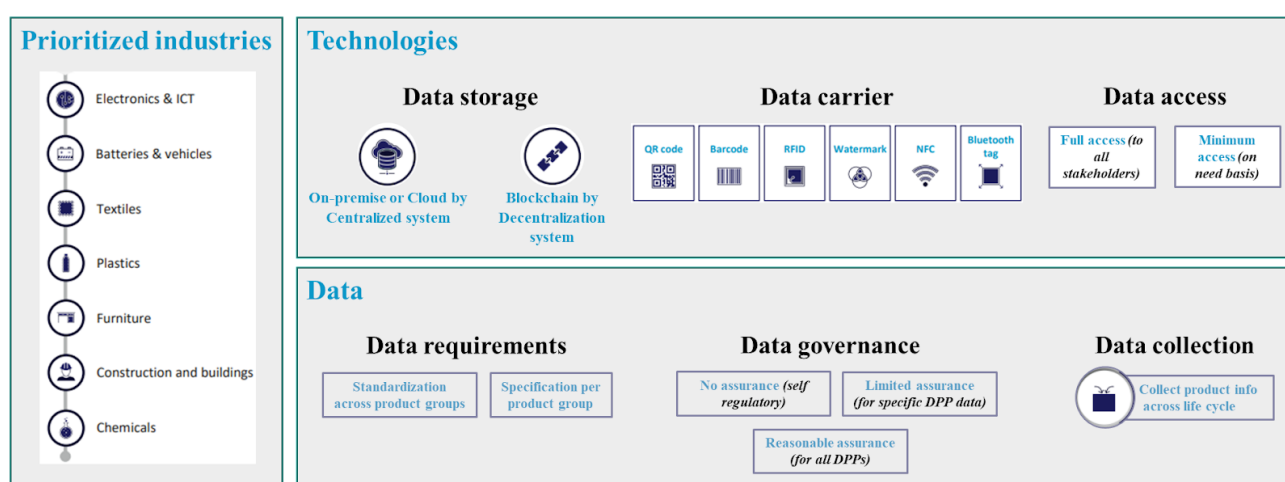


Figure 2. Overview of prioritized industries, technologies and data in the DPP (Beanland, 2023)

### 2.2.3 Piloted digital product passports

#### 2.2.3.1 Battery passport

As the EU is now leading the DPP development process, its expertise might be used as a resource and as a model for their widespread implementation (Götz et al., 2022). By enabling the interchange of data on the sustainability aspects of products, such as their carbon footprint and recyclability, throughout value chains, DPPs are projected to play a crucial role in encouraging novel methods (Götz et al., 2022). As seen by the adoption of the International Material Data System (IMDS), which is utilized by the vast majority of the automotive sector globally, digitalization of material and product information has proven advantageous for industrial value chains (Walden et al., 2021). According to Walden et al. (2021), the materials used in the production of finished automobiles are gathered, kept up with, analyzed, and preserved in the IMDS. The Purpose of IMDS is to gather all necessary data to satisfy the requirements of the European End-of-Life Vehicles Directive and It was created to enable the rapid exchange of information on all the materials used in a product throughout the full supply chain (Walden et al., 2021). According to Götz et al. (2022), the methodology suggested for the Eco design for Sustainable Product Regulation (ESPR) and lessons learned from the EU Battery Passport should be tightly integrated and linked with any upcoming EU legislation and activities for which DPPs are explored and serve as a means of accelerating the shift to a more sustainable European economy through digital solutions. Berger, Schöggel & Baumgartner (2022) proposed Digital Battery Passport for an Electric Vehicle Battery (EVB) and delineates the associated information needs with the idea includes 54 data points that are organized into four major information categories: (1) battery, (2) sustainability and circularity, (3) diagnostics, maintenance, and performance, and (4) value chain players.

#### 2.2.3.2 Material passport

According to Honic, Kovacic, Sibenik & Rechberger (2019), Resource and waste management is a growing concern for society. The Building Information Modelling (BIM) supported Material Passport is another illustration of an industry wide digitalization initiative that enables data collection related to, and the assessment of the recycling potential and environmental impacts of building materials, along with a full life cycle assessment of the ecological footprint of the building (Honic et al., 2019). The Building Information Modelling technique, which is based on the coupling of various digital technologies including BIM, a quality-control tool, and a material inventory and analysis tool, defines the process for producing a Material Passport and accompanying Life Cycle Assessment (Honic et al., 2019). According to Götz et al. (2022), several building-related construction items have very lengthy useful lives, so it will be a while before we know how much old materials will cost to recycle and how much they will cost in the future. DPPs and BIM may thus be required to make the idea of the building as a material bank a reality. Munaro, Fischer, Azevedo & Tavares (2019) indicated that the material passport must serve as a link between data and the element/material, and it must include information about quality, safety, sustainability, usage and operation, disassembly, reuse possibilities, history of inspections, and material traceability.



## 2.2.4 Benefits and Challenges of DPPs

### **Benefits of DPP:**

The primary benefits of DPPs are enabling access to trustworthy and comparable product information for businesses, customers, and policymakers to validate sustainability claims, which will enable the opening up of new business prospects and models (Götz et al., 2022). According to Walden et al (2021), Design, sourcing, manufacturing, buying, and finance choices can be influenced by DPPs, which can develop into a useful information system that satisfies policy and regulatory criteria. Product passports are often viewed as a means to persuade users to make sustainable procurement and product stewardship decisions by drawing attention to aspects of the sustainability of a product's entire life cycle (King, Timms & Mountney, 2023).

It may be said that DPP can enhance sustainability practices across a product life cycle, boost transparency for both customers and companies, and offer centralized information flow among stakeholders to, for example, prevent data loss over a product's life (Saari et al., 2022). Most people agree that having access to sustainability data and making changes throughout cascade value chains are worthwhile in and of themselves, as well as giving customers the knowledge that helps them make more sustainable buying decisions (Götz et al., 2022). Also, Stretton (2022) says DPPs to be implemented in various value chains in order to help firms embrace circular business models to produce value and secondly to ensure that customers achieve smarter purchasing selections.

According to Götz et al. (2022), DPPs have the potential to provide extra layers of reliable product information about recycled content, raw materials and including information on recycling by end consumers, thus, each link in the value network will have more transparency, tracking, and uniformity. Hence DPPs will eventually improve each value chain actor's visibility, responsibility, and traceability (Walden et al., 2021). DPPs enhance communication among the many stakeholders in the distribution network (such as manufacturers and recyclers) but it also raises customer awareness and facilitates wiser decision making (GCEurope, 2022). DPPs might be used as digital-based supply chain compliance tools to track and report metrics like Scope 3 GHG emissions (Götz et al., 2022), and help in determining material value, evaluate and lessen environmental consequences, and encourage more environmentally friendly design, sourcing, manufacturing, and purchasing choices (Walden et al., 2021). Moreover, it enables resource optimization and energy saving techniques (Götz et al., 2022).

### **Challenges of DPP:**

Determining what details a DPP may or should include during a product's lifespan, including repairs and usage, will be a significant task (Götz et al., 2022). Theoretically, the DPP principle will give the evaluators a wealth of data from which it is required to conduct multiple levels of inspections (Durand, Goetz, Hettesheimer, Tholen, Hirzel & Adisorn, 2022). The other aspect is practical considerations mostly relate to the data included in the DPP and what should be gathered and maintained once the product has been launched. This will become the crucial issue about the level of specificity of the data as it might be the production batch, an individual item, or a model specific (Durand et al., 2022).

The availability of various access levels is necessary to protect company secrecy, thus the subject of information transparency is also a crucial aspect to consider (Götz et al., 2022). They further add that the availability of data at the item level will enable policymakers to provide accurate and thorough evaluations that take the entire marketplace into account (Durand et al., 2022). While the information gathered at the model level will only be helpful in describing the variety of items put on the market and will not be connected to the magnitude of the market. The process for maintaining the product passport updated throughout a product's life cycle is mainly unclear at this moment and if industry is to accept the idea, issues of secure intellectual property and secret corporate information will need to be addressed (Walden et al., 2021).

How exactly the DPP criteria are to be defined is one of the primary issues. Consumers and recyclers should be free to choose the information they need to know, according to some business stakeholders (Götz et al., 2022). Another possible constraint is the need for policymakers, consultants, and academics who assist the policy-making process to have access to the data in the DPP database. Likewise, the level of data specificity will be a major element (Durand et al., 2022). Also, customers must be able to comprehend instructions on how to recycle or repair items, as well as whether manufacturers or retailers would accept their products for recycling (Götz et al., 2022). Regarding the design and functioning of DPPs, many questions remain unsolved like Data infrastructure, potential regulatory repercussions, conceptual design, and integration (Adisorn et al., 2021; Donetskaya & Gatchin, 2021). The fact that several policy instruments control various aspects of sustainability information presents another difficulty (Götz et al., 2022).

### *2.2.5 Timelines of DPP according to Circular Economy Action Plan*

Initially, DPP discussions were started by the European Resource Efficiency Platform in the year 2014 with an emphasis on the recycling of materials during manufacturing (Götz et al., 2022). After that, the circular economy and product sustainability have become heated legislative subjects. The European Green Deal and the circular economy, which signaled a new period of product-related EU policy, eclipsed the introduction of a DPP in 2019.

The DPP is a ground-breaking mechanism for regulating circularity. It still has a number of scope-related, technological, and data-related features that are unresolved and at various stages of development (Wbcsd2, 2023). The potential of a protracted timescale for widespread DPP adoption across sectors exists since the EC is creating DPPs that are tailored to particular product groups. Moving rapidly and enabling DPP-enabled transparency early, however, can assist in decoupling economic development from material extraction, waste streams, and carbon emissions, having a substantial impact on the world and mankind.

At a certain point, the DPP will be applicable to at least 30 product categories. The DPP is unveiling one sector at a time, though, to make things simpler. The test case will be batteries, more especially industrial and electric car batteries (Inriver, 2023). Industrial organizations are already implementing the required measures to assure conformity despite the fact that it won't be legally enforced until 2026, and the first proof of concept was shown at this year's Economic Forum in Davos (Umicore, 2023; Inriver, 2023). The creation and execution of the digital product passport is a challenging undertaking that requires cooperation from a multitude of stakeholders such as producers, buyers, and regulators. Hence, depending on a number of circumstances, the project's timeframe may fluctuate and the below illustrated Figure 3 is the high level timeline EC is looking at (Wbcsd1, 2023).

## European Commission plans first product group regulation to come into force in 2026/7

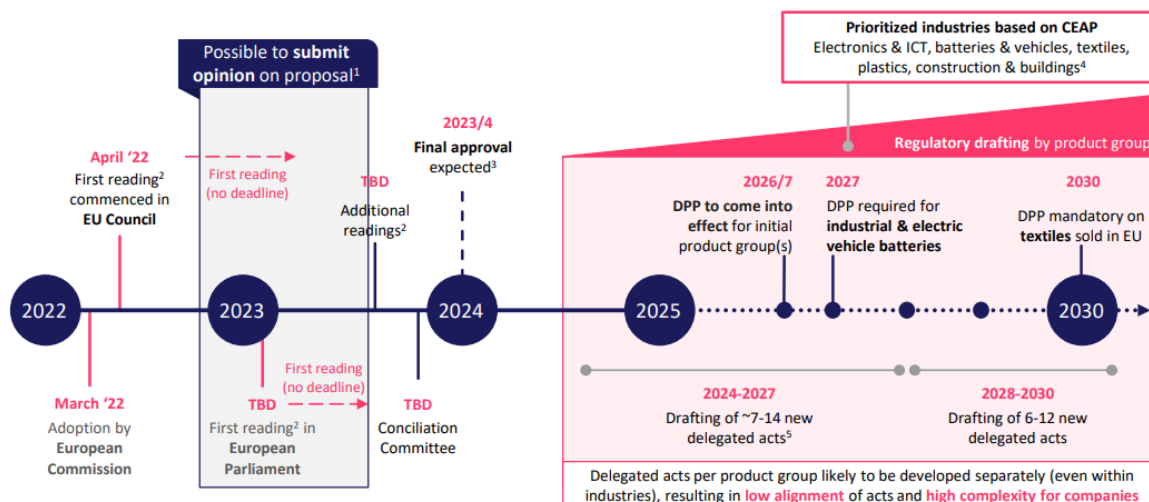


Figure 3. Timeline for the DPP Implementation (Wbcsd1, 2023)

### 2.3 Theoretical Summary of DPP role in stages of CE

DPP is a mechanism that is essential to the circular economy's stages, especially the design and production phases. The DPP is a ground-breaking digital tool that offers thorough and standardized data on a product's overall environmental and social effect, from the extraction of raw materials through the conclusion of its useful life (EU Commission, 2020). The DPP can assist producers in the product design stage by giving them a thorough understanding of the environmental effect of each component and material used in the product. The production process may be optimized for increased productivity and minimal environmental impact using this information to find chances for material substitution. The Extended Producer Responsibility (EPR) and the utilization of recycled materials are two circular economy ideas that the DPP may assist throughout the production stage. The DPP can also assist in identifying possibilities for material reuse or recycling as well as the construction of suitable collection and recycling systems by giving information on the materials and components utilized in the product.

As highlighted by EU Commission (2020), DPPs can also be utilized during the circular economy's distribution and utilization phases. DPPs can aid in promoting more sustainable consumption habits, for instance, by giving customers access to information regarding a product's environmental impact and end-of-life possibilities. This may result in less waste being generated and more reusable goods being used. DPPs may also be used in the circular economy's end-of-life management phase. DPPs can contribute to more effective and efficient recycling procedures by offering comprehensive information about a product's composition which will further encourage the recovery of priceless resources and help decrease waste.

## 2.4 Contribution towards IS

According to Klaus (2016) & Waite (2022), the transformation of the digital age which is unfolding into a new unpredictable disruptive revolution is called the fourth industrial revolution (IR 4.0) where the digitalization of product and product information is becoming more relevant and important. According to Walden et al. (2021), the European Commission is establishing appropriate ways to regulate several aspects of life cycles of products as a part of the Circular Economy Action Plan (CEAP) in improving not only reusability, durability, upgradability of a product but also in addressing presence of chemicals in products and increasing their resource efficiency. The action plan mentions using the potential of digitalizing product information, including tools like watermarks, tags, and digital passports (Walden et al., 2021). The primary objective of Circular Economy is to enhance the usage of materials while producing the products in a sustainable manner by reducing the usage of resources with reduced carbon footprint (Zeiss et al., 2021). According to Zeiss et al. (2021), Information Systems discipline is at a very initial stage and even yet to realize the full potential of its role in enabling Circular Economy. They have expanded on two IS research goals such as Transformative and Solution oriented roles that would promote a better understanding of how IS can help comprehend and implement circular material processes, thereby tackling issues of wicked material and social complexity inherent in reuse and recycling. Moving towards a Circular Economy will pave the way for Sustainable society. Many consider the Circular Economy is an enabling strategy model to tackle the global sustainability challenges to the bounded ecosystem's persistence by reconciling the business and the environment (Zeiss et al., 2021).

The Digital Product Passport (DPP) is a new idea for digitalizing product information across its life cycle which provides an opportunity for Circular Economy acceptance and scale. The Wuppertal Institute (Götz et al., 2022) has defined DPP in a general way as a data collection that describes a product's components, materials, and chemical compounds, as well as information on reparability, replacement parts, and suitable disposal instructions. The data contained in the DPP, according to their definition, is collected from all phases of the product life cycle and may be utilized to improve design, manufacture, usage, and disposal.

As stated by Schrödl and Simkin (2014), the Supply networks established by primary product providers, whose products are made from raw materials, are necessary and must be utilized efficiently in order to be capable to manufacture and provide goods and services. They also motivate the notion of 'Green Supply Chain Management (SCM)', which combines the circular economy with resource optimization to address environmental sustainability challenges and growing environmental degradation before they become problems. In order to make the overall supply chain system more sustainable, it also takes the recycling of commodities into account. In this regard, Green SCM significantly improves environmental management. Additionally, Götz et al. (2022) highlighted that the lack of standardized protocols within the present linear economy makes it difficult to access much of the product's information. In reality, the majority of the data necessary to enable a circular economy is lost at various points along the supply chain, beginning with the producer and distributor. When it gets to the consumer and recycler stages, the information is frequently lost or unavailable. Berg, Le Blèvenec, Kristoffersen, Strée, Witomski, Stein, Bastein, Ramesohl and Vrancken (2020) emphasize the notion of "digital twins" and how they can follow a product or substance throughout its existence and preserve information on its composition, usage and exploitation, maintenance, different forms of utilization, and in the end the likelihood and requirements for recycling and disposal.

Zeiss et al. (2021) in their paper discuss that, by prolonging product life cycles, digitalization has enabled business model changes that have enhanced product utilization during the in-use stage and therefore reduced waste. As enhanced resource usage necessitates integrating material flows with information flows to enable coordination amongst diverse actor networks, establishing a Circular Economy is largely an issue of effective information provision and use. A large spectrum of additional actors, such as municipalities, trash controllers, and recyclers, must coordinate material flows between PLC phases in addition to a standard supply chain. This venture is essentially a “sociotechnical informational challenge” that asks questions like, ‘What is the status of a product?’, ‘What are the attributes of its components?’ ‘Can we access present and prospective information about such attributes?’ DPPs can be easily used in the circular economy since they are intimately linked to the industrial transition to Industry 4.0 (Berg et al., 2020). Given existing investment cycles, a significant R&D and investment priority should be to transition Industry 4.0 concepts to a Circular Economy.

## 2.5 Theoretical Framework

A valuable framework for comprehending the function of DPPs in allowing a circular economy is provided by the Information System theory of knowledge management. According to the IS theory of knowledge management, knowledge is a crucial resource for organisations to use in order to accomplish their goals and objectives (Alavi and Leidner, 2001). Information Systems can be used to produce, store, and distribute knowledge to enhance innovation and decision-making (Nonaka and Takeuchi, 1995). In this context, DPPs can be seen as an IS that promotes knowledge production and sharing regarding product information throughout the life cycles of products in the context of the circular economy.

As emphasized by Alavi and Leidner (2001), the processes of knowledge generation, knowledge preservation and retrieval, knowledge transmission, and knowledge application are different yet interrelated in knowledge management. The DPPs are regarded as a knowledge base that comprises data on the product life cycles. A product's manufacturing, distribution, usage, and end-of-life disposal are all included in its life cycle (Asmatulu, Twomey & Overcash, 2012). DPPs include details on the effects a product's life cycle has on the environment, including the resources it utilizes and the waste it produces (Götz et al., 2022). Organizations will benefit by utilizing this information to streamline processes, reduce waste, and promote sustainability. An organisation can utilize the information in the DPP to find ways to use less raw materials or to create new, ecologically friendly products. According to Walden et al. (2021) sharing and generating information about product life cycles result in the production of new, more sustainable goods and services from the perspective of the circular economy. An organisation can utilize the data in the DPP to find opportunities to create new products from recycled materials or to create new business models that encourage the reuse of items.

Knowledge Management (KM) theory as stated by Alavi and Leidner (2001), comprises four essential processes. First and foremost, knowledge creation refers to the act of creating new information through a variety of methods, including investigation, experimentation, and creativity. The process of creating knowledge comprises an ongoing interaction between intuitive and explicit knowledge aspects as well as a developing spiral movement as knowledge passes through many stakeholders at various phases. By combining, identifying, reclassifying, and synthesizing already existing explicit information, the combination mode signifies the formation of new explicit knowledge (Nonaka and Takeuchi, 1995; Alavi and



Leidner, 2001). The knowledge that can be stated in words and figures and communicated through data, information, scientific computations, specifications, and manuals is referred to as explicit knowledge.

Secondly, knowledge storage entails gathering information from internal and external sources, categorizing and organizing it for eventual access, and preserving it. The knowledge is preserved in a variety of constituent forms, such as textual documentation, structured data maintained in digital databases, and standardized knowledge kept in expert systems (Tan, Teo, Tan & Wei, 1998; Alavi and Leidner, 2001).

Thirdly, knowledge sharing is the process of disseminating information throughout the business through different methods including training, teamwork, and communication. The information flow and communication procedures are significant forces behind knowledge sharing. Alavi and Leidner (2001) underlines the significance of knowledge sharing routes and channels in order to achieve knowledge sharing (Holtham and Courtney, 1998).

The use of knowledge to provide value for the firm, such as through enhanced goods, services, or procedures, is known as knowledge utilization. According to Alavi and Leidner (2001), the knowledge can be implemented and used as the foundation for decisions. Additionally, the fundamental knowledge is absorbable and useful for problem-solving and decision-making (Gioia and Poole, 1984). According to Serrat (2017), the four agents of knowledge anticipated by knowledge management models are an individual, a team, an organization, and an inter-organizational domain. He further mentions consumer stances regarding their goods, vendor patents, and recorded practice as a form of knowledge from the perspective of the inter-organizational domain. In our research, the concepts and processes of knowledge management are broadened to regulate the outflow of knowledge across firms to their potential customers.

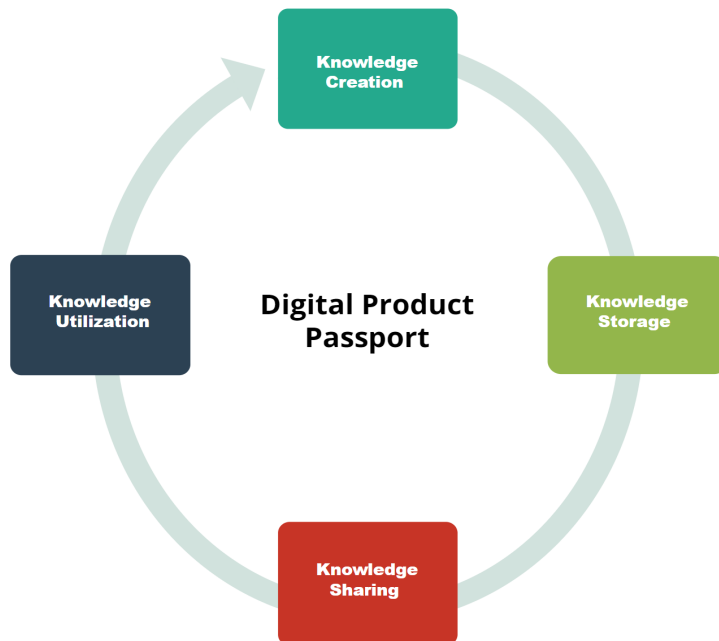
### *2.5.1 Integrating the Knowledge Management theory with the DPP*

One important concept in knowledge management theory is collaboration, which involves individuals and groups working together to achieve a common goal (Wenger, 1999). In the context of the DPP, collaboration is the creation and storage of knowledge, which involves manufacturers, retailers, regulators, customers, and suppliers working together to create and maintain a shared repository of information about a product. This collaboration is essential for creating a standardized approach to product information management and ensuring that all stakeholders have access to the same information. Within an organisation, the product design team can work with the sustainability team to ensure that the DPP contains accurate information about the product's environmental impact. Another key concept in knowledge management theory is knowledge sharing, which involves the transfer of knowledge from one person or group to another (Choi & Lee, 2002). In the context of the DPP, knowledge sharing involves the sharing of information about a product's design, materials, and manufacturing process between manufacturers, retailers, customers, and recyclers. This information sharing is essential for creating a transparent supply chain and ensuring that products are produced sustainably and ethically. As mentioned in the previous section, the knowledge utilization phase helps with decision making and problem solving by using the shared knowledge. Moreover, knowledge management theory emphasizes the importance of technology in facilitating knowledge sharing and collaboration. In the context of the DPP, technology plays a critical role in enabling manufacturers, retailers, regulators, customers, and suppliers to share information about products efficiently and securely.

As stated by Ellen MacArthur Foundation (2019), different organizations in the textile sector can share information and knowledge on the effects of textile manufacturing on the environment and society, as well as how to recycle and dispose of textile waste. According to Appleyard (1996, p. 138), knowledge sharing is the "transfer of practical know-how or information between different organizations". As highlighted in the study by Loebbecke, Van Fenema and Powell (2016), firms participate in several temporary or more long-term partnerships for collaboration. The DPP operates in this sense as a forum for knowledge transfer and exchange across enterprises, assisting them in developing greater circularity and sustainable production models.

The research conducted by Demir, Budur, Omer and Heshmati (2023) indicated that knowledge storage acted as a mediator in the connection between knowledge generation and knowledge use. Thus demonstrating the significance of initially storing knowledge in order to share and utilize it subsequently. Additionally, they also highlighted that the processes of knowledge creation, storage, and sharing had a major influence on the utilization of knowledge. As stated by Demir et al. (2023), the knowledge storage is crucial for sorting out the undesirable portions of the knowledge, which will make it easier to share and utilize the knowledge that has been created. Moreover, they contend that knowledge storage is a crucial step in reutilizing the knowledge that has been developed (Lueg, 2001; Nemati, 2002). They also emphasized the significance of knowledge sharing as a key aspect of knowledge utilization.

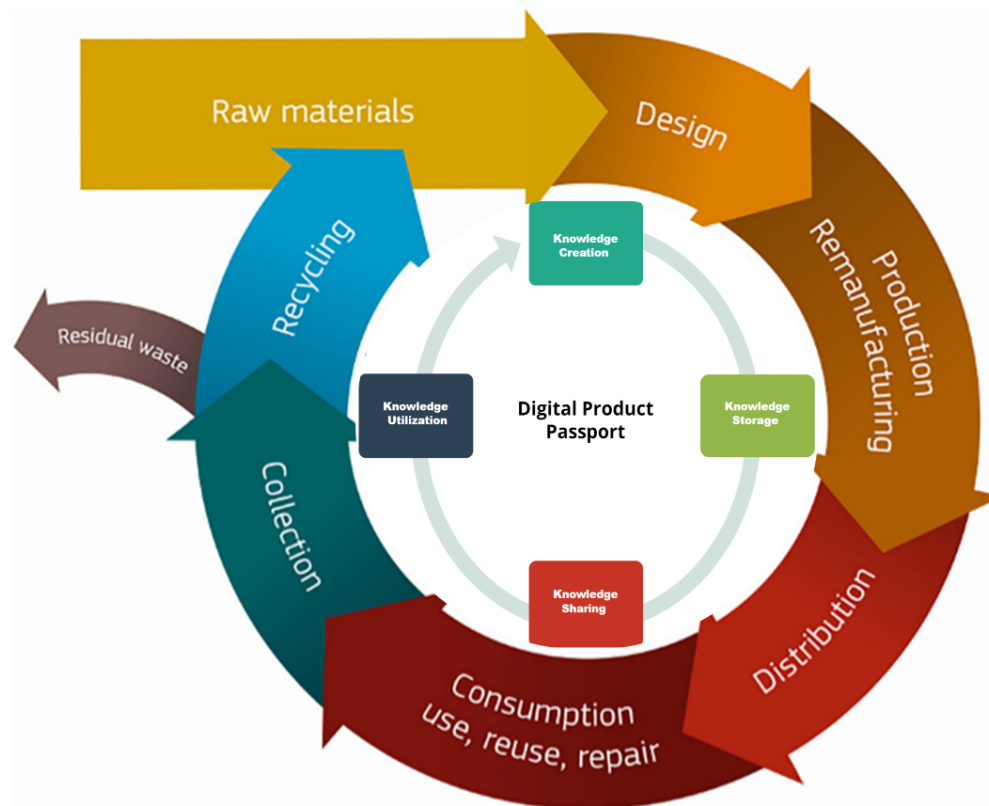
Our theoretical model in Figure 4 is based on the above-discussed IS theory of Knowledge management and further combining the understanding from Demir et al. (2023), hence in our research the knowledge management framework is utilized as a circular process that promotes continuous value creation and development via the creation, storage, sharing, and utilization of knowledge which further provides a suitable framework for understanding the product information to carry by DPP and its role in enabling a circular economy.



**Figure 4. Theoretical Framework based on KM Theory adapted from Alavi and Leidner (2001)**

Using the knowledge accumulated, a product can be made more effective and sustainable by minimizing waste and maximizing resource usage. According to Adisorn et al. (2021), the "European Green Deal" and the "Circular Economy Action Plan" are two initiatives that support information sharing and the development of a thorough information flow on the level of the EU and with regard to product policy. DPPs will also be used to trace a product's lifespan, enabling improved resource management and more effective material usage (Walden et al., 2021). Knowledge management theory, the digital product passport, and the circular economy are all related in that they all work to build more effective and persistent systems. A DPP offers a digital track of a product's history, specifications, and other pertinent information (Götz et al., 2022). Knowledge management theory, in accordance with Alavi and Leidner (2001), helps to ensure that information is gathered, organized, and shared in an efficient manner. Figure 5 depicts the theoretical framework which helps to conduct this research study by integrating Knowledge Management theory with Circular Economy.





**Figure 5. Theoretical Framework by integrating Circular Economy (European Commission, 2014) and the Knowledge Management Theory (integrated by authors)**

When we look at circular economy in the context of knowledge management theory, as shown in Figure 5, knowledge relates to the information about products that is vital to supporting various stages of circular economy in reducing waste. That is the information about materials used, the product design aspects (like design for assembly, design for disassembly, spare parts, reparability, etc.) (Bocken et al., 2016), and manufacturing insights would generate the core information of the product, and this relates to knowledge creation. Through the development of creative product designs, the definition of requirements, and the execution of simulations, the design phase contributes to the process of knowledge creation (Ulrich, Eppinger and Yang, 2008). Manufacturing phase generates knowledge when production teams build quality control protocols, improve production lines, and refine manufacturing processes. Documenting knowledge about quality standards is an essential component of this phase (Lee, Lapira, Bagheri and Kao, 2013). As Walden et al. (2021) have noted that in order to facilitate all stakeholders in the value and supply chain to collaborate on the development of a circular economy, a digital product passport will collect and preserve product information and data in a standardized and consistent manner. Thus, knowledge created is stored and captured in DPP contributing to knowledge storage of the product information. By establishing a standardized method to transmit information such as recycled materials or carbon emissions across intricate supply chains, DPPs can offer a common platform for transferring product information (Götz et al., 2022). When the product is available in the market for sale, which is at the consumer end, then the knowledge about the product would need to be shared with consumers and all other stakeholders. A deeper understanding of the circular economy with regard to the content, qualities, and usage of products and materials will be possible due to the anticipated

functions of DPPs to significantly enhance transparency and knowledge (Götz et al., 2022). The knowledge about the product would be further utilized to extend the life of the product and make the materials flow in a circular way to eliminate waste.

## 3 Research Methodology

The objective of this section is to describe our research's methodology, which covers the research strategy, collection of data techniques, and respondent selection. The design of the interview guide, which aided in the creation of the interview questions used in the interviews, is also addressed. The study's research quality and ethical consideration will be explored in the later part of this section.

### 3.1 Research Strategy

According to Hassan, Mingers & Stahl (2018), any researcher must respond to a number of pre-research philosophical concerns in order to conduct any type of investigation. They also suggest that IS researchers should approach philosophy thoughtfully when addressing modern opinions and emphasize the necessity for the successful application of philosophical innovations. The interpretive method of organizational studies asserts that the methods of natural science are incompatible to the study of social phenomena. This kind of thought holds that the physical world that natural science investigates and people, the material and social objects they generate are fundamentally different (Lee, 1991). Through this study, we anticipate gaining knowledge of the major stakeholders' perspectives about the product information DPP carries and its role in enabling a circular economy.

According to Aakhus, Ågerfalk, Lyytinen & Te'Eni (2014), referencing the qualitative evaluation would enable one to comprehend various aspects of a study issue. Furthermore, using a qualitative research approach allows the researcher to comprehend individual emotions integrally and inductive manner (Patton, 2015). For qualitative research studies in the Information Systems, two viable and important investigation concepts are pragmatism and interpretivism (Goldkuhl, 2012). The main component of IS research findings is knowledge obtained via interpreting processes (Goldkuhl, 2012). It becomes crucial to have a comprehensive grasp of the examined region in an interpretative study rather than just a knowledge of its component pieces. The knowledge develops as a result of dynamic interactions between the comprehensive and component specific understandings. Goldkuhl (2012) contends that this idea serves as the cornerstone of all interpretative research. Given that interpretivism strives to analyze data from qualitative research in a thorough and holistic manner that would be compelling to explore, it is the ideology that best matches our research technique in order to carefully understand the opinions of stakeholders from different organisations in the usage of DPPs.

A qualitative research approach will be used as the foundation for this research in order to investigate the ideas and perspectives of stakeholders from different organisations in a more comprehensive manner about DPPs. According to Recker (2013), the qualitative approaches are intended to increase comprehension of a phenomenon within the context. Further he describes that, in order to facilitate researchers to examine phenomena in their actual surroundings, qualitative methodologies have been created in the social sciences. They are especially useful when it is difficult to distinguish among phenomena and their surroundings or when a researcher wishes to thoroughly examine a single phenomenon. As a result, the qualitative technique accomplishes the research philosophy outlined in the preceding part since it offers a justification for gaining an insight into the viewpoints and opinions of the key

stakeholders, in this context referring to primarily Retailers, concerning the enablement of DPPs. Recker (2013) mentions that with the use of qualitative methods of research, there is a thorough and in-depth understanding of complicated phenomena. This strategy often entails presenting a phenomena from a variety of angles, creating a bigger picture, and paying enough attention to several facets of the topic without isolating or limiting it to single or few devoted factors. In our research, a clear and comprehensive image from stakeholders' such as Retailers' perspective of the deployment of DPPs is crucial since it helps to infer the product information to carry by DPP, its role and potential future outcomes in enabling the circular economy.

### 3.2 Data Collection Methods

The purpose of this research study is to investigate and get a thorough knowledge of the product information DPP carries and its role in enabling a Circular Economy. A Qualitative research technique has been chosen for data collection to support this study. Typically, qualitative research is carried out in the field to examine a phenomena in its natural environment (Creswell, 2009). According to Recker (2013), a knowledge of people's attitudes, actions, and motives may be attained via the use of qualitative research techniques, which include procedures like focus groups, interviews, and observations. In-depth exploration of a specific issue or problem and a greater understanding of people's thoughts and feelings about a certain subject are frequently achieved through qualitative research (Recker, 2013). Conducting interviews is one of the popular methods for gathering data, and an interpretive approach has been selected as the best option for gathering information for more study. It is believed that interviews offer in-depth, comprehensive information with unique perspective and evaluation, which is suited for this research (Bryman, 2006). Interviews are a good data gathering tool when used in a qualitative research method and in conjunction with an interpretative strategy (Bhattacharjee, 2012; Recker, 2013). In addition to having varied natures, interviews may also be classified as unstructured, semi-structured, or structured (Myers & Newman, 2007). The structure that has been chosen to conduct interviews is semi-structured, which is the most prevalent type of interview structure. Respondents will be asked about the research topic with some general questions, followed by some predefined structure of interview questions, new questions can be brought up or added up during the progress of the interview, and the flexibility in conducting depends on the responses given by the interviewee (Recker, 2013).

Semi-structured interviews provide a number of benefits like encouraging two way communications, providing opportunity for not only learning or obtaining information but also reasons for the knowledge gained. Depending on the purpose of the interview, procedures are often more or less rigorously organized. In certain cases, the respondents are given early notice of these protocols so they may get ready with responses (Recker, 2013). And as our topic is new and emerging, and according to Recker (2013), we decided to send interview questions ahead of the interview for ensuring comfortability of respondents during the interviews. Recker (2013), says that it is crucial to provide a purpose rather than choosing respondents at random since expertise and knowledge of the particular study topic are required, particularly for qualitative methodologies. Maxwell (2008) states that the focus of a qualitative research is not just on the physical mechanisms and conduct that are occurring, however also on how well the research participants interpret these occurrences and how their interpretations affect their behaviour. He further adds that the research is done on a relatively small group of individuals in a qualitative manner, retaining the uniqueness of each in their

analysis as opposed to gathering information from huge samples and averaging it across people or circumstances. Therefore, it is essential to construct a complete stakeholder analysis to identify the main stakeholders connected to the DPPs for the identified organizations in order to have a thorough awareness of the various viewpoints to support performing potential critical analysis (Recker, 2013). The focus of interviews should be on selected topics, insightful and provide a casual interface in order to highlight the advantage of being targeted. According to Recker (2013), some challenges in conducting interviews are: 1) Reflexivity - the response of the interviewee matches with that of the interviewer. 2) Artificiality - the researcher and the interviewee are strangers to each other. 3) Improper structure of questions can lead to biased responses. To enable maximum trust, honest environment and openness from the interviewee, it is suggested to aim for face-to-face interviews when possible which is regarded as the most acceptable mode of data collection methods. If this is not possible then the next option is to have the video interviews conducted over digital channels such as Zoom/Microsoft Teams.

### 3.3 Conducting Interviews

Recker (2013) asserts that interviews in a qualitative study can be conducted in a variety of methods, including in-person, over the phone, or through conferencing. The greater part of our interviews were conducted using video conferencing, as the majority of our respondents were situated outside the Lund and Malmö region. The software selected for the purpose of the interview was Microsoft Teams, which was the top preference software of our respondents. We consistently adhered to the time limits during our interviews since Walsham (2006) emphasizes the value of being punctual and being considerate of the respondents' intense schedules.

### 3.4 Selection of Respondents

To identify and categorize the respondents, the sampling technique proposed by Bhattacharjee (2012) is employed. Sampling is the statistical procedure of choosing a segment of an interested demographic in order to make observations and draw conclusions from the data. The sampling procedure is structured into various sections. Identifying the target population is the first step. Any individuals or objects having the desired qualities make up a population. The selection of a sample frame is the second stage in the sampling procedure. This is a segment of the target group that is reachable and can serve as a source for a sample. Selecting a sample from the sampling framework constitutes the final stage in the sampling process (Bhattacharjee, 2012). Moreover, Bhattacharjee (2012) suggests using the expert sampling approach, which involves selecting respondents according to their level of knowledge and expertise in the topic being investigated.

Thus in accordance with Bhattacharjee (2012), the participants were selected with the intention of interviewing the key people and stakeholders working at the retailers' side primarily who are involved in the decision making process of implementing and administering the DPPs. As the retailers will be legitimately responsible for assembling, providing, and modifying the required DPP information (Beanland, 2023; European Recycling Platform, 2017), we believe that by interviewing individuals primarily at the

retailers' end who fall under the distribution phase of the circular economy, we will be capable of acquiring a comprehensive and multifaceted perspective on our research topic about the product information DPP carries and its role in enabling the circular economy as shown in Figure 6.

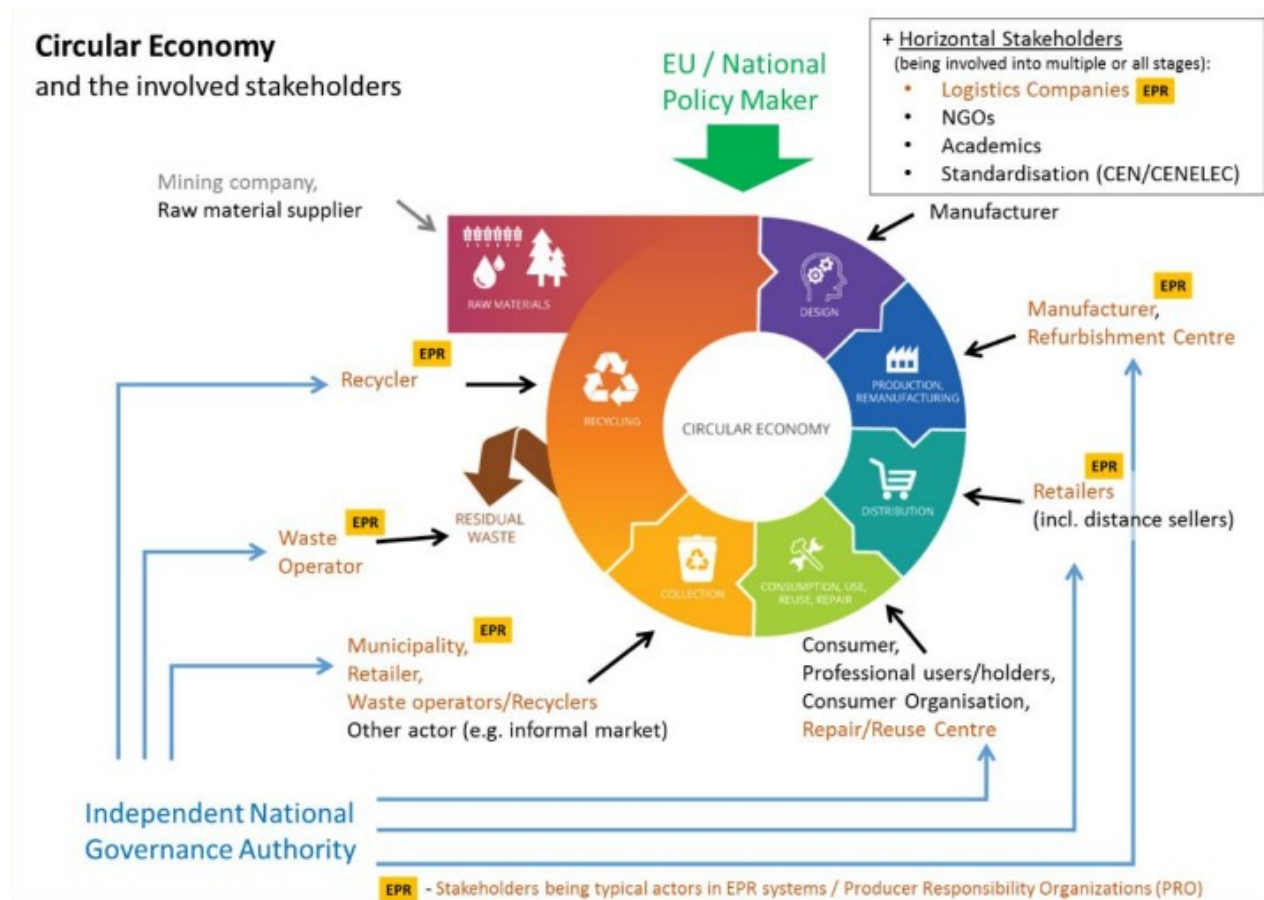


Figure 6. Stakeholders in stages of Circular Economy (European Recycling Platform, 2017)

A total of seven respondents were chosen for our research study. We have concentrated on large-scale industries for our study, and there are a total of four of these firms represented by our seven respondents. The codes for the respondents are mentioned in Table 1. P1 works as the Program Manager for Sustainable production and consumption in her organisation. Three of our respondents namely P2, P3 and P4 work with the retailer side of the supply chain and hold a key position in their organisations respectively, where the digital product passports have been a topic of discussion since the recent period of time. One of our respondents, P5, works as a Sustainability Strategy Manager and advises organisations on strategies related to sustainability and circularity. The respondents P6 and P7 work with the organisation PEAB. P6's focus area is on climate change and its mitigation and P7 works with standards focussing on working with principles that emphasize sustainability and circularity.

Below presented is a background about our respondents and the field of work they have been involved within during their years of experience.

**P1 Viveka Risberg:** Viveka Risberg works as the Program Manager for Sustainable production and consumption. She oversees specific initiatives relating to traceability and



sustainability in global value chains. One of the projects she is working on currently is the Propare project which makes investments in creating the supporting framework and infrastructure for digital product passports. She has experience in sustainability, and a wealth of knowledge on sustainable supply chains. She also serves as the chairman for ETI (Ethical Trading Initiative) of Sweden. She formerly served as Swedwatch's responsible publisher and director of the office. She headed H&M's sustainability department before that and spent four years managing programs pertaining to labour conditions and environmental concerns in Bangladesh (Axfoundation, 2023).

**P2** (Anonymous) works as a Digital Product Leader with 16 plus years of experience. He leads the solutions to help the organization meet its business goals and works in the Product Lifecycle Management sector. His main area of focus is on the way they can record the product information and how the suppliers will benefit from this information when they attempt to make the items.

**P3** (Anonymous) works as a Product Management Leader. He is in charge of managing all the vital information regarding their products. And also is engaged in the team project that aims to alter the data flow in the development of information declaration over the last five years in order to increase accuracy and efficiency.

**P4** (Anonymous) works as a Digital Transformation Leader within the Digital Transformation Office of her organisation. She holds 13 plus years of experience in delivering IT products and projects. She leads in the area where her team is more suited to drive transformative changes in the perspective of her organisation.

**P5** (Anonymous) works as a Sustainability Strategy Manager and specialized in energy, climate change, clean technology investing, and decarbonization strategies. She advises businesses on sustainability and circularity initiatives. Currently, she has been working on a new product that is both connected to circularity data sharing and to the manufacturing industry.

**P6** Embla Winge works as a Climate development manager at PEAB. She works for the whole PEAB organization, which has 16,000 people and deals with climate change and its mitigation. Formerly she was working as the project manager in PEAB.

**P7** Fredrick Berg works as a BIM (Building Information Modelling) Business developer with PEAB with an emphasis on standards that define, catalogue, and describe the built environment. Additionally, his work area also focuses on working with principles that emphasize sustainability and circularity.

In the Table 1 presented below, information about the Respondents' interviews is provided.

**Table 1. Overview of Participants and Interview Details**

<b>Respondent Code</b>	<b>Position</b>	<b>Date of Interview</b>	<b>Length of Interview</b>
P1	Program Director Sustainable Production and Consumption	24/04/2023	40 minutes

P2	Digital Product Leader	01/05/2023	45 minutes
P3	Product Management Leader	27/04/2023	43 minutes
P4	Digital Transformation Leader	25/04/2023	40 minutes
P5	Sustainability Strategy Manager	01/05/2023	1 hour 15 minutes
P6	Climate Development Manager	02/05/2023	1 hour 10 minutes
P7	BIM Business Developer	02/05/2023	1 hour 10 minutes

### 3.5 Designing the Interview Guide

The interview guide is created in line with the knowledge management theoretical framework that was selected, and the questions are framed according to the theme of the framework and the research question. So, as advised by Myers and Newman (2007), we chose to initiate the interview with generic, open-ended questions that centered on the respondent's introduction and gave them the opportunity to introduce themselves.

We started the interview with the general DPP questions followed by the deep dive questions to explore the role of DPP across various stages of CE. This is consistent with Ritchie and Lewis (2003) view that you may accomplish depth as well as breadth in interview questions by organizing them into categories and then creating a range of questions based on each category's chosen topics. We formulated our questions in such a way that enabled us to have further leading questions (Recker, 2013).

From the chosen theoretical framework of Knowledge Management, interview questions that would align with our chosen semistructured interview were designed and depicted as shown in Table 2. The entire guide to interviews is available in Appendix.

**Table 2. Interview Questions categorised to show significance and applicability**

Category	Significance and applicability to framework	Reflected in Questions
<b>Opening Questions</b>	Ethical considerations	1, 2, 3
	Interview process, data collection, feedback and any clarifications	4, 5
<b>Introduction Questions</b>	Introduction of participants and research students	6, 8
	Purpose of research study	7



	Participants role in relation to Circular Economy of their organisation	8, 9
<b>Digital product passport related Questions</b>	Awareness of DPP, CE and applicability to participant's organisation	10, 11, 12, 13, 14, 15
	<b>Knowledge Creation of Products</b> - Product information evolution across various stages of CE	16(a), 17(a), 18(a)
	<b>Knowledge Storage of Products</b> - Digital technologies and managing data specific insights	16(b), 17(b), 18(b), 19(b), 20, 23
	<b>Knowledge Sharing of Products</b> - Information consumed by various stakeholders across the stages of CE	16(c), 17(c), 18(c)
	<b>Knowledge Utilisation of Products</b> - How the information is utilised for various decisions and extending product lifetime	16(c), 17(c), 18(c)
	Overall perception about the benefits, challenges to face and any solutions to overcome while adoption of DPP	21, 22, 24

### 3.6 Data Analysis Methods

As a qualitative research approach is selected for our research study, both data collection and data analysis methods go together due to the interwoven dependency and require further follow up with the interviews to gather additional insights while exploring associations with other constructs (Recker, 2013). As Recker (2013) indicated that a key aspect of the analysis stage in the qualitative research is the amount of data which would be analyzed when it may not be clear initially how the related parts are connected together and how it will influence the final outcome of the research. Hence while conducting interviews, the information to be documented and transcribed which would typically result in the generation of large amounts of data (Patton, 2015).

Due to the large amount of data collected, the coding process would be a more relevant and useful approach to analyze the data gathered from the semi-structured interviews which would help to reduce the large amount of data into meaningful information (Recker, 2013; Bryman & Bell, 2015). As stated by Linneberg and Korsgaard (2019), a common coding technique used is a hybrid of inductive and deductive coding, often known as abduction (Alvesson and Kärreman, 2007) or a blended approach (Graebner, Martin & Roundy, 2012). Inductive coding guarantees proximity to the information, with the potential for theory to emerge afterward. Deductive methods enable a more in-depth inductive investigation of the deductive codes in subsequent coding rounds while still guaranteeing structure and theoretical significance from the outset. The concept of abduction therefore promotes an adaptable theoretical structure and an approach to the empirical framework, that demonstrates itself in an integration of both inductive and deductive coding in accordance with the requirements of

the developing analysis. A combination of deductive and inductive coding will be used in this study, with the initial coding structure being based on the framework and later being adjusted in light of what is learned from the interviews (Linneberg & Korsgaard, 2019). The study framework, assessment questions, and potentially inductive creation during analysis all serve as the foundation for the codes that are formed (Kaplan & Maxwell, 2005).

As mentioned by Bryman and Bell (2015), there are different levels of coding starting with the initial level of coding which is considered as generic coding, followed by the second level of coding which is to consolidate the insights against categories and further following the third level of coding, which entails transferring the participant's statements from a specific context to a more general, inclusive viewpoint (Coffey and Atkinson, 1996). With the recommendation of Bryman and Bell (2015), in combination with insights gathered from Linneberg and Korsgaard (2019), we have transcribed the insights of participants' views post the interview. We have used the code as \*\*\* to anonymize where the respondents felt like not disclosing the information in the interview. There were certain corrections performed based on the received feedback from participants. In addition, Charmaz (2006) has made a point of emphasizing the value of utilizing color to accentuate and outline the statements. Then we started the first level of coding which is basic coding by following the below coding schemes and assigning them with colors.

Knowledge Management codes = (Light Magenta color)

- (KC) - Knowledge Creation
- (KST) - Knowledge Storage
- (KSH) - Knowledge Sharing
- (KU) - Knowledge Utilization

Benefits (Light Green color) and Challenges (Light Blue color) codes

- (BNF) - Benefits
- (CHN) - Challenges

When we are looking at digital product information, this information is considered as knowledge, which adds greater value to taking various decisions and actions to extend the life of a product in its life cycle and eventually enable a circular economy. The insights mentioned by participants about product information that is generated across the stages of CE is considered 'Knowledge Creation (KC)', the details about the storage of digital product information are considered 'Knowledge Storage (KST)', the product information that would be shared with various stakeholders in order to enable them to take certain decisions or actions is considered 'Knowledge Sharing (KSH)', and how the product information is leveraged to extend the life of the product and/or eventually enable material flow in the circular economy is considered 'Knowledge Utilization (KU)'. These coding schemes are targeted to code the insights in accordance with the chosen theoretical framework of Knowledge Management. While analysing the results and going through transcripts, we also established two important attributes which are perceived benefits and challenges in accordance with the DPP implementation to gain deeper understanding about the DPP role. Thus, we have included two additional codes as mentioned above, targeted to gather the

insights about the perceived Benefits (BNF) and the Challenges (CHN) which could be faced by organisations while implementing DPPs.

After that, we compiled the key takeaways from each respondent's comments on a specific subject and further classified them, as shown in table 4, 5, 6, 7, 8 and 9 in chapter 4. And this leads us further to visualize a broader perspective of the overall findings. As an example shown in below Table 3, a sample transcription which helps to visualize the coding approach followed.

**Table 3. An illustrative example of coding followed**

Speaker/ Row #	Transcription	Code
1.3	<b>Could you please walk us through your understanding about digital product passport and how it plays a role in the circular economy?</b>	
1.4 VR	I think that <b>it's important with traceability and transparency in order to just transition in society versus more sustainable production and consumption for that matter.</b> And I think that the only way to reach that is through increased transparency in the supply chain and that needs to be regulated mandatory, otherwise, it won't happen because as we all know, global supply chains are completely crazy when it comes to Tiers. <b>So it's very difficult to know how and where a product is produced.</b> So the only way to really get hold of that problem is to force the <b>producer to make a digital twin and input data on the circumstances and the content in the specific product.</b> So in that sense, I think It also will enable circular economy because it will <b>create a new value through circular business models more businesses can implement service and repair-based business models,</b> for instance, consumers can make more <b>informed purchasing decisions.</b> And it's also possible for, like public buyers, to verify <b>compliance with legal obligations.</b> With the product passport. So I think in that sense <b>DPP will spur a circular economy and sustainable production and consumption.</b>	<b>BNF</b>  <b>CHN</b>  <b>KST</b>  <b>BNF</b>

As our research question is to find what product information DPP carries and its role in the life cycles of products in enabling a circular economy, we believe that the above indicated coding process is a more appropriate method to drive the relationship between DPPs and circular economy.

### 3.7 Research Quality

The significance of using standard concepts of scientific quality such as reliability and validity in the research perspective, has been discussed by Recker (2013). Malterud (2001) recommends practices and guidelines such as triangulation, participant verification, thorough specification of data collecting and analytical methodologies, reflexivity, focus on negative instances, and integrity to increase validity. Additionally, he considers that qualitative research techniques are based on the concept of research as a methodical and reflective process for the creation of information that can be challenged and distributed, indicating objectives of transferability beyond the research framework. Credibility of findings refers to the extent to which the researcher has indeed been capable of substantiating the conclusions made via qualitative data analysis with adequate, well supported evidence (Recker, 2013). Dependability refers to the ability of others outside of the study team to analyze the same observations/data and come to the same or very similar conclusions. Measures regularly yield identical findings, which is a characteristic of both dependability and reliability. High degrees of internal and external validity are essential for the finest research designs. Such designs would protect against erroneous correlations, increase confidence in the assessment of the hypotheses, and guarantee that the conclusions gained from a limited sample are applicable to a larger extent of the population (Bhattacharjee, 2012).

The compatibility between the theoretical framework and interview ensures that the interview questions, and their answers target the identified problem; thereby meeting the main purpose of answering the research questions. According to Recker (2013) and Bhattacharjee (2012), all of our interviews which we emphasize served as important sources of information from the interviewees, thus were recorded and then transcribed out. After each interview, both of the study's researchers thoroughly transcribed the recordings of the interviews while keeping in mind that transcription takes time (Oates, 2006).

Bhattacharjee (2012) also highlights that there is a possibility that not all participants or data sources are equally reliable, objective, or informed about the topic of interest, or that some have hidden political motivations. It is very important to create a trust between the respondent and the researcher, in order for respondents' ability to fully and honestly self-represent themselves and create that trust takes time. He suggests that the interpretative researcher's role is to "look through the smoke" for covert or prejudicial motivations and comprehend the underlying nature of the issue in order to allay this concern. A lack of generality in the context may result from a research emphasis on a specific feature of DPP that revolves around a limited sample of interviewees from the views of the key stakeholders. Although, the scientific quality was strongly maintained by taking into consideration the points surrounding the credibility and reliability of the respondents' responses. Additionally, we did theoretical background research on the areas of digital product passports and the circular economy prior to the interviews to deepen our understanding of the research area.

### 3.8 Ethical Considerations

The ethical issues are extremely important since this study uses qualitative analytic techniques and conducts interviews with a variety of subjects to get opinion. Thus in order to prevent manipulation and exploitation of research for improper purposes, qualitative research is often bound by a variety of distinct ethical principles as mentioned by Bhattacharjee (2012).

It is crucial to be aware of our obligations to safeguard the real consent and best interests of everyone engaged because this study falls within the category of information systems, a social science (Recker, 2013). One very important ethical consideration is informed consent, which gives participants the chance to decide for themselves whether or not to participate in a research study. Thus we made sure that all research participants are informed about the study's purpose, what will happen to the results and how they will be shared, the potential risks and rewards of participating, and how anonymity and confidentiality issues will be addressed (Wiles, 2013). Additionally, as emphasized by Recker (2013) the researchers must preserve participant confidentiality while safeguarding their privacy and anonymity since it is our duty to defend their rights, as well as their sensitivity and privacy. Thus the participants, who wished to be anonymous through our study are therefore assured confidentiality, which implies that their replies would be treated privately and that no personal information will be released, in addition to anonymity, and are thoroughly informed about how their responses will be used (Patton, 2015).

It is vital to note that permission to record the interviews was requested in advance, as advised by Bhattacharjee (2012) and as well as whether or not they wanted to be anonymous throughout our study (Bhattacharjee, 2012). Before the interviews began, the respondents were made aware of their ability to refuse participation and to end the procedure at any time. As advised by Oates (2006), the respondents were also given information regarding the research area, and the justifications for the interview prior to the interview scheduled.

## 4 Findings

The analysis of the results acquired using the methods described in Chapter 3 is presented here in this chapter. According to the knowledge management theoretical framework of our research, the findings are described below, along with the perceived benefits and challenges for implementing Digital Product Passports.

### 4.1 Knowledge Creation of Product

This subsection provides an overview of the empirical findings from the knowledge creation perspective which are consolidated and depicted in Table 4. As P1 mentioned, it is crucial to know a product's durability, reusability, recyclability, and upgradeability information, in order to create knowledge of how to further recycle or reuse that product (P1: 1.14, 1.20). This further relates to the statements, where P2 indicates that understanding how particular components are formed and manufactured beginning with the use of raw materials and knowing about their renewable and recyclable intent goes a long way in understanding the product throughout its lifespan (P2: 2.8, 2.16).

The verification results are likely the greatest method to already know as much as you can about a product according to P1, and P2 also emphasizes the importance of certifications, safety guidelines and compliance related information about a product in terms of reliability standards (P1: 1.18, P2: 2.38). Discussing the importance of certifications, P1 claims that:

*“I think certifications play big role when it comes to reliability standards and verifications is probably the best way to already know as much as possible about a product. So therefore I also think that certifications will play an important role in the future with digital product passports, because otherwise it will be very, very difficult to compile all different attributes. But if you have certifications that will be an effective way to know that ok, so this product is certified by these third parties certification.”* (P1: 1.18)

Discussing about the generation of the information, which the consumers need to know about a product, P2 claims that:

*“Primarily both the manufacturer and then retailers, I see that they are the key contributor to this information. When I say manufacturer because they are the ones who are going to use the raw materials when they try to produce the product. So, they are the ones known better than anybody else to give the information of what materials are used and then when it comes to instructions support, extend the life of the product from the design aspect and then replacement aspect, those things typically based on the organization it depends on. But from our organization perspective, we do own the design of the product. So it falls under retail in this case. So primarily manufacturing and retailers both of them need to be generating this information”* (P2: 2.26)

P4 highlights the significance of tamper proof information in relation to a product, all the way from cradle to grave and creating knowledge about its carbon footprints details (P4: 4.4). P4 and P7 additionally draws attention to standardizing the information across many stakeholders



that are involved in the value chain, which becomes a crucial success element or a crucial driver to enable the circular economy (P4: 4.32, P7: 6.44).

When talking about collecting downstream user information, P5 claims that the manufacturer still is in the center of collecting this information. Moreover, P5 adds that one of the most crucial stages when you'd genuinely want to enable circularity is during the design process, where eighty percent of a product's impact on the environment is already determined (P5: 5.18, 5.22). Highlighting the importance of design phase in creating information about a product, P5 states that:

*“We know that environmental impacts of the product, let's say in general sense, 80% of the environmental impact is already locked at design phase. So, I think the design phase can never be overlooked, right? This is one of the most important phases where you would actually want to enable the circularity.”* (P5: 5.22)

When asked about ensuring the protection of patents, information security, and data privacy for the information DPP collects and administers, P7 underlines the significance of detailing of data that is intended to be added to the DPP (P7: 6.42). P7 further argues that we often state that manufacturers are in charge of producing the data or filling out the data template into a data sheet; however, given that the DPP is monitoring data along the supply chain, additional stakeholders ought to contribute to the entirety (P7: 6.23).

**Table 4. Knowledge Creation phase based on participants responses**

<b>Knowledge Creation</b>	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>P5</b>	<b>P6</b>	<b>P7</b>
Product information such as durability, reusability, recyclability, and upgradability	1.14						
Product components data	1.14, 1.20	2.8	3.22			6.22	
Certificates & Verification Results	1.18	2.38					
Repair and Replacement instructions		2.16, 2.22					
Collecting downstream user information by manufacturers					5.18		
Standardized Information				4.32			6.44
Information to be added by stakeholders						6.29	6.28



## 4.2 Knowledge Storage of Product

This subsection provides an overview of the empirical findings from the knowledge storage perspective which are consolidated and depicted in Table 5. By establishing a centralized location for storing and managing the information about a product, the digital product passports provide that the information is accurate, up-to-date, and easily accessible to the stakeholders who need it. According to P1, the manufacturer must develop a digital twin and store information about the conditions and the content of the particular product (P1: 1.4). The thoughts of P2 align in the same direction, as P2 claims that a type of digital twin should be created so that the stakeholders may easily plan and carry out various activities from the perspective of recycling (P2: 2.32). As P1 argues that:

*“It’s very difficult to know how and where a product is produced. So the only way to really get hold of that problem is to force the producer to make a digital twin and input data on the circumstances and the content in the specific product.”* (P1: 1.4)

On similar lines, talking about the significance of digital twin, P2 highlights that:

*“We are investing heavily in the digital aspect. So we do have solutions which are enabling us to capture the digital twin of the product through the various digital technologies.”* (P2: 2.42)

P2 and P3 discuss about the significance of granularity of data and what level of product information is to be saved in the DPP (P2: 2.32, 2.42; P3: 3.6, 3.10, 3.16, 3.34). P1, P2, and P3 emphasize the necessity to have a specific means to restrict access to select stakeholders as well as data confidentiality and access to protect patents, while talking about the information stored in the DPP (P1: 1.48; P2, 2.48; P3: 3.16, 3.22, 3.34, 3.46). P4 and P5 claim that recording the information inside a DPP will make things easier, and how it is important for the manufacturers to collect the data on granular levels (P4: 4.6; P5: 5.8, 5.16, 5.26). P5 also emphasizes on the need of data infrastructure to manage the several layers of data, containing the information of DPP (P5: 5.8, 5.16, 5.26). Additionally, P5 adds that Product Performance Data and the Product Manual is to be used to cover the parts of the information a DPP contains. Moreover, data as a new service for their respective customers is emerging as a popular concept (P5: 5.12).

P7 brought to light various ways in which information can be stored and saved. Data dictionary, data templates, data sets, log book and safety sheets are a few of them which were highlighted (P7: 6.6, 6.8, 6.13, 6.30, 6.32).

**Table 5. Knowledge Storage phase based on participants responses**

<b>Knowledge Storage</b>	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>P5</b>	<b>P6</b>	<b>P7</b>
Digital Twin	1.4	2.32, 2.42					
Data access in common way across stages	1.26, 1.46	2.10, 2.12					

Granularity and level of product data		2.42	3.6, 3.10, 3.16		5.8		
Need of data infrastructure, Blockchain, Cloud technology				4.8, 4.30	5.10, 5.28, 5.34		
Security Perspective, Patented information			3.16, 3.22, 3.34	4.22		6.12	
Data dictionary, data templates, data sets							6.6, 6.8, 6.13

### 4.3 Knowledge Sharing of Product

This subsection provides an overview of the empirical findings from the knowledge sharing perspective which are consolidated and depicted in Table 6. Knowledge Sharing requires stakeholders to share their expertise, experience, and information about the product, its components, and its manufacturing processes. The process of creating a digital product passport involves the collaboration of various stakeholders, such as designers, manufacturers, suppliers, consumers and recyclers. This collaboration requires knowledge sharing to ensure that all entities are aware of the product's life cycle and can provide accurate information to create the digital product passport.

This subsection provides an overview of the empirical findings from the knowledge sharing perspective. Talking about awareness on Carbon Footprints, Climate footprint, reusability, recyclability and durability as a result of sharing information, P1, P2 and P3 claims that consumers want to know about these important attributes in a value chain (P1: 1.36; P2: 2.24; P3: 3.24, 3.42).

P1 and P2 further highlight that government authorities must be aware of the hazardous materials and Chemical content inside a given product (P1: 1.36). P4 indicates that all stakeholders throughout the value chain have access to information flow (P4: 4.6). P4 and P5 discussed that Transparency inside the whole network is very vital to the enablement of a circular economy (P4: 4.16; P5: 5.6). Mentioning the importance of transparency inside the network, P4 states that:

*“I think it's again a general point of view on this is that from all the raw materials that you're procuring to even the factories where you would be putting these raw materials together and how much water you're using, how much electricity is being consumed, all of the associated taxes on the environment. I think that kind of knowledge, if it's made available, I think it's relevant to provide on how you are giving transparency into how that product is actually put together from a circular economy point of view.” (P4: 4.16)*

P5 also emphasizes that increase in the collaboration of supplier, manufacturers, consumers and recyclers is a good approach which further helps in knowledge sharing process (P5: 5.6).

*“I think what we might refer to not sharing data, no transparency that will hinder the circular economy transition and digital product passport is a vehicle to push forward the sharing of that increasing of transparency increasing collaboration of supplier, manufacturers and consumers” (P5: 5.6)*

Discussing about ideas, mutually beneficial incentive system or a feedback system for customers can be created, so that customers can share their thoughts with the producers (P5: 5.6). P5 further mentions that Retailers and manufacturers need to share information about the products (P5: 5.26).

*“If a brand is serious in designing a circular product, they need to collaborate much more with the users and build this whole visibility and insight on how their end of life product or how their product has been used throughout the lifetime. So, I think it's a dynamic then users and manufacturers or retailers need to build this relationship and need to build a mutually beneficial incentive system to have a feedback system. Users are more kind of motivated to share this information or care more about information.” (P5: 5.18)*

Through the blockchain and cloud technology, the access to information on a DPP can be shared only with relevant stakeholders (P5: 5.34). P2 and P4 highlights the significance of sharing the insights on Assembling and Disassembling the product and instructions related to it with the consumers as well as with the recyclers (P2: 2.22; P4: 4.20).

**Table 6. Knowledge Sharing phase based on participants responses**

<b>Knowledge Sharing</b>	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>P5</b>	<b>P6</b>	<b>P7</b>
Climate impact and footprint	1.22	2.24	3.24, 3.42	4.14			
Retailers and manufacturers need to share information					5.26	6.9	6.23
Mutually beneficial incentive system or feedback system					5.18		
Information flow across value chain				4.6	5.6, 5.18, 5.32		
Data and knowledge for retailers, consumers						6.9	
Reusability, Recyclability and Durability	1.36						

## 4.4 Knowledge Utilisation of Product

This subsection provides an overview of the empirical findings from the knowledge utilisation perspective which are consolidated and depicted in Table 7. One of the most important point highlighted by the interviewees was regarding how the knowledge provided by the DPPs will lead the consumers into making better and wiser purchasing decisions (P1: 1.26; P2: 2.24; P4: 4.6, 4.8, 4.14; P6: 6.20, 6.23). As P1 describes that:

*“About the future, I think that the digital product passports will hopefully then be the norm and that it will also be very normal to look at the product passport when you buy something in order to make a good decision and know that, OK, so this is a good deal for me because I know I can repair it, I know I can recycle it and it's also good for the planet.”* (P1: 1.26)

Talking about enabling wiser decisions, P2 highlights that:

*“I would like to understand when I try to buy a product, what are the materials used and then how those materials are impacting the planet. I would like to have a clear understanding about it. So that if I have multiple product options available, then I can pick the one which is an eco-friendly product. So that is one piece of information I look for. The second information is how easily I am able to maintain the product at my end. So it could be if something is broken how easily I can replace the broken part rather than buying a new product. So I will be expecting easy accessibility to repair instructions and then replacing instructions primarily to understand if something will not work in the future then I have a way to extend the life of the product.”* (P2: 2.24)

P4 also sheds some light on the similar line of thoughts about enabling the consumers to make wiser purchasing decisions.

*“You do want to give the power to the consumer on making wise decisions.”* (P4: 4.14)

*“And the consumer can then make wise decisions based on the information that they're seeing.”* (P4: 4.6)

*“So it gives you that kind of contextual so that it's not just the content of the information, but who is putting that information that gives you that confidence that I can make wise decisions.”* (P4: 4.8)

Additionally, the reusability and repairability of the products was an important part of the discussion (P5: 5.16; P1: 1.20; P2: 2.22). P1 and P2 highlighted the significance of the information which will be utilized in determining the attributes such as repairability, reusability and recyclability of a product which will ultimately lead to prolonging life of a product (P1: 1.30; P2: 2.34). When asked about the contribution and how this information can be utilized in the circular economy perspective, P1 mentioned that:

*“The more you know about a product the easier it is to handle the product consciously so that you can, loop it back in the circular loop if you know what to do with it. So in that sense, I think more information is the first step and then its behavior and action. So, but you have to start with the data and information.”* (P1: 1.28)

According to P2 (2.44), the knowledge and information captured by DPP will also give a competitive advantage to the retailers and hence incentivize the organization. In addition, P7 mentions that if the information generated by DPPs is utilized in an efficient manner, it will also be a good opportunity for manufacturers and will benefit them, when the consumers would want to make a choice based on the information related to the environmental impact provided about a product (P7: 6.10).

**Table 7. Knowledge Utilization phase based on participants responses**

<b>Knowledge Utilization</b>	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>P5</b>	<b>P6</b>	<b>P7</b>
Purchasing decisions by consumers	1.26	2.24		4.6, 4.8			6.13, 6.20
User Behaviour, User Interaction					5.16, 5.22		
Competitive advantage		2.44					
Loop back of Product and materials	1.28	2.16					
Recycling of Materials	1.30	2.34		4,20		6.22	

## 4.5 Perceived Benefits

Based on the empirical data collected through interviews, most of the interviewees share the below indicated key benefits of DPP which are consolidated and depicted in Table 8.

According to P2 (2.4, 2.24), DPPs provide information about sustainable materials being utilized in a product, which encourages consumers to purchase and promotes in buying eco-friendly products (P3: 3.28). The majority of interviewees concur that having access to sustainability data with traceability, transparency and standardization (P6: 6.46, P4: 4.4) is preferable to more sustainable production and consumption (P1: 1.4). And they are working to develop a workable solution for this, as well as activate and enhance traceability and accuracy in all the data (P3: 3.20).

In order to comply with the numerous safety rules, we must get certain certificates and verification data. Therefore, including these certifications and the compliance related data in DPP (P2: 2.38) helps consumers verifying compliance with legal responsibilities is also feasible for public purchasers with the product passport (P1: 1.4). As an organization, we are ready for adjustments to adopt new rules, which is why P3 thinks they are ready for the DPP implementation very well (P3: 3.34).

Knowing more about the product means Knowing the facts which is necessary to measure and compare which product is better (P6: 6.9), which is enabled by implementing DPPs which increases the likelihood that the product and we can have a knowledge by which we may

extend the life of a product by repairing it, reusing it (P2: 2.4) or taking other actions that will make the product last longer and will be maintained at the consumer's end for a longer period of time (P2: 2.30). P2 says they can also have a certain type of store that specializes in refurbishing (P2: 2.30). An opportunity for them to actually see more circular business models (P5: 5.32). As more companies adopt service and repair based business models (P1: 1.4), it becomes simpler to understand how we can get things for repair and reuse (P1: 1.20) which in turn enables bringing in new products that use circular business models (P1: 1.20, P6: 6.22). To produce new value doesn't necessarily require us to spend additional money (P2: 2.30, P6: 6.22) which finally helps customers in Informed purchasing decisions and in increasing the life of product (P1, P2, P7). P2 says they firmly believe that pursuing the circular economy will be extremely challenging without digital product passports (P2: 2.6). DPPs are one of the most important key enablers in facilitating the transition to a circular economy with this product passport (P2: 2.4). Whereas according to P1 (1.6), DPPs are enablers for the circular economy and in providing information across different stakeholders or different parties (P6: 6.6).

**Table 8. Perceived benefits of DPP based on participants responses**

Benefits	P1	P2	P3	P4	P5	P6	P7
Promotes Eco-friendly products		2.4, 2.24	3.28				
Traceability, transparency, standardisation and accuracy of product information	1.4		3.20	4.4		6.46	
Sustainable production and consumption	1.4						
Circular business models	1.4, 1.20	2.30				6.22	6.10
Service and repair based business models	1.4	2.30					
Informed purchasing decisions to consumers	1.4	2.24					6.10
Products complaint with legal regulations and brings more safer products	1.4	2.38	3.34				
DPP is an enabler for Circular Economy	1.6	2.4, 2.6		4.6	5.32	6.9	6.6
Competitive advantage for business	1.8	2.44					6.10
Informed decision making support	1.8					6.40	6.23, 6.25
A contribution to increasing recyclability, reparability or reusability, and extending product lifetime	1.22	2.4, 2.22, 2.30			5.38	6.40	
Easy access of product information to all stakeholders	1.26	2.10, 2.20, 2.40, 2.46					



Good support for taking care of products	1.28	2.30					
Regulatory driving force to speed up and accelerate circular economy journey					5.4		

## 4.6 Perceived Challenges

Based on the empirical data collected through interviews, most of the interviewees share the below indicated key challenges organisations are going to face while traversing the DPP journey which are consolidated and depicted in Table 9.

The main challenge is about understanding DPPs at an organization level with the framework/guidelines provided so far (P6: 6.37, P1: 1.10). Another challenge P1 believes that product data is not as readily available as per future expectations, and there is poor assistance for tracing where and how products are made nowadays (P1: 1.26). P6 says only a significant portion of this information is now available in non-material, non-machine readable format; therefore, this must be changed into machine-readable formats (P6: 6.32). According to P3's opinion, at the recycler end, only around 15% to 20% of the information is available, so we can notice the gap clearly for performing recycling efficiently (P3: 3.30). It is hindered according to P1 and P2 because we lack the data and the knowledge about each product.

According to P3, maintaining records and engaging with end recyclers in the circular economy (P3: 3.32) also need significant investments in terms of gathering (P2: 2.44), storing, and transmitting the information with end recyclers (P3: 3.32) and how big of an effect it will have financially on the economy and business (P3: 3.8). For instance, if P3 is to be believed, the cost of maintaining the information and coordinating communications with other parties along the value chain, will increase the cost from the original estimate of €100 to €250. Since we can see there will be significant inflation in the economy (P3: 3.32), it is also important to take into account how the industry can adapt and bear these additional expenses in order to effectively supply the necessary data and compliance (P5: 5.26).

Furthermore, some of the business models are challenging the stakeholders' own established businesses, so it is tough to persuade them to move to a different path (P5: 5.12). The largest problem for small and medium-sized businesses is the approach to data collecting, how to absorb those additional administrative expenses and how to keep your business competitive (P5: 5.30). Government policy makers must work well with all the stakeholders involved in the journey and then consider their inputs in implementing DPPs (P5: 5.30, P2: 2.50). Therefore, it will be a game changer if governments permit some sort of incentives for products that have the DPP activated (P2: 2.44).

Another challenge is there will be lots of digital solutions which will not be compatible with each other and will be a mess if not structured in a good way and based on centralized databases where the data gets outdated quickly (P1: 1.44). According to P2 each stakeholder has their own set of applications and solutions which are maintained at their end, having accessibility to it to the entire stakeholders in the value chain is a major gap. Without a proper suggested framework guidelines from the EU, it will be difficult for organisations to establish their digital solutions for managing DPP (P6: 6.12). Finally, according to P1, P2, and P6,



without standardization, there will be lots of solutions that will not be compatible with each other and difficult to maintain.

According to P2, lower level insights are not accessible, and it is unclear what information DPP must collect and how it will be disclosed to the various stakeholders (P2: 2.12) because it concerns the amount to which you must make your material and product transparent. It is one of the most important and difficult aspects to comprehend what level of granularity information of a product we need to capture in the DPP (P1: 1.48) as DPP is still in the exploration phase (P2: 2.42). We must have a method to limit access to particular stakeholders depending on the need point of view in order to prevent the production of counterfeit products since the more information we reveal, the riskier it will be from the perspective of patents (P2: 2.48). P3 and P5 mean that certain information contained in shareholder agreements is secret, and a patent is undoubtedly one of them (P3: 3.46, P5: 5.38). And businesses are concerned about revealing business-sensitive information (P5: 5.34). If regulations try to push the granularity too much, then it will be fall back and it will lead to cheating, lying things (P3: 3.44).

The other aspects are how product information is to be made public, and who has access to contribute to that information on the DPP (P4: 4.30) is unclear. Previously, several manufacturers did not have the granularity of data necessary (P5: 5.8) which will not be the case in future with DPP. At present as stated by P3, it is always simple to follow, trace, and obtain information from the initial layers and then, generally, certain levels in the middle are skipped, and tiers go to the lower level as well (P3: 3.14). According to P3, Data traceability across supply chain levels (P3: 3.16), data reliability, correctness, and validity that flows into DPP (P3: 3.46), difficulty in identifying the original manufacturer (P5: 5.24), upholding data integrity (P6: 6.43) are additional challenges. The key to overcoming these challenges is to design DPP guidelines that necessitates close coordination with all parties/stakeholders involved.

**Table 9. Challenges to face while adoption of DPPs based on participants responses**

Challenges	P1	P2	P3	P4	P5	P6	P7
Lack of understanding about DPP	1.10					6.37	
Lack of product data availability and no good support to trace where and how product is produced today.	1.4, 1.6, 1.26		3.30				
Requires heavy investments in building the solutions and maintaining data so adoption requires some incentives from governments		2.44, 2.50	3.8, 3.32		5.12, 5.26, 5.30		
Without standardisation, there will be lots of solutions that will not be compatible with each other and difficult to maintain.	1.44	2.20				6.12	
Heavy burden on administration to manage the data.	1.44			4.26	5.12		
Granularity and extent of data to expose	1.48	2.12,	3.6,	4.30	5.8,		

while protecting confidentiality and patents.		2.42, 2.48	3.10, 3.12, 3.44, 3.46		5.34, 5.38		
Brings counterfeit products to markets if data access rules are not governed and entire information is exposed.		2.48					
Reliability, traceability, accuracy and authenticity of data which feeds into DPP across tiers of supply chain.	1.46		3.4, 3.16, 3.46		5.24	6.43	6.32
The required support to provide by European Commission while implementing DPP	1.50				5.4		
Requires good collaboration with all stakeholders while designing DPP guidelines.		2.50	3.50	4.28	5.4		

## 5 Summary of Findings

This thesis study has leveraged the theoretical framework represented in Figure 5, which is indicated as part of the second chapter, enabling us to conduct the empirical study to gather insights about what product information to carry by DPP and its role to play in the life cycles of products in enabling a circular economy. The summary of the insights gathered is represented here.

The primary focus is to gain understanding about the knowledge creation of the product when it is moving across the life cycle, who will generate this information, how the information is shared across various stakeholders in the circular economy, and how that knowledge can be utilized while applying R-cycles to extend the life of products. This entire product information is carried forward and evolved across the stages of the circular economy as a means of DPP. While understanding more about DPP in a circular economy, we also gathered its role to play in terms of the benefits organizations can gain and the challenges they are going to face while adopting DPP. The below indicated Figure 7 gives the overall summary of this empirical study conducted based on participants' views.

**Note:** As knowledge is continuously evolving when the product is moving across its life cycle, the below-represented figure shows that the elements of the knowledge management model are being associated across the stages of CE.

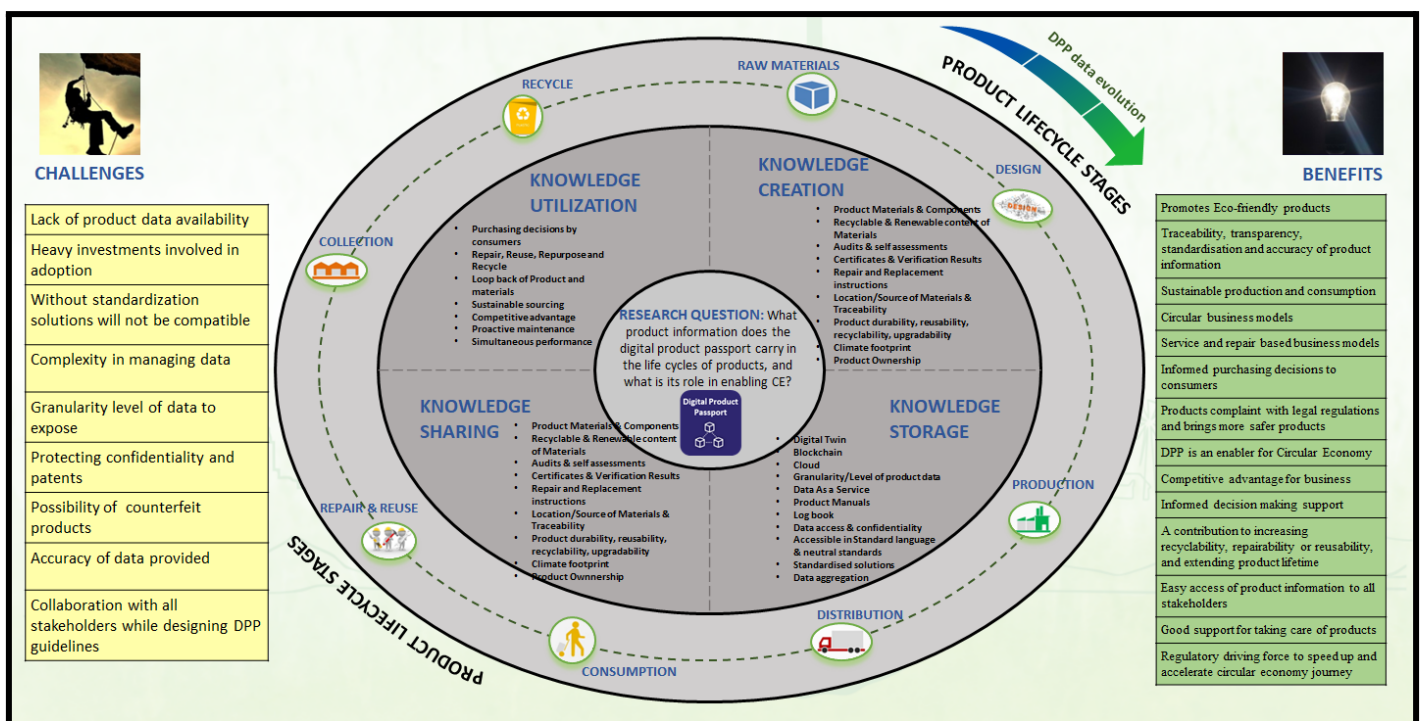


Figure 7. Summary of findings to indicate Product information to carry by DPP and its role in Circular Economy

## 6 Discussion

As it is clearly evident that DPP is an enabler for the circular economy based on the respondents' views and the literature review, there is a lack of literature and only a few studies have been conducted to understand what information is to be carried by DPP, who contributes to the information, where it needs to be stored, who consumes the information, and how crucial that information is to be utilized by various stakeholders in the life cycles of products while enabling the circular economy. As the details of this research study are presented in the Findings section, this section aims to juxtapose the findings by highlighting similarities and differences in respondents' views and also connecting the views with the literature wherever available.

Moreover, according to the respondents' responses, knowledge is created and stored across practically every stage of a product's lifecycle, though it is primarily generated during the design and manufacturing stages. Further, it can be inferred that the knowledge is shared with stakeholders based on the applicable data access and confidentiality rules. Once the knowledge is shared, the same would be utilized further to use, reuse, repair, or recycle product components or materials as per the needs of the respective stakeholders.

### 6.1 Knowledge Creation of Product

Knowledge creation is a key component of the knowledge management theory in Information systems, and it is an important process that involves the creation of new knowledge through the combination of existing knowledge and information. As stated in previous sections, explicit knowledge is classified as knowledge that can be expressed in numerals and words and transmitted through information, data, specifications, and manuals. (Alavi and Leidner, 2001). The majority of our respondents discuss developing knowledge of a product's components and component information. Along with this, the information about the recyclable and renewable content of materials, repair and replacement instructions, assembly and disassembly instructions were a common point discussed by a few respondents. All of the knowledge produced by means of these manuals and instructions falls under the classification of explicit knowledge creation. This is consistent with Götz et al. (2022) assertion that through digital product passports, the information on the product's origin, structure, and ability to be repaired and disassembled, as well as details on how each component may be repurposed or disposed of after its intended lifespan, will be generated.

Two of the respondents P4, P6 place a strong emphasis on the usefulness of developing standards and producing standardized information throughout the value chain. This is aligned with the Götz et al. (2022) statement that certain firms created their own criteria for component transparency as a result of the absence of industry-wide standards for interacting with products. However, due to the lack of these standards and regulations, some of the relevant information remains unavailable throughout the supply chain. This is in line with Walden et al. (2021) who notes that a digital product passport would collect data on social and environmental sustainability in a uniform, comparable manner to allow all participants in the value and supply chain to collaborate on the development of a circular economy.

Two of our respondents highlighted the importance of Certificates, Safety guidelines and verifications results and how they contribute to creating knowledge by providing necessary details about the product. They point out that the existence of certifications helps build knowledge by setting a baseline of product quality and safety that has been independently confirmed through reliability standards and verifications. This concurs with Götz et al. (2022) viewpoint where they focus on the claim that certification programs are essential to the future development of the European sector.

Two responders stress the need of placing items' tamper-proof information within a digital twin and preserving it there. P1 strongly advises that the best method to get specific information about a product is to make sure the manufacturer creates a digital twin and inputs data on the conditions and content of the particular product. According to Götz et al. (2022), the certifications are stored on a blockchain that contains carefully curated, reliable sustainability data that will be included in the digital product passports. This is congruent with the argument made by Demir et al. (2023), who contend that once knowledge is generated, it must be stored in order to filter out the undesired sections and make it simpler to share and further utilize. The next section goes into deeper detail about the knowledge storage phase.

## 6.2 Knowledge Storage of Product

According to Walden et al. (2021), the move to a circular economy now requires that a product be represented digitally. As a product's digital twin, it has all the data necessary for stakeholders to make well-informed choices about a product's design, manufacture, use, reuse, and recycling. It makes it possible to trace a product's life history, enabling the provision of services for remanufacturing, second-life, reparability, recycling potential, and innovative business approaches. This is aligned with one of the respondent's P2 viewpoints, since he notes that their organization is actively investing in the digital front and they do, therefore, have solutions that facilitate them to use different digital technologies to obtain the product's digital twin. In relation to the digital twins, P1 is adamant that the best approach to learn how and where a product is made is to compel the manufacturer to create a digital twin and enter information about the conditions and the content of the particular product. This is supported by responder P5, who pointed out that manufacturers are required to gather and obtain the information.

Majority of the respondents placed a lot of emphasis on the significance of standardization of information which is comparable to a global standard. Another respondent P6 emphasizes how crucial it is to be aware of all the product information in order to be able to take into account the numerous layers of data. On the other hand, she also mentions that knowing details about how the product is performing which is referred to as product performance data is also equally significant. Hence there arises the need of building a strong data infrastructure for the organisations to get ready for the future, she added. This concurs with the assertion presented by Alavi and Leidner (2001), where they mention that knowledge is retained in a range of component forms, including textual records, structured data held in digital storage systems, and standardized knowledge stored in expert networks. Additionally, this is in line with Houston et al. (2019) viewpoint that the standardization of parameters across the product life cycle is extremely important.

As discussed by Beanland (2023), to help firms decrease unpredictability, data requirements can be standardized across industries, but this could also limit the utility of the data in certain product groupings. However, as opposed to this when talking about standardization of data and information, none of the respondents expressed any concern about the limit of data usage put on any of the product groups. This could suggest that the benefits of standardizing data and information outweighed any potential drawbacks or limitations on specific product groups.

Respondent P5 talks about how large amounts of data can be assembled and managed using blockchain and cloud technologies, where the sensitive data is also being protected. In order to facilitate circular value chains on a global basis, this is in accordance with Walden et al. (2021) where they assert that Blockchain technology has the potential to offer novel opportunities to safeguard data, accountability, and product provenance. Moreover, this also concurs with Beanland (2023) study as he claims that blockchain technology promotes greater data security, openness, and traceability.

As pointed out by respondent P2, gathering product information will assist their organization in adopting a horizontal or harmonic method of communicating with stakeholders about the products. Another responder P1 is concerned about disclosing confidential details regarding the product's specifications, therefore she advises that data be stored and then shared in a way that only allows the data necessary for circular transition to be delivered. Respondent P2 affirms this statement, noting the necessity for a mechanism to limit access to certain stakeholders depending on the need in order to prevent the production of counterfeit products as more knowledge is captured and stored. This leads us to the knowledge sharing phase in the knowledge management process, which is covered in detail in the next section.

### 6.3 Knowledge Sharing of Product

The majority of respondents emphasized the idea that information should be made available to different stakeholders based on their specific needs for using it. Stakeholder-based access to knowledge about the products should thus be presented. Two respondents P1, P4 reinforced the need of sharing insights on a product's chemical composition, hazardous substances, and conflict minerals, in addition to more common characteristics like reusability, recyclability, and durability. Taking into consideration, Götz et al. (2022) viewpoint where they argue that it could be sensible to have distinct DPPs for complicated items like vehicles and buildings, however, this method could require some time or might not be practical for things like chemical substances or materials like plastics. On the other hand, Walden et al. (2021) outlines DPPs as a data set that will share the elements, materials, and chemical compounds in a product as well as details on reparability, replacement parts, and directions for correct disposal.

According to respondent P5, a digital product passport is a vehicle for advancing knowledge sharing, which in turn fosters more collaboration and transparency among suppliers, producers, and customers. This aligns with Walden et al. (2021), as they affirm that during the whole product life cycle, every stakeholder engaged must have access to transparency-enhancing information on the product composition. P5 continues by stating that during the production and retailing phases, manufacturers and retailers must provide the



specifics of the information pertaining to the products. This level of detail should include knowledge on Greenhouse Gas emissions, material utilization, repairability, and recyclability.

P5 also pointed out how industry-wide data and knowledge disclosure is facilitated by network collaboration, which is one of the key industry driving forces. This is in agreement with Walden et al. (2021) as they add that more stakeholders are collaborating effectively by sharing information than ever before in order to fulfil their commitments and discover a method to start circular product cycles. The digital product passport as seen by Walden et al. (2021) can be expanded further, preferably through collaboration among multiple stakeholders throughout the whole industry value chain, since it has the potential to be a key component of the digital circular economy. Götz et al. (2022) points that this will also incentivize businesses to make their products more environmentally friendly by facilitating easier access to accurate and consistent information throughout the supply chains. However, on the contrary, in an effort to draw attention to the producer and retailer perspectives, respondent P5 expresses her concerns with the dissemination of sensitive business data to all parties, which puts their ability to secure their confidential information in jeopardy. She further added, a manufacturer may not always be able to reveal all aspects of a product's design during the design process, for instance, intricate details on the pattern design.

Speaking from the standpoint of manufacturing, Respondent P5 indicates the need to specify the use cases in order to create a consortium or a network of stakeholders to begin working together, since end products from one industry may be a resource for another industry, and this applies to all industries in the circular economy. Therefore, in order to share the use case, the producer has to work with stakeholders from different industries, she emphasized. This concurs with the theory provided by Serrat (2017) where he explores the knowledge flow from an inter-organization domain.

Moreover, it is implied by all respondents that customers need the knowledge to make better selections and choices. Therefore, it is crucial for suppliers and retailers to provide customers with accurate knowledge, in order for them to utilize this knowledge up to its potential, which is discussed in the next section.

## 6.4 Knowledge Utilization of Product

All of the respondents recognized the primary utilization of product knowledge, notably assisting consumers in making better, more informed, and sustainable purchase decisions. For instance one respondent P2, mentioned that he wants to understand every detail there is to know about the product he bought, as a customer. So that if he has a choice among several products, he may choose the one that is environmentally friendly. One of the respondents P4 also discusses empowering the customer to make informed selections by enlightening them on aspects like recyclability, repairability, upgradeability, and carbon footprint. This goes in accordance with Götz et al. (2022) point of view, as he highlights that the businesses and customers can make well informed judgments about their purchases that take sustainability standards into account provided they are given adequate details.

Many of the respondents discussed how the knowledge that is used will provide a competitive advantage and have a significant influence on businesses, including retailers, manufacturers, and suppliers, and could potentially be a game changer in terms of overall development. For



instance, one of the respondents P6 pointed out that if the manufacturer employs the appropriate kind of knowledge, then it can be a business opportunity for them and it's advantageous for them and their product will sell more if the consumer is basing their decisions on low environmental impact. This, however, conflicts with Götz et al. (2022) study, which argues that organizations regularly bring up the problems because they fear losing their competitive edge in the market if discrete data about their products were made public.

Majority of the respondents mentioned that when customers are aware of the environmental effect of the development of a product they are using, they may be willing to use it repeatedly in a circular manner and as a result of utilizing this knowledge, they help to promote the circular economy. Hence, the customers will choose to reuse the previous material, which will increase reusability, she added. This aligns with Götz et al. (2022) point of view where they indicate that consumers who want to fix broken or defective items could be interested in detailed information on reparability aspects.

The majority of respondents stated their belief that utilizing knowledge regarding a product will help one comprehend its total climatic footprint and impact, which will help promote the circular economy. This is in agreement with Walden et al. (2021), who asserts that a digital product passport is a crucial instrument for establishing a resource and climate-conscious economy. Furthermore, this is also aligning with Götz et al. (2022) where they claim that DPPs can hasten the dual transitions to the environmental and technological sectors as a component of EU initiatives to promote effective climate action and sustainable economies.

Many respondents expressed that the recycler would also need to have knowledge about recycling the specific sort of materials and be aware of the best techniques to recycle them when questioned about the relevance of using the knowledge from a recycler's viewpoint. And one of the respondents who had direct contact with a recycler noted that recyclers have a big decision to make about whether to repurpose, remanufacture, or just declare the product to be past its useful life. She underlined the need of using the manufacturers' and suppliers' information as a result. This acknowledges Götz et al. (2022) perspective where they suggest that recyclers should use this knowledge so that they are able to more accurately determine if a product is recyclable as well as how to reuse and recycle it.

Moreover, a mutually beneficial incentive system or a system for customer feedback can be established, as highlighted by one of the responders P5, so that consumers can communicate their opinions to the manufacturers. Thus, after using the knowledge given by the producers, customers now produce new knowledge by sharing feedback, which initiates the knowledge management process.

## 6.5 Perceived Benefits and Challenges

This section focuses on the key advantages and challenges organisations might face while adopting DPP and how DPPs are anticipated to play a significant role in supporting novel methods, such as facilitating the exchange of information about a product's sustainability features, its carbon footprint, recyclability, increasing transparency, traceability, and consistency throughout value chains (Walden et al., 2021), encouraging more environmentally friendly design of products, resource optimization, and energy saving techniques, and

providing credible and comparable product information for enterprises, customers, and policymakers (Götz et al., 2022).

We can clearly see the benefits as a part of Piloted Digital product passports, digitalization of material and product information has proven useful for industrial value chains and consumer value chains, as evidenced by the adoption of the International Material Data System (IMDS), which is used by the great majority of the automotive sector internationally (Walden et al., 2021). In the IMDS, materials used in the creation of finished autos are gathered, tracked, examined, and archived (Walden et al., 2021). Another example of a widespread industrial digitization program is the Material Passport, which is backed by Building Information Modeling (BIM) (Honic et al., 2019). It enables data gathering for, and evaluation of the recycling potential of building materials as well as a full life cycle evaluation of the ecological footprint of the building (Honic et al., 2019).

The findings from this research study are mostly consistent with the literature review on the benefits of sharing DPP data at different phases of products life cycle in Circular Economy, and it is widely acknowledged that these findings are significant elements that play a vital role in achieving CE. According to P2 and P3, DPP promotes eco-friendly products by providing information on sustainability materials being used in the products, helping end consumers in taking conscious purchasing decisions. Data traceability across supply chain levels, data reliability, data accuracy, and data validity that flows into DPP, problems in identifying the original manufacturer, and maintaining data integrity are additional issues raised from the standpoint of P3, P5, and P6. Also, P4 raises a key aspect, which is unclear at this point of time, about *'who has access to contribute to that information on the DPP is unclear?'*

Not only that, two of our participants P2 and P6 say that knowing about the facts of the product helps the customer compare and measure the options available to buy a sustainable or eco-friendly product, which is aligned with King et al. (2023), Product passports are frequently seen as a tool for convincing consumers to make sustainable purchasing and product stewardship decisions by highlighting aspects of the sustainability of a product's entire life cycle. While P1 questions the trustworthiness of the data supplied, such as Who will work? Who will validate all of this information? One of the most critical problems highlighted by all participants is that the amount of granularity information about a product that must be included in the DPP is unclear, and firms are apprehensive about disclosing business sensitive information. This is consistent with Durand et al. (2022) views and this will become a critical problem regarding the amount of specificity of the data since it might be the manufacturing batch, an individual item, or a model in particular.

Whereas most participants say that DPP can bring traceability, transparency, standardisation and accuracy of product information across the value chain which increases sustainable consumption and production of products. P1 feels that product data is not as easily available as anticipated in the future, and that there is inadequate aid for identifying where and how things are manufactured now. Another intriguing point raised by P1, P2, and P6 is that without standardization, there will be a plethora of solutions that are incompatible with one another and difficult to maintain. According to P2, each stakeholder has their own set of applications and solutions that are maintained at their end, so having access to them for the entire value chain is a major gap, which is aligned with perspectives mentioned in Wbcsd2 (2023) where there are numerous challenges with regard to scope, technology, and data still need to be resolved and are in various stages of development.

According to the interviews, another crucial challenge is about who needs access to the product information and what level of information should be accessible for certain stakeholders based on necessity in order to avoid the manufacturing of counterfeit products, because the more information we expose, the riskier it is from a patent standpoint. P3 and P5 clearly imply that certain information contained in shareholder agreements is confidential, and a patent is unquestionably one of them that corresponds to the literature viewpoint of Götz et al. (2022). The availability of varied access levels is required to maintain firm confidentiality, therefore information transparency is also an important factor to consider.

P2 says that having knowledge about a product helps in extending the life of a product by reusing and repairing it, which aligns with most of our participants views about DPP need in increasing recyclability, repairability or reusability instructions and extending product life time, in turn bringing new Service and repair based business models and generating new products that use circular business models. This is aligned with Götz et al. (2022), where the DPP would cover a product's origin, composition, ability to be repaired and disassembled, as well as details on how the individual pieces may be recycled or disposed of after their useful life. One factor to consider according to P3, only around 15% to 20% of the information is available at the recycler end, indicating an obvious gap for doing recycling efficiently. P3 presents one of the most crucial views, namely that if rules try to push the granularity too far, it will result in a fallback, which will lead to cheating and lying. This is clearly aligned to Götz et al. (2022) and also customers must be able to comprehend instructions on how to recycle or repair items, as well as whether manufacturers or retailers would accept their products for recycling.

In addition P1, P2 says DPP is an enabler of sharing product information across different stakeholders, even some of them ensure that attaining or pursuing CE without DPP is challenging. Whereas the majority of them claim that maintaining records and engaging with end recyclers in the circular economy require significant investments in terms of gathering, storing, and transmitting information with end recyclers and the financial impact on the economy and business. According to P5, it is also crucial to consider how the industry can adapt and bear these additional costs in order to efficiently offer the necessary data and compliance. The procedure for keeping the product passport up to date throughout a product's life cycle is still unknown, and if industry accepts the proposal, concerns of protecting intellectual property and confidential corporate information must be addressed (Walden et al., 2021).

The key to overcoming these obstacles, according to all participants, is to develop DPP rules that require greater collaboration with all parties/stakeholders engaged. A significant contribution from P2 and P5, Government policymakers must collaborate effectively with all stakeholders engaged in the journey and then incorporate their inputs when implementing DPPs. This is consistent with the views reflected in Wbcds1 (2023), where they believe that developing and implementing a digital product passport is a difficult process that involves participation from a variety of stakeholders, including producers, purchasers, and authorities. In addition, P2 believes that it will be a game changer if governments provide some sort of incentives for products that have the DPP activated which will be a motivators for the organisations to adapt early. Despite challenges, everyone in the interview is confident that DPP is an enabler of CE which is aligned with study reflected in Wbcds2 (2023). As suggested by the EC, DPPs should act as a vital tool to increase product transparency, promoting the shift towards a circular economy and boosting economic growth.

## 7 Conclusion and scope for future research

According to the literature review, when industry is striving for carbon neutrality and greater circularity, DPPs are an excellent digital tool for modernizing and digitizing product information, allowing for the adoption of R-cycles with the goal of eliminating waste and embracing the circular economy. However, the scholarly literature on DPPs shows a lack of knowledge of the product information that DPPs must contain and their role as the product passes through several stages in a circular economy. The goal of this study was to address the following research question by interacting with participants from various organizations that are required to adhere to DPP implementation guidelines.

*What product information does the digital product passport carry in the life cycles of products, and what is its role in enabling a circular economy?*

This research study leveraged IS theory of Knowledge Management framework to gather the insights as Knowledge Management model is suitable framework for gathering the knowledge of: individual, team, organization, and inter-organizational domain (Serrat, 2017). In our study, the Knowledge Management framework is viewing the DPP evolution as an IS that promotes continuous value creation and development through the creation, storage, sharing, and utilization of knowledge, and it also provides a suitable framework for understanding the product information carried by DPP and its role in CE.

To answer the above indicated research question, we have conducted a literature review in assessing the research conducted so far, followed by seven participants interviewed with the intention of interviewing the key people who are involved in the decision making process of implementing and administering the DPPs at their respective organisations. The study findings are depicted in ‘Section 4 - Findings’ with subsections such as Knowledge Creation, Knowledge Storage, Knowledge Sharing, Knowledge Utilisation of Product, along with Perceived Benefits and challenges. The summary of findings from this research study is depicted in Figure 7 of ‘Section 5 - Summary of Findings’.

In summary, DPP is a revolutionary digital instrument that provides comprehensive and standardized data about a product's environmental footprint and social impact, from raw material extraction through the end of its life. DPPs will help manufacturers and retailers throughout the product design stage by providing them with a complete understanding of the environmental impact of each component and material utilized in the product. Using this information to identify opportunities for material substitution, the manufacturing process may be improved for higher productivity, lowest environmental effect, and sustainable buying decisions. By providing information on the materials and components used in the product, the DPP may also aid in finding opportunities for material reuse or recycling, as well as in the design of appropriate collection and recycling systems. Though there are numerous benefits highlighted by everyone interviewed and from the already implemented passports such as Battery and Material Passports, lot of challenges emphasised by the interviewees about granularity of product data to manage, level of data access while protecting the patents and confidentiality, standardisation of solutions to manage the data, the reliability and ownership of data, the huge investments required in establishing the required digital technologies, and the required support by government authorities are vital for the successful implementation of DPP.

To conclude DPPs can assist in making recycling more successful and efficient by providing detailed information on a product's composition, which will stimulate the recovery of valuable resources and help reduce waste which helps the planet move towards a more sustainable and circular world.

## **7.1 Scope for Future Research**

As mentioned in the delimitation section, this research study is focused primarily on interviewing stakeholders representing retailers and does not consider all the stakeholders involved in Circular Economy. We therefore propose that future research studies consider all the stakeholders such as raw materials suppliers, manufacturers, retailers, end consumers, recyclers and government authorities to get a comprehensive view. Moreover, this study considered seven participants from various organizations which helped us to gather the insights but a large number of interviews representing across product groups would help to gain a deeper level of insights. Though this study has gathered a high level of insights about the data storage, data access and digital technologies required to manage DPP, it lacks any standardized solutions already available in the market or any proposed digital technologies framework to consider for organizations, thus this opens up an opportunity to explore this area further. As it is clearly evident from this research study that there are numerous challenges foreseen by every participant for adoption of DPP, the solutions to overcome these challenges can also be researched further which will help for smoother implementation of DPPs.

# Appendix 1 - Interviews Preparation

## Reaching out to Respondents

Email message sent to respondents:

### Title:

Academic Interview about Digital Product Passports as part of the Master Thesis

### Message:

Dear <Name of respondent>,

Hope you are doing well!

We are currently studying for a Master's degree in Information Systems at Lund University (final year) and writing our thesis. We would like to request an interview with you regarding your perspective and views on **Digital Product Passports (DPPs)**.

**Background** of thesis study: Our thesis on the topic “Digital Product Passports: Exploring Product information and its role in fostering the Circular Economy” by exploring the question “*What product information does the digital product passport carry in the life cycles of products, and what is its role in enabling a circular economy?*”. As DPPs are at very early stages of evolution, the knowledge gained through this study can serve as a foundation for organizations and companies to better understand DPPs' role and plan for it while building the digital technologies required to support capturing DPPs.

Based on our initial exploration and by looking at the developments happening around Sustainability and Circularity ambitions, we believe that your views would add great value to our research study. As the interview might take around 45 minutes to 1 hour of your time, we are flexible to connect with you based on the time you are available on the day which suits you. Although we can be flexible depending on your availability, we plan to conduct the interviews during the final week of April. The information which we collect from the interview will be kept confidential and will be used based on the agreement with you.

We are eagerly looking to hear from you and will be happy to share any further information or clarification!

Thanks & Regards,  
Abhishansa Sharma & Sunitha Kopparapu  
Master's Students at Lund University



## Appendix 2 - Interview Guide

The below questions to leverage while conducting interviews

### Opening Questions:

1. Is it ok if we record this interview?
2. Is it ok if we use your name, job role and company name or do you want to be recorded as anonymous?
3. Is it ok if we make the recording available within university for academic purposes or do you see this should be removed post this study?
4. Information about sharing the transcribed document of the interview with the respondent for their feedback.
5. Do you have any questions before we start with the interview?

### Introduction Questions:

6. Introduce ourselves as Master research students.
7. Explain the purpose of our research study and how this study would contribute to future research work.
8. Please help us to understand about your role in your company and how is your role contributing to Sustainability and Circularity ambitions of your company?
9. What aspects come to your mind when you hear or when you are supposed to describe the Circular Economy?

### Digital product passport related Questions:


10. Could you please walk us through your understanding about Digital Product Passport and how it plays a role in the Circular Economy?
11. Do you believe that lack of digital product passports is hindering the Circular Economy transition? If yes/No then please elaborate your thoughts.
12. How digital product passports support the decisions or actions of various stakeholders (Material/Component Suppliers, Manufacturers, Retailers, Consumers and Recyclers etc.,) in the Circular Economy?
13. What will be your thoughts on your organization's level of understanding about the information DPP should carry to meet EU guidelines?
14. Do you believe that your organization is prepared to consider and implement DPPs?



15. Which product groups of your organisation need to comply with DPPs?
16. During the product design and manufacturing stages, what kind of information is vital to gather for understanding the usage of Materials in producing the products.
  - a. Who needs to generate this information?
  - b. Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.
  - c. How does this information contribute to the Circular Economy?
17. Let us imagine that the product is at Consumer end, what kind of information Consumer expects to have access in supporting his/her buying decision, once the product is at Consumer end then what information he/she expects for prolonging life of the product.
  - a. Who needs to generate this information?
  - b. Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.
  - c. How does this information contribute to the Circular Economy?
18. Let us imagine that the product is at the Recycler end, what kind of information Recycler expects to have access to better extracting and recycling the materials.
  - a. Who needs to generate this information?
  - b. Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.
  - c. How does this information contribute to the Circular Economy?
19. Let us imagine that government authorities need to have access to product information from Compliance and Safety aspects, what kind of information they expect Retailers should provide when asked for information.
  - a. Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.
20. Does your organisation have the necessary digital technologies already in place to support DPP? If Yes/No, then please elaborate.
21. What are the key drivers and challenges you see while implementing DPPs? For the challenges, what could be the best practices to overcome?
22. How do you envision the future of digital product passports and the circular economy? What potential benefits and drawbacks do you anticipate as this concept continues to evolve?


23. What are your thoughts about securing protection to Patents, Information security and data privacy for the information DPP collects and manages?
24. What role do you see government and policy makers play in the adoption and implementation of DPP for enabling the Circular Economy?

## Appendix 3 - Interview Presentation



### Digital Product Passports – Enabler for Circular Economy

*What product information does the digital product passport carry in the life cycles of products, and what is its role in enabling a circular economy?*




**Opening Questions:**

1. Is it ok if we record this interview?
2. Is it ok if we use your name, job role and company name or do you want to be recorded as anonymous?
3. Is it ok if we make the recording available within university for academic purposes or do you see this should be removed post this study?
4. Information about sharing the transcribed document of the interview with the respondent for their feedback.
5. Do you have any questions before we start with the interview?

## Digital Product Passports

Master Thesis: Interview



**Research students:**  
Abhishansa Sharma, Sunitha Kopparapu

**LUND UNIVERSITY**

A world top 100 university >

**Sunitha Kopparapu**  
Pursuing double Master's degree in Information Systems

**Abhishansa Sharma**  
Pursuing Master's degree in Information Systems

## Introduction

- Your role in your company
- Your role contribution to Sustainability and Circularity ambitions of your company

## Digital Product Passports – Enabler for Circular Economy

*What product information does the digital product passport carry in the life cycles of products, and what is its role in enabling a circular economy?*

MASTER THESIS

**Prioritized Industries**

- Electronics & ICT
- Textiles & Apparel
- Batteries
- Plastics
- Vehicles
- Construction and Building
- Chemicals

**Technologies**

Data storage	Data carrier	Data access
Cloud storage, Blockchain, Distributed ledger	QR codes, NFC, RFID, Smart labels	Web portals, Mobile apps, IoT gateways

**Data**

Data requirements	Data governance	Data collection
Product lifecycle, Environmental footprint, Repair & replacement instructions	Consent, Transparency, Accountability, Data ownership	Manufacturing, Distribution, Retail, End-user

Source: Beanland (2023)

**European Commission plans first product group regulation to come into force in 2026/7**

Source: Wbcsd1 (2023)

**Business Opportunities**

Circular Economy

Reuse & Recycle

Social Compliance

Reduce Carbon Footprint

Environmental Reporting

Digital Supply Chain


Renewable Energy

## INTERVIEW

Exploring Product information and its role in fostering the Circular Economy...









## Digital Product Passports – Enabler for Circular Economy

*What product information does the digital product passport carry in the life cycles of products, and what is its role in enabling a circular economy?*




1. Could you please walk us through your understanding about Digital Product Passport and how it plays a role in the Circular Economy?
2. Do you believe that lack of digital product passports is hindering the Circular Economy transition? If yes/no then please elaborate your thoughts.
3. How DPPs support the decisions or actions of various stakeholders (Material/Component Suppliers, Manufacturers, Retailers, Consumers and Recyclers etc.,) in the Circular Economy?
4. What will be your thoughts on your organization's level of understanding about the information DPP should carry to meet EU guidelines?
5. Do you believe that your organization is prepared to consider and implement DPPs?



## Digital Product Passports – Enabler for Circular Economy

*What product information does the digital product passport carry in the life cycles of products, and what is its role in enabling a circular economy?*




6. Which product groups of your organisation need to comply with DPPs?
7. During the product design and manufacturing stages, what kind of information is vital to gather for understanding the usage of Materials in producing the products.
  - i. Who needs to generate this information?
  - ii. Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.
  - iii. How does this information contribute to the Circular Economy?
8. Let us imagine that the product is at Consumer end, what kind of information Consumer expects to have access in supporting his/her buying decision, then once the product is at Consumer end then what information he/she expects for prolonging life of the product.
  - i. Who needs to generate this information?
  - ii. Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.
  - iii. How does this information contribute to the Circular Economy?
9. Let us imagine that the product is at the Recycler end, what kind of information Recycler expects to have access to better extracting and recycling the materials.
  - i. Who needs to generate this information?
  - ii. Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.
  - iii. How does this information contribute to the Circular Economy?
10. Let us imagine that government authorities need to have access to product information from Compliance and Safety aspects, what kind of information they expect Retailers should provide when asked for information.
  - i. Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.



**Digital Product Passport**

## Digital Product Passports – Enabler for Circular Economy

*What product information does the digital product passport carry in the life cycles of products, and what is its role in enabling a circular economy?*



11. Does your organisation have the necessary digital technologies already in place to support DPP? If Yes/No, then please elaborate.
12. What are the key drivers and challenges you see while implementing DPPs? For the challenges, what could be the best practices to overcome?
13. How do you envision the future of digital product passports and the circular economy? What potential benefits and drawbacks do you anticipate as this concept continues to evolve?
14. What are your thoughts about securing protection to Patents, Information security and data privacy for the information DPP collects and manages?
15. What role do you see government and policy makers play in the adoption and implementation of DPP for enabling the Circular Economy?

Thank you



## Appendix 4 - Interview Transcript - P1

**Company:** Axfoundation - An independent, Non-profit organization working practically and concretely towards building a sustainable society.

**Interviewee:** Viveka Risberg

**Job Title:** Program Director Sustainable Production and Consumption

**Date and Time:** 1 PM to 1:40 PM on 24th Apr, 2023

Knowledge Management codes = (Light Magenta color)

- (KC) - Knowledge Creation
- (KST) - Knowledge Storage
- (KSH) - Knowledge Sharing
- (KU) - Knowledge Utilization

Benefits (Light Green color) and Challenges (Light Blue color) codes

- (BNF) - Benefits
- (CHN) - Challenges

Speaker	Transcribed Text	Code
1.1	<b>Introduction of Interviewee</b> <b>If you can please go through your role in your company and what is your contribution towards the sustainability and circularity ambitions of your company?</b>	
1.2 VR	OK so we are a nonprofit and independent organization working with sustainability projects. We have three programs and I am the program director of one of these programs called Sustainable Production and Consumption. And we'll have another program called Circular Economy and a third one called Future Food. So we do different things which are a bit overlapping, but we work with innovation. We work in large collaborations with businesses, academia, and civil society. With pilot projects we aim to find solutions that can be scalable toward a sustainable society.	

1.3	<b>Could you please walk us through your understanding about digital product passport and how it plays a role in the circular economy?</b>	
1.4 VR	<p>I think that it's important with <b>traceability and transparency</b> in order to just transition in society versus more <b>sustainable production and consumption</b> for that matter. And I think that the only way to reach that is through increased transparency in the supply chain and that needs to be regulated mandatory, otherwise, it won't happen because as we all know, global supply chains are completely crazy when it comes to Tiers. <b>So it's very difficult to know how and where a product is produced.</b> So the only way to really get hold of that problem is to force the producer to make a <b>digital twin</b> and input data on the <b>circumstances and the content in the specific product.</b> So in that sense, I think It also will enable circular economy because it will create a new value through <b>circular business models</b> more businesses can implement <b>service and repair-based business models</b>, for instance, consumers can make more <b>informed purchasing decisions.</b> And it's also possible for, like public buyers, to verify <b>compliance with legal obligations.</b> With the product passport. So I think in that sense <b>DPP will spur a circular economy and sustainable production and consumption.</b></p>	<p><b>BNF</b></p> <p><b>CHN</b></p> <p><b>KST</b></p> <p><b>BNF</b></p>
1.5	<b>Do you believe that the lack of digital product passport is hindering the circular economy transition? If yes, how do you see it? If no, can you elaborate your thoughts?</b>	
1.6 VR	<p>Yes, I think <b>it hinders</b> because if we don't have the data, the <b>information about each product</b>, it's not we don't have the incitement to really you know to convert into a circular economy. <b>So I think that digital passports will be enablers for the circular economy.</b> As I just mentioned. So yeah, so obviously the lack of DPP is hindering the transition, yes.</p>	<p><b>CHN</b></p> <p><b>BNF</b></p>
1.7	<b>How DPP support the decisions or actions of various stakeholders in circular economy?</b>	

1.8 VR	<p>Yeah, this is just a guess. Since we don't know yet because it's really ongoing, but it will <b>for sure support decisions and will have a large impact on businesses whether it's you know, material component suppliers or on the manufacturing side the design phase, the retailers I think that, the impact will be great</b> And therefore the decisions will have to be based on that. Data will have to be available regarding all products because it <b>will be a competitive advantage for businesses</b> to have this digital product passport so. And also it will be very much more efficient for businesses to work with. There's supply chains and their production. <b>When everything is automated, in that sense it will definitely support decision-making.</b></p>	<p><b>KU</b></p> <p><b>BNF</b></p>
1.9	<p><b>What will be your thoughts on your organization's level of understanding about the information DPP should carry to meet EU guidelines?</b></p>	
1.10 VR	<p>Yes, because this question is directed to me when talking about my organization, have I understood it right? So since we are not a company, we don't buy or produce any products. So I would say that <b>my organizations level of understanding about DPP is quite low</b>, even though it has increased in the last six months thanks to a project where we are involved and myself I have been the project leader. So I have also presented this to my colleagues to raise the level of knowledge about the digital product passports. But I would say in general that the <b>knowledge is quite low.</b></p>	<p><b>CHN</b></p>
1.11	<p><b>According to you, which product groups of an organization need to comply with DPPs? (Which product groups of your organization need to comply with DPPs?)</b></p>	
1.12 VR	<p>OK. But I think what the EU says right now is that it should be all products except for food and medicine. That's how I understand it, so basically all products, all product groups. As well as some raw materials too. Not only products, but some materials also.</p>	
1.13	<p><b>During the product design and manufacturing stages, what kind of information is vital to gather for understanding the usage of Materials in producing the products?</b></p>	
1.14 VR	<p>I mean, <b>I think durability, reusability, recyclability, upgradability.</b> That kind of information will be vital. Meaning</p>	<p><b>KC</b></p>

	that you have to know about every component in the product and if it's, you know, recyclable or how you can reuse it and how long-lasting it is, and so on.	
1.15	<b>And if you can tell us about what you think. Who needs to generate this kind of information?</b>	
1.16 VR	I think I mean this is a guess, but as far as I'm done, it's the brand owners that are responsible for the data to be provided. But they are in the intern reliant on the producers, so I guess that the producers will have to generate the information. From, you know, raw material to processing manufacturing.	KC
1.17	<b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.</b>	
1.18 VR	I am not sure. I think it depends very much on product type. If the information is already available. I think in most cases not to some extent in some cases, but it's very different depending on what type of product you're looking at. And also if it's reliable, that's a good question. I think certifications play big role when it comes to reliability standards and verifications is probably the best way to already know as much as possible about a product. So therefore I also think that certifications will play an important role in the future with digital product passports, because otherwise it will be very, very difficult to compile all different attributes. But if you have certifications that will be an effective way to know that ok, so this product is certified by these third parties certification. So then I get what I need in an efficient way. So I think that in that sense certifications will play a big role even though they will not be legally mandatory because certifications need to be independent. But, I think it will be self regulated in that sense. So that certifications will be important because that's where the information also is and it's hopefully also quite reliable.	KC
1.19	<b>How does this information contribute to the Circular Economy?</b>	
1.20 VR	I think the information will contribute to that. It will be, as I said, easier to know how to repair and reuse products and also how to form circular business models for company. It will be much easier to know how to innovate new business models. And new products that are circular, if you know what's in them, if	KU BNF KC

	you know if you have all the data. Then you can also place demands if you know how to place the demands. You can place demands on what should the product be containing, what should the components be made of and not.	
1.21	<b>Let us imagine that the product is at Consumer end, what kind of information Consumer expects to have access in supporting his/her buying decision, then once the product is at Consumer end then what information he/she expects for prolonging life of the product.</b>	
1.22 VR	Yes, I think consumers want to know the <b>climate footprint</b> , and I think they want to know how they can <b>prolong the product's life</b> and what to do with it when it's <b>broken and what to do with it</b> when they don't want it anymore? So how can it be repaired? <b>What component can be replaced</b> and so on to make it more circular. That's what I think consumers would like to know.	KSH BNF KU
1.23	<b>Who needs to generate this information?</b>	
1.24 VR	Yeah, I think it's the <b>brand owner</b> that plays the product on the market.	
1.25	<b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.</b>	
1.26 VR	I think it's not very available today to some extent. It's like the same answer to the previous question. Now see to some extent, I mean, there are progressive brands that provide information and full traceability. But it's not the norm. So I would say that some products, some brands provide the information today And they have. You know, they don't reach all consumers. They're like very high end brands I would say and very conscious consumers. So I think that hopefully answering this, the last part of the question. About the future, I think that the digital product passports will hopefully then be the norm and that it will also be very normal to look at the product passport when you buy something in order to make a good decision and know that, OK, so this is a good deal for me because I know I can repair it. I know I can. Recycle it and it's also good for the planet.	CHN  KST  BNF  KU



1.27	<b>How does this information contribute to the Circular Economy?</b>	
1.28 VR	Yeah, it's basically the same. The more you know about a product the easier it is to handle the product consciously so that you can, loop it back in the circular loop if you know what to do with it. So in that sense, I think more information is the first step and then its behavior and action. So, but you have to start with the data and information.	BNF KU
1.29	<b>Let us imagine that the product is at the Recycler end, what kind of information Recycler expects to have access to better extracting and recycling the materials.</b>	
1.30 VR	I think the information is about the materials so that they know what kind of materials are inside the product. So they know how to recycle it and how to take it apart. So that is basically. Yeah, my guess.	KSH, KU
1.31	<b>And if you can like, tell us about what you think, who needs to generate this kind of information?</b>	
1.32 VR	The product owner and maybe also the retailer. But I'm not sure if, it's a guess. I don't think that they have everything you know that they know exactly how this is gonna work. So I'm not sure.	KC
1.33	<b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.</b>	
1.34 VR	Yeah, I think it's the same answer as I said in the earlier question that it's partly available, but in the future, it will be more accessible through the digital passports.	
1.35	<b>Let us imagine that government authorities need to have access to product information from Compliance and Safety aspects, what kind of information they expect Retailers should provide when asked for information?</b>	
1.36 VR	I think it's very very important that they know about, attributes like climate, Climate footprint and all the other, normal attributes like reusability, recyclability and durability but also if it's compliant with different kind of standards or requirements, it can be, chemical content, hazardous material, conflict minerals, things like that.	KSH

	Which I think will be very important. And also maybe, even social parameters like working conditions because that is already in the public. A procurement law I think that will also be important for authorities, Human rights aspects.	
1.37	<b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.</b>	
1.38 VR	I think the same is to some extent it's available and it's captured by, you know, manual audits or self assessments and certifications and things like that. But it's very manual today. And in the future it will be more automated and digitalized.	KC
1.39	<b>As you talk about in the future, it will be more digitalized. And, so regarding to that like does your company have the necessary digital technologies in place to support the DPPs and if yes or no, can you please elaborate?</b>	
1.40 VR	Yeah, that is also a little difficult for me to answer since we don't have any products in our you know? So now we don't have the technology since we don't, yeah, no.	
1.41	<b>But, if in the future I may ask a follow up question to that, do you see your organization as implementing the DPP's?</b>	
1.42 VR	Yeah, it's, I think since we do things for what should I say, the higher purpose is to share our knowledge with others. It's more like we want others to implement digital technologies. So it's not so much ourselves, but what I can say is that I think it's important with standardized, technology language ahead for all businesses, messages that are to implement the digital technologies for the I think it's very important that it will be based on a standardized language in a global standard and not silo solutions where every company can seek for their own build, their own product passport which cannot then talk passports. So I think it's very important that there will be a global standard for digit product passports in the future. That's more on a general note.	KST
1.43	<b>What are the key drivers and challenges you see while implementing DPPs? For the challenges, what could be the best practices to overcome?</b>	

1.44 VR	<p>I think a key driver is <b>standardized language</b> to go for open <b>global competition neutral standards</b> and the challenges will be that there will be <b>lots of solutions</b> that will not be compatible with each other and where everything <b>will be a mess</b> and based on centralized databases where the data gets outdated quickly. And so I think that could be a big challenge and a big hindrance. So therefore I think that the more people start to explore and make pilot projects to see how the best you know to create these best practices already now to also undo that in parallel when the legislation is actually written, I think that is important to show the legislators what will work and what will not work because it can also be it will be a very, you know, <b>heavy burden</b> With <b>administration for companies</b>, so it's important to make pilots to <b>try to test and try what works and what will be</b>. A competitive advantage for good companies and not a burden. And also the compatibility when it comes to language.</p>	<p>KST</p> <p>CHN</p>
1.45	<p><b>How do you envision the future of digital product passports and the circular economy? What potential benefits and drawbacks do you anticipate as this concept continues to evolve?</b></p>	
1.46 VR	<p>I see a challenge ahead with all the data that is required and the reliability of the data. Who will work? Who will verify all this data? That is like a question mark. Once we have reliable data, it will be great, but I don't think that.</p> <p>I mean, digital product passports will be enablers just as you know when they are.</p> <p>Communicating reliable data and will, if we don't have that, then the digital product passports will not serve any purpose. So I think that is the the main challenge of everything to create the data and know that it's true. And once we have that, I think there are huge benefits and that there are digital product passports, will, you know, be fantastic enablers. But the drawbacks might be then that <b>it will be difficult to generate all the necessary data and verify it</b>. The data, I mean, we need true data, reliable data and it needs to be verified. Because I think it's important, <b>passports are only carriers of data</b>, so they will not be the salvation for the planet on their own, <b>they need to carry through data there</b>. So that's the key to find this data.</p>	<p>CHN</p> <p>KST</p>
1.47	<p><b>What are your thoughts about securing protection to Patents, Information security and data privacy for the information DPP collects and manages?</b></p>	

1.48 VR	<p>Yeah, that's a very important question and something that will be a challenge because it's about to what extent you need to be transparent with your content of products and confidential information. As you say, that will have to be the law has to be written in a way that, the data that should be provided is the data that is relevant for circular transition and not anything else. So that is up to the legislators to Draft the law so that it really spurs a circular economy and still gives competitive advantage to the ones who comply but not having to share all their, you know, confidential information, obviously.</p>	<p>CHN KST</p>
1.49	<p><b>What role do you see government and policy makers play in the adoption and implementation of DPP for enabling the Circular Economy?</b></p>	
1.50 VR	<p>I think that as this will be an EU regulation, it will be, you know each government in the EU needs to implement the law. And see to that it's implemented and of course also support companies so that they can. And get the help they need in order to be compliant with the legislation so I think that it has to be a combination from policymakers side with, you know, enforcing the law and also is running the burden for companies and making sure that the competence level is high and that. You know, Swedish companies are in the forefront. If we talk about Sweden, when it comes to competence and knowledge level so that they stay stark inkompetens (strong incompetence).</p>	<p>CHN</p>

## Appendix 5 - Interview Transcript - P2

**Company:** Anonymous

**Interviewee:** P2

**Job Title:** Digital Product Leader

**Date and Time:** 03 PM to 3:45 PM on 1st May, 2023

Knowledge Management codes = (Light Magenta color)

- (KC) - Knowledge Creation
- (KST) - Knowledge Storage
- (KSH) - Knowledge Sharing
- (KU) - Knowledge Utilization

Benefits (Light Green color) and Challenges (Light Blue color) codes

- (BNF) - Benefits
- (CHN) - Challenges

Speaker	Transcribed Text	Code
2.1	<b>Introduction of Interviewee</b> <b>If you can please go through your role in your company and what is your contribution towards the sustainability and circularity ambitions of your company</b>	
2.2 P2	My role is presently Digital Product Leader, Primarily targeting how we can document the product information and how that information is going to be helpful for the suppliers when they try to manufacture the products. And at the same time as you already indicated about the product passports, the information which we are going to capture the digital aspects that is going to be a kind of key enabler for sharing the information to be the consumers who are going to use our products or be it the European commission and or any government regulations to enable and then help them to understand what are the materials being used and then how the life of the product is going to be maintained. So for all of those aspects, we do have certain solutions within the Product	

	Lifecycle Management area. So I'm leading the solutions to support the business to enable their business ambitions.	
2.3	<b>Could you please walk us through your understanding about Digital Product Passport and how it plays a role in the Circular Economy?</b>	
2.4 P2	So as it is like any other passport, the digital product passports primarily target the details about the specific product. So meaning <b>how the product is made-up of using the various materials</b> considering together and then from where those <b>materials are being sourced</b> and how those, products are getting manufactured and how that information is going to be a kind of key enabler for consumers to understand how it is made-up of and then <b>what kind of sustainable materials</b> are being used so that it will help them to understand. The primary intent of eco-friendly products because the millennials are currently focusing more on <b>buying the eco-friendly products</b> so that everybody understands the resources are very finite in nature and then the organization needs to be very cautious and then they need to use the resources in an efficient manner. So what my perception about DPP is, by knowing about what are the materials being used in the product and then how <b>the life of the product can be extended by repairing or reusing, or by doing any other manner to keep the product life stay for longer time.</b> From the consumer point of view, we will not be in a position to move into the circular economy without DPP. So that's where <b>this product passport is a key enabler in making us move towards a circular economy.</b>	KC  BNF
2.5	<b>Do you believe that lack of digital product passports is hindering the Circular Economy transition? If yes/No then please elaborate your thoughts.</b>	
2.6 P2	<b>Yeah I do believe if we don't have digital product passports, then definitely it is going to be very hard to pursue the circular economy.</b> Of course, DPP alone is not going to solve everything to go to the circular economy, <b>but it is one of the key enablers which will help us to move into the direction.</b>	BNF CHN
2.7	<b>How DPPs support the decisions or actions of various stakeholders (Material/Component Suppliers, Manufacturers, Retailers, Consumers and Recyclers etc.) in the Circular Economy?</b>	



2.8 P2	<p>As the product moves from different stages in the value chain, be it starting from the <b>raw materials</b> how those are going to be stored and then how those will be made use and then trying to create certain <b>components</b>, our <b>product parts</b> and then how those are going to be manufactured. And then finally the retailer's going to make those products available to consumers during the entire journey point of time. Everybody in the value chain needs to understand what is the input I'm receiving? How do inputs of the respective materials make us move into the sustainable? Be it sustainable material sourcing or sustainable manufacturing or sustainable ways to keep the product life long for a long time. For every aspect in the journey, there are so many insights and inputs that are involved and to make those decisions, we need to have an insight of the product. So that's where DPP is a kind of a identifier where all the information about the product maturity, starting from the raw material to reaching to the recycling point of view, they're going to hold the key information And then the respective stakeholders, they can make use of the information and then they can ensure that the products and the materials will have a longer lifetime.</p>	<p>KC</p> <p>KSH</p>
2.9	<p><b>What will be your thoughts on your organization's level of understanding about the information DPP should carry to meet EU guidelines?</b></p>	
2.10 P2	<p>So when it comes to our organization, we do recognize that the products which we are going to sell in the markets, we should be knowing how it is made up of with the various materials that we do believe in and then we need to have that insight to be made available through DPP. We have the DPP in one or the other format, maybe with EU guidelines, all the organizations will be aligned towards one way of Sharing the digital product passport so that the entire ecosystem will align to one way of communication. But as an individual organization, everybody has their own way of capturing the product information. But this initiative is going to help us to move in one horizontal or one harmonious approach to communicate the product information to everybody.</p>	<p>BNF</p> <p>KST</p>
2.11	<p><b>Do you believe that your organization is prepared to consider and implement DPPs?</b></p>	
2.12 P2	<p>yeah, from the organization point of view we are ready to implement. But the only challenge is what exactly this product</p>	

	<p>passport meaning, what information it has to capture and then how that information will be exposed to the various stakeholders. Those lower level insights are not available, but definitely when we know more about how the DPP needs to be constituted, and making it available to everybody, then definitely we'll be in the front runner and then we will be able to enable it for the business and then make it enabled for the consumers and all the stakeholders.</p>	<p>CHN</p> <p>KST</p>
2.13	<p><b>Which product groups of your organisation need to comply with DPPs?</b></p>	
2.14 P2	<p>Yeah. Yes. Our organization is the primary player on the home furnishing retailer aspect, we deal with a lot of product groups, be it textiles, be it furniture, be it electronics, be it batteries, which are also there. So we kind of see that most of our product groups are falling under the DPP scenario.</p>	
2.15	<p><b>During the product design and manufacturing stages, what kind of information is vital to gather the understanding and the usage of materials in producing the products?</b></p>	
2.16 P2	<p>From my perspective, during the product design primarily when it comes to the material aspect, what kind of materials we need to use primarily, from the sustainability aspect like what kind of <b>recyclable content</b> the material is bringing up, what kind of <b>renewable intent</b> and then how <b>recyclable the specific material</b>. So those key properties of materials are going to be kind of vital when I decide which materials need to be used in my product. I mean definitely there would be various materials that can be used to make the product.</p> <p>When you try to compare which is the better sustainable aspect, then this information is going to be better to pick and choose in a similar manner from the manufacturing point of view. Also primarily it's not about just materials alone, but the product, how the design is intended in that sense. But then my design is meeting to that design for assembly, whether my design is meeting to the design for disassembly. So that when a customer is having the product at their home, they should be in a position to easily disassemble and reassemble when they try to move from one place to another place. And then if there is any part malfunctioning, they want to replace the part which brings the product should have repair instructions clearly available to the user so that they can replace and then extend the life of the</p>	<p>KC</p> <p>KU</p>

	<p>product. So there could be a situation where you may want to altogether change the product from one dimension to another dimension. So in that perspective how the various parts of my product can be repurposed. So that's where the design is going to be the key in that sense to have various elements to be understood when we try to make the product manufactured.</p>	
2.17	<b>Who needs to generate this information?</b>	
2.18 P2	<p>So here before the product reaches the consumer, it moves from various levels of suppliers. In that sense, raw material suppliers that could be an entire subset of suppliers will be there and then the design aspect and then the manufacturing aspect.</p> <p>So each stakeholder will be responsible to provide the information so that the next set of stakeholders will have the information available. But from my perspective, primarily the information will be prepared and then given by various stakeholders in the journey, but the primary ownership will fall under the retailer who is the front face to the consumer and where the product is going to be sold, so the information generation will be contributed by everybody in the product life cycle, I mean in the entire value chain, but the ownership lies on the retailer.</p>	<p>KSH</p> <p>KC</p>
2.19	<b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future?</b>	
2.20 P2	<p>So the information available in that sense from the respective stakeholders, the information is available. The challenge is each stakeholder has their own set of applications and the solutions. So they are maintaining it at their end, but having accessibility to it to the entire stakeholders in the value chain is a major gap today. So we are seeing that with the DPP which is an identifier of a product where all stakeholders can keep feeding that information about the product. So that will be kind of exposing the information to everybody in an easier way to access. But today the information available but it is not easily accessible to everybody.</p>	<p>CHN</p> <p>BNF</p>
2.21	<b>How does this information contribute to the Circular Economy?</b>	

2.22 P2	<p>Yeah, as we touched upon a few key aspects earlier, so from a circular economy perspective, it's primarily around how I can reuse, how I can recycle and then those are the elements which are kind of a very key to increase the life of the product. So the materials sustainability aspect will indicate how it can be repurposed and then reused and then produce different products. But when it comes to the product design aspect, as I indicated, it's more about how easily you can <b>disassemble</b> and then how easily you can <b>repair</b> and then how easily you can even refer to it. Though it may not really malfunction but you want to keep the product life in a good way, so how easily you can <b>replace</b> the parts, So those are going to be kind of refurbished. The consumers do not buy a new product rather extend the life of the existing product. So that way we will not end up creating more and more products where that is not really required. So that way the circular economy is going to be enabled.</p>	<p>KU</p> <p>KC</p> <p>BNF</p>
2.23	<p><b>Let us imagine that the product is at Consumer end, what kind of information Consumer expects to have access in supporting his/her buying decision, then once the product is at Consumer end then what information he/she expects for prolonging life of the product ?</b></p>	
2.24 P2	<p>So if I had to imagine myself as a consumer, I would like to understand when I try to buy a product, what are the materials used and then how those materials are impacting the planet. I would like to have a clear understanding about it. So that if I have multiple product options available, then I can pick the one which is an eco-friendly product. So that is one piece of information I look for. The second information is how easily I am able to maintain the product at my end. So it could be if something is broken how easily I can replace the broken part rather than buying a new product. So I will be expecting easy accessibility to <b>repair instructions</b> and then <b>replacing instructions</b> primarily to understand if something will not work in the future then I have a way to extend the life of the product. So I expect these two are the key information to be available if I am a consumer .</p>	<p>KSH</p> <p>BNF</p> <p>KU</p> <p>KC</p>
2.25	<p><b>Who needs to generate this information?</b></p>	
2.26 P2	<p>So here primarily both the <b>manufacturer and then retailers</b>, I see that they are the key contributor to this information. When I</p>	<p>KC</p>

	<p>say manufacturer because they are the ones who are going to use the raw materials when they try to produce the product. So, they are the ones known better than anybody else to give the information of what materials are used and then when it comes to instructions support, extend the life of the <b>product from the design aspect and then replacement aspect</b>, those things typically based on the organization it depends on. But from our organization perspective, we do own the design of the product. So it falls under retail in this case. So primarily manufacturing and retailers both of them need to be generating this information.</p>	
2.27	<p><b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.</b></p>	
2.28 P2	<p>So when it comes to the information about the materials being used and then extending the life of the product point of the instructions, this information is already available. We do provide this information to the users. So I don't see much difference here, but rather how easily users can get this information, be it from one retailer to another retailer. Maybe that simplification will happen in the future, but today it's more around as I am the consumer then I bought a product from a so and so retailer, then I always need to go to the respective retailer website and then get this information. Maybe in the future DPP point of view, it will be a kind of simplified portal where irrespective of where you bought the product, you will have access to this information in an easier way to understand and then make use of the information that change simplification may happen in the future. But definitely this information is already exposed to the consumers from our organization point of view.</p>	KST
2.29	<p><b>How does this information contribute to the Circular Economy?</b></p>	
2.30 P2	<p>No, it was similar to the earlier case. So when as a consumer you know more about the product then always you have a possibility to Maintain the product for longer duration at the consumer end. So that way it saves the money from the consumer point of view and also from the planet point of view. We don't really need to spend more resources to keep bringing the new products and we do also have a kind of <b>refurbishment kind of stores</b>, we are enabling it so that as a consumer you can come and then sell</p>	BNF

	<p>your product and then we try to <b>do the minor repairs to that and then we try to sell those products to the consumers</b> who are planet conscious and they don't really see a need to buy new products all that time. So that way from both a retailer and then consumer point of view we have a responsibility to try to use the resources at a very minimal level to keep the planet life longer.</p>	
2.31	<p><b>Let us imagine that the product is at the Recycler end, what kind of information Recycler expects to have access to better extracting and recycling the materials?</b></p>	
2.32 P2	<p>yeah, so far the challenge for the recycler is, when you are recycler and looking at a product to recycle and then <b>if they don't have inside support</b>, what are the materials used then it is going to be a nightmare for them because they need to dismantle each and every piece of the product to understand what materials <b>being used</b>. It takes a longer time for them to plan for the action. So with the DPP it will be a kind of, we could say that health card of a product so that they can understand What materials are used and then put those materials in a kind of <b>digital twin</b> so that they can easily plan and then do various actions from the recycler point of view. So this will be a game changer for recyclers with the DPP.</p>	<p>CHN</p> <p>KST</p>
2.33	<p><b>Who needs to generate this information?</b></p>	
2.34 P2	<p>Yeah from the information point of view it's more like. So again it goes towards <b>both the manufacturer and retailer in that sense the manufacturing aspect, what kind of materials used, it's the primary responsibility of the manufacturer to provide this information and from the retail point of view repair and replacement instructions to indicate how the life of the product can be extended</b>. Retailer but in this case recycler point of view, they are looking more on the materials that it is being used. So from that perspective <b>I see that the manufacturer will play a key role in providing this information for the recycler needs</b>.</p>	<p>KU</p>
2.35	<p><b>How does this information contribute to the Circular Economy?</b></p>	
2.36 P2	<p>So <b>when the recycler knows more, much more about the product then it will be easier for them to plan the recycling actions</b>. With better recycling, obviously now we'll have better control on <b>how those materials shape from one form to another form</b>. So</p>	<p>KU</p>



	that will help moving the circular economy direction and <b>not to scrap everything, rather try to reuse and then recycle the materials.</b>	
2.37	<b>Let us imagine that government authorities need to have access to product information from Compliance and Safety aspects, what kind of information they expect Retailers should provide when asked for information.</b>	
2.38 P2	So from the government authorities point of view, <b>now they typically expect the safety of the consumers.</b> So in that case <b>how safe the product is at the consumer end that primarily will be a kind of a compliance and then safety aspect, some certifications we need to undergo in aligning to the various safety guidelines.</b> So having these certificates and the compliance related information added as part of the DPP will be an easier way for the government to get the easy access and in today's world it's more a kind of a manual. And there are different ways the different retailers are sharing this information of the compliance details to the government authorities. But maybe with the DPP again, <b>it may be simplified in one way of communication of complex information from all the retailers across the markets to government authorities.</b>	BNF  KC KSH  KSH
2.39	<b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.</b>	
2.40 P2	Yeah, this information is already available. In that sense without all these <b>compliance certificates</b> , we are not legally eligible to sell our products in the markets. <b>So this information is there and then this is shared with the respective markets.</b> But again It's more a manual effort and then on a need basis this information is shared, it's not really structured in that sense. So <b>I think with the DPP it will be more organized and in an easier way authorities will have the information accessible.</b>	KSH  BNF
2.41	<b>Does your organisation have the necessary digital technologies already in place to support DPP? If Yes/No, then please elaborate.</b>	
2.42 P2	Yeah, we are. We are investing heavily in the digital aspect. <b>So we do have solutions which are enabling us to capture the digital twin of the product through the various digital technologies.</b> But the only thing is <b>what granularity, what level</b>	KST

	<p><b>of a product information</b> we need to keep it part of the DPP that is to be known and <b>still it is in the exploration phase</b>.</p> <p>When you know more about what information has to be tagged to the DPP, then our solutions will enable us to share that information and be exposed in the form of the DPP.</p>	CHN
2.43	<p><b>What are the key drivers and challenges you see while implementing DPPs? For the challenges, what could be the best practices to overcome?</b></p>	
2.44 P2	<p>So the key driver one could be like when we invest more on the data and then having this information captured across the stakeholders, <b>it involves a lot of investments</b> as well. So if governments are going to enable some kind of incentives for the products which have the DPP enabled, then that will be a game changer. So capturing all the details in a common way and then they try to make the DPP a success. Otherwise if it is just kind of a guidelines and then there is no incentive or anything is given, then it will be kind of people may not really believe in and then implement in not a good way rather they try to meet the guidelines and then try to fulfil it. So that's where one is from the incentivizing the organization and second one is promoting the eco friendly products to the consumer. <b>So that some kind of a tagging and the products will make a competitive advantage to the retailers</b>. I think these incentives will be a game changer. But as I mentioned the information across the various stakeholders to be captured. So that's where there are going to be various challenges involved because <b>not all the stakeholders will be in a position to invest heavily because of the size and then because of the investments required</b>. So we need to see how the DPP channel is going to evolve further, OK.</p>	<p>CHN</p> <p>BNF KU</p> <p>CHN</p>
2.45	<p><b>How do you envision the future of digital product passports and the circular economy? What potential benefits and drawbacks do you anticipate as this concept continues to evolve?</b></p>	
2.46 P2	<p>Yes, it is at the very initial stage. Today people may have a lot of scepticism and then dilemma how this is going to be there. But if you try to see maybe post 10 years down the line, then what I see irrespective of where you bought the product, <b>there is one way of looking at the product information</b>, kind of easy accessible by looking at the product, maybe some kind of QR code or some kind of tagging on the product and then it's kind of</p>	<p>BNF</p> <p>KST</p>

	<p>easy, what to say retailer agnostic accessing the product. This will enable all the consumers to have seamless access to the product information. So those digital solutions may become a regular normal in the future. But today we don't know how this DPP is going to be captured and then how this is going to be accessible to the various stakeholders. So that's where a lot of things are still in the dilemma. But from the benefits point of view, it is definitely going to be a kind of enabler for everybody to move towards the circular economy. So I see this is a game changer and then we need to explore more and then invest more into this channel.</p>	
2.47	<p><b>What are your thoughts about securing protection to Patents, Information security and data privacy for the information DPP collects and manages?</b></p>	
2.48 P2	<p>Yeah, this is also one of the key and challenging aspects to understand what is <b>the granularity level we need to capture in the DPP</b>. The more information we expose then it is going to be <b>risky from the patents aspect</b>. So we need to have a certain way to restrict access to certain stakeholders based on the need point of view so that <b>we should avoid counterfeit products</b> when we expose more information. So the <b>accessibility for the different stakeholders, what level of information</b> that those regulations should be clearly defined and then adopted. Otherwise it is going to create a lot of challenges.</p>	<p>CHN KST</p>
2.49	<p><b>What role do you see government and policy makers play in the adoption and implementation of DPP for enabling the Circular Economy?</b></p>	
2.50 P2	<p>Yeah, primarily the government policy makers need to <b>have a good collaboration with all the stakeholders involved</b> in the journey and then take their inputs. So while they design the guidelines then it is acceptable for everybody and then it is manageable also. <b>And then what are the benefits primarily from incentivizing the adoption point of view also to consider</b> when they try to make these elements considered then definitely we can make good progress on to this journey.</p>	<p>CHN</p>

## Appendix 6 - Interview Transcript - P3

**Company:** Anonymous

**Interviewee:** P3

**Job Title:** Product Management Leader

**Date and Time:** 9AM to 9:45 AM on 27th April, 2023

Knowledge Management codes = (Light Magenta color)

- (KC) - Knowledge Creation
- (KST) - Knowledge Storage
- (KSH) - Knowledge Sharing
- (KU) - Knowledge Utilization

Benefits (Light Green color) and Challenges (Light Blue color) codes

- (BNF) - Benefits
- (CHN) - Challenges

Speaker	Transcribed Text	Code
3.1	<b>Introduction of Interviewee</b> <b>If you can please go through your role in your company and what is your contribution towards the sustainability and circularity ambitions of your company</b>	
3.2 P3	Yeah, I'm working in a company, which is the development of all furniture products mainly. I am presently called Product management leader, handling and working with all the core information which is mandatory to be able to make yourself willing to pay you. And I've been part of the team project that we are trying to change the data flow to improve accuracy and efficiency in the development during the last five years about declaring information.	
3.3	<b>Could you please walk us through your understanding about Digital Product Passport and how it plays a role in the Circular Economy?</b>	

3.4 P3	<p>I have a question here as well. When you say that or concede the regulation in the European Union, which will come in that sense, I would say at least have always been important. Even in the past, this is how we have been working for a long time. And we have been. It's also you can put whatever head on this circular thing. It's also economical circle or aspect is also quality in general physical quality circular aspect.</p> <p>Any kind and of course sustainability in such is also a valid circular model and I'm not so deeply involved in the regulation personally. Other people under try to understand that. I have a big challenge to be detailed enough to understand what it actually means with the digital product passport. I have still not figured out with support of my colleagues and others about <b>What is the accuracy? Of this passport, How should you be able to do it? And in what content, should the data actually be considered?</b> So, Honestly, I don't have much detail. I have the simple flow and in the worst case flow in my head and <b>it will have different complexity.</b></p>	CHN
3.5	<p><b>Do you believe that lack of digital product passports is hindering the Circular Economy transition? If yes/No then please elaborate your thoughts.</b></p>	
3.6 P3	<p>As I said, I think this has been on the table or on the agenda for a very, very long time. I think the digital product passport is more of a regulation method tool. To stress the question to the industry, and it can be good and it can also be bad. And it's too early, in my opinion, to say. If this will help or it will be just a problem. <b>Depends very much on what I said in which level of granularity or talking about.</b></p>	CHN KST
3.7	<p><b>How DPPs support the decisions or actions of various stakeholders (Material/Component Suppliers, Manufacturers, Retailers, Consumers and Recyclers etc.) in the Circular Economy?</b></p>	
3.8 P3	<p>And support decisions or actions, I mean it, of course. As the ambition, it's super good. I think everybody, every company. Every question should be conceived during this anyhow. <b>is it more? How much will it be? How much will it actually impact the business, the economic business from money, perspective and costs?</b> But I think as a principle, as ambition.</p>	CHN

	I love it. It's perfect. We should do this. This is just good, <b>more stress to it as a regulation.</b>	
3.9	<b>What will be your thoughts on your organization's level of understanding about the information DPP should carry to meet EU guidelines?</b>	
3.10 P3	As I said before, I'm not personally involved in the regulation of such, but we as a company have negotiation. <b>All the way to understand the granularity and what should we? Actually could feel this in detail.</b> And I'm, but I don't have the answer and I just know it's ongoing. And I'm waiting for clarity basically.	CHN KST
3.11	<b>Do you believe that your organization is prepared to consider and implement DPPs?</b>	
3.12 P3	It feels like a carrot(hard), but it depends on the details. We are ready to do the simple version absolutely. I think we are well prepared. When to a certain level? <b>If it will be too granular, we will have a problem.</b>	CHN
3.13	<b>Which product groups of your organisation need to comply with DPPs?</b>	
3.14 P3	I don't know we are using the aspect of <b>everything</b> . We are not differencing, our different groups or I thought <b>we were considering everything</b> .	
3.15	<b>During the product design and manufacturing stages, what kind of information is vital to gather for understanding the usage of Materials in producing the products.</b>	
3.16 P3	This is a very generic principle. When you're creating a physical thing in the world through industrial production, you'll divide industry into interiors. And so it's level one, level 2, Level 3, level 5 and you can break that down. That is also the granularity. And, some products may involve 20 layers. <b>And it's always easy to track and trace and have information from the first tiers. And then normally you skip some tiers in the middle and tiers go to the lower level as well.</b> And then, yeah, it depends. It also again, connects to the economical things. If you want to own the complete value, saying it's very <b>expensive because of the economy of scale.</b> It's built on partnership and some things <b>you actually consider company secrets</b> . You have patents and different things in the	KST CHN  KST

	valuation which you can't really touch if you don't own it. So, again, I repeat myself, <b>granularity</b> is the question.	
3.17	<b>Who needs to generate this information?</b>	
3.18 P3	As a retailer, I think you need to collect the level to be responsible to put something to the market and the environment and people. But you are not content responsible, you cannot be a retailer. Maybe all the time, depending on the partnerships you'll have created in the value shelf.	KC
3.19	<b>Is this information already available? If yes then how this is captured today? If not then do you have any views about how it will be in future.</b>	
3.20 P3	I mean send this IP product that we are changing our data structure and we see that we are not equipped good enough today to capture, keep and trace all the data properly. So that is why we change, it has been continued for many years. And, you can't say that we have a good logic, a model that we can see how we can trace all this in theory now. And we're trying to create a practical approach to this and activate and improve <b>traceability and accuracy</b> in all the data.	BNF
3.21	<b>How does this information contribute to the Circular Economy?</b>	
3.22 P3	I mean, we are trying to fetch all the data if I call data or information, according to the needs. Of course, some of that information is confidential and you need to be during the agreement's perspective and <b>confidentiality</b> . But as the retailer, of course, we need to understand if it's good or bad and we need to, we will do that. That is the ambition.	KC KST
3.23	<b>Let us imagine that the product is at Consumer end, what kind of information Consumer expects to have access in supporting their buying decision, then once the product is at Consumer end then what information they expect for the prolonging life of product.</b>	
3.24 P3	Based on <b>confidentiality</b> rules, we cannot expose everything. But we need to be able to give trust to the consumer and have traceable proof. That'd be all. At least it's a <b>good product from a circular economy</b> point of view.	KSH



3.25	<b>Who needs to generate this information?</b>	
3.26 P3	All stakeholders in the validation.	KC
3.27	<b>How does this information contribute to the Circular Economy?</b>	
3.28 P3	It will drive and create attention and focus on these relevant questions. Generically, I'm not so fond of doing it through regulation. If you are a nice human, you think like this, you take care of the earth and want to save the planet in general. So of course it should be natural. Everybody, unfortunately, it's not decades in real life for me, but it should be. We have a saying in our company, we say we should be naturally introduced into daily work and that is what we try to achieve.	BNF
3.29	<b>Let us imagine that the product is at the Recycler end, what kind of information Recycler expects to have access to better extracting and recycling the materials.</b>	
3.30 P3	This is an extremely complex question and OK, I'll say they are not prepared. The granularity to make the end of life for cycling I would say generally, In and also depends on the country of course. But if you take Sweden, which is quiet Well developed in this perspective, I think the recycler in the end or prospective only have around 15% or 20% of the information they actually need to make recycling properly and so you see the gap. Here is the huge issue to recycle end of life products. We don't have the precondition anywhere I would say to do that properly.	CHN
3.31	<b>Who needs to generate this information?</b>	
3.32 P3	Every stakeholder in the value chain needs to provide information. The big questionnaire is How much will that cost? For the end consumer, If you say something costs €100 today. If you should collect and keep information and communicate to the end recycler all that information they need €100 will become €250. It's huge inflation in the economic world, right? And I don't know, I don't think anybody have cracked the code. To make the perfect circular economy from Sustainability perspective.	KC CHN
3.33	<b>Let us imagine that government authorities need to have access to product information from Compliance and Safety</b>	

	<b>aspects, what kind of information they expect Retailers should provide when asked for information.</b>	
3.34 P3	Yeah I mean, the mandatory is towards the regulations and loss so everybody needs to fulfill the minimum level. We as a company always say it's not enough. We want to fulfill the legal aspects and the minimum level and be better than that, is our daily approach. We always want to be better. It helps us as well because then we are at the forefront, we are prepared for changes, we can take new regulations and that is why I say we. We believe that we are quite well prepared for the digital product passport. But of course, it depends on the granularity. We cannot do whatever from one day to another, but we're way prepared in general, I hope.	KST  BNF
3.35	<b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.</b>	
3.36 P3	Yeah, we have a lot of data and available information. Today, we are improving and we are trying to build even better systems to keep track of this. And we will continue the journey. The question is just how much will the regulation force us and everything. It doesn't come for free.	
3.37	<b>As retailers what kind of information on DPPs do you expect from other stakeholders in the value chain?</b>	
3.38 P3	We have another saying in our business, we say togetherness. And that I really see it. Everybody should sit around the same table and contribute to the total value chain, so we'll stay close and need to be together and do the best they can do to fulfill this and save the planet.	KC, KSH
3.39	<b>Does your organisation have the necessary digital technologies already in place to support DPP? If Yes/No, then please elaborate.</b>	
3.40 P3	No, not yet. I would say we have a theoretical plan. And we are all trying to catch up in time to make it real and functional. We are in a good way, we estimated this. We saw this many years ago and we have stopped the yarning. But we are not done.	

3.41	<b>What are the key drivers and challenges you see while implementing DPPs? For the challenges, what could be the best practices to overcome?</b>	
3.42 P3	<p>No, I'm guessing a little bit, so take it for what it is. My personal opinion, if I have understood digital product passports it is defined to refer to the exact one piece you have in your hand. I think that is extremely difficult. What I've been working on, or actually controlling and navigating quite well is what we call mass balance. And, I think if we can provide mass balance information instead of actual physical piece information, it is so much easier. My definition of mass balance, I would say, is if you have a living room, for example. You have one physical chair. You see one that is the physical piece and you can say this has an impact from a circular economy. But you can also say we have a thousand living rooms with tables and chairs. And we can say this thousand rooms will on average impact like this. Then you can collect the information and control navigation on all these aspects in a much more efficient way.</p> <p>So you actually aggregate to a bigger perspective which is more realistic and easy I mean.</p> <p>For example, if you cut a forest, say I cut down 10 trees I will not make one chair.</p> <p>Or maybe we'll make one chair, one table, and one door from these trees. And I can understand how they impact together coming from 10 trees to be 10 different colors.</p>	<p>KC, KST</p> <p>KSH, KU</p>
3.43	<b>How do you envision the future of digital product passports and the circular economy? What potential benefits and drawbacks do you anticipate as this concept continues to evolve?</b>	
3.44 P3	<p>Again, then I think I have said it. If they're trying to prove push the granularity too much, it will be fall back and it will lead to cheating, lying things like this. But, if they are realistic and keep it on a good feet to the industry perspective I think it can be very good. But if it's if they're pushing by regulation, that is too granular, It's a big risk.</p>	<p>CHN</p>
3.45	<b>What are your thoughts about securing protection to Patents, Information security and data privacy for the information DPP collects and manages?</b>	

3.46 P3	<p>Saying I think I mentioned that as well before, I mean some information is <b>confidential</b> in the agreement through stakeholders, and <b>patent</b> is for sure one of them.</p> <p>And also, if they don't want to declare or share from this, the information security is not there, then they will lie instead, or they will modify and give wrong information. So that is the risk.</p>	<p>KST CHN</p>
3.47	<p><b>What role do you see government and policy makers play in the adoption and implementation of DPP for enabling the Circular Economy?</b></p>	
3.48 P3	<p>It's as I said before, it is about to get on us. You've, but if the behaviour is more, we and them. Government versus industry or it will be a problem, but if we say we as humans on the planet will do it together then it's positive. And then you need to be realistic.</p>	<p>CHN</p>

## Appendix 7 - Interview Transcript - P4

**Company:** Anonymous

**Interviewee:** P4

**Job Title:** Digital Transformation Leader

**Date and Time:** 10:00 AM to 10:40 AM on 25th April, 2023

Knowledge Management codes = (Light Magenta color)

- (KC) - Knowledge Creation
- (KST) - Knowledge Storage
- (KSH) - Knowledge Sharing
- (KU) - Knowledge Utilization

Benefits (Light Green color) and Challenges (Light Blue color) codes

- (BNF) - Benefits
- (CHN) - Challenges

Speaker	Transcribed Text	Code
4.1	<b>Introduction of Interviewee</b> <b>If you can please go through your role in your company and what is your contribution towards the sustainability and circularity ambitions of your company?</b>	
4.2 P4	I'm working right now in *** within the Digital Transformation Office. So we are more to drive transformational changes, more organizationally speaking. So we're not specifically focused on any technology and specifics. So it's more the organizational transformation that my group focuses on.	
4.3	<b>Could you please walk us through your understanding about Digital Product Passport and how it plays a role in the Circular Economy?</b>	
4.4 P4	Yeah. So again, I'm not a subject matter expert in this topic, but I think I have a general understanding of what the circular economy is about and what role the digital product passport	

	<p>would play. So I think it gives you a better positioning on how you can tamper proof information in relation to your product from all the way from cradle to grave and depends again on what product information you make available. But from a circularity perspective it could be related to how you recycle it. What's the carbon footprint? Have you sourced it from an ethical perspective so you could cover many different dimensions of information, but again all the way from cradle to grave of your products. From the materials to your product in itself to recycling points, etc. So I have a generic understanding. But again, I think the benefit of a digital product passport in this setup would be that you would be secure in the information that's provided about your product. So it's not someone who can hack into it and just provide some. Yeah, misinformation about it. So how do you keep that information secure as well?</p>	<p>KC</p> <p>BNF</p> <p>BNF</p>
4.5	<p><b>Do you believe that lack of digital product passports is hindering the Circular Economy transition? If yes/No then please elaborate your thoughts.</b></p>	
4.6 P4	<p>Yeah. Now I'm gonna sound like a consultant when I answer this question. It's a yes and no. No, I don't think the circular economy is strictly dependent on the Digital product, but digital product passports are an enabler for a circular economy. More from again, like I said, from a circularity perspective, from a transparency perspective, it's a means to the end, the end being the circular economy. But the means is definitely an enabler. So if we don't have it, that doesn't take away the responsibility of the companies in the decisions they make. So the decision is independent of your digital product passport, but the DPP will be making things more easier on where you record that information, how you make it accessible to the stakeholders across your value chain and how secure that information is and the consumer can then make wise decisions based on the information that they're seeing. So I think it's an enabler, but it definitely is not a critical element. The decision still lies in the stakeholders across the value chain.</p>	<p>BNF</p> <p>KST</p> <p>KSH</p> <p>KU</p>
4.7	<p><b>How DPPs support the decisions or actions of various stakeholders (Material/Component Suppliers, Manufacturers, Retailers, Consumers and Recyclers etc.) in the Circular Economy?</b></p>	

4.8 P4	<p>So I think if you take as an example, starting from the cradle, the raw materials you procure, I think of course you depending on how it has been technologically put together, it gives them, the people who are procuring the raw materials to make an assessment that- is this raw material the right one?</p> <p>Am I sourcing it from the right supplier, for instance, is my carbon footprint too much if I source it from here or from some other vendor instead? Or other suppliers? I think it does play a role that if you are feeling confident that the source of the information in relation to the product itself across your value chain is secure, then it can enable wise decisions.</p> <p>So I think if for example, I think on one of your slides you showed <b>the blockchain as one of the technology background</b> backbones that you could use. So that kind of makes it confidence in the stakeholders making the decision that, yes, this information provided you can trace back on who updated that information. So it gives you that kind of contextual so that it's not just the content of the information, <b>but who is putting that information that gives you that confidence that I can make wise decisions.</b> So I think it's not just, you know, you fall back on the contract show, you know signage that yes, the company as a whole is entitled to expect this kind of a compliance, but you can't really have that technical security that yes, this information really provided by the necessary stakeholders who are competent in it. So I think it definitely does enable wiser decisions and the subsequent action that follows.</p>	<p>KST</p> <p>KU</p>
4.9	<p><b>What will be your thoughts on your organization's level of understanding about the information DPP should carry to meet EU guidelines?</b></p>	
4.10 P4	<p>I think we definitely have a lot of emphasis on this, and I only say that because our the CEO of ***, he's on the Action Group for the European Green Deal and the action plans that's coming out of which this was based out of. This came out of the action plans. He's on the board that's associated with that. So I guess by association that means that we do have to take it seriously within our company. But from a practical point of view, I don't know what strides we have made there. I don't think I'm the right person to speak that because I don't have the insights into that, but perhaps people on the *** side, because that's where the products are actually procured put together and we are more the franchisee end of it. So I'm not sure I'm the right person to speak</p>	



	but by theory of association I think we do have a lot of emphasis on it.	
4.11	<b>Do you believe that your organization is prepared to consider and implement DPPs?</b>	
4.12 P4	Yes. Again, like I said, by theory of association, yes, we do have to and more, not just from a moral standpoint, but I think since we have put out our position on this topic, I think we are taking it seriously.	
4.13	<b>Which product groups of your organisation need to comply with DPPs?</b>	
4.14 P4	I think it's almost all of it. So our company is like in the furniture business. So it's more the home furnishing business, but we are also on the food side of it as well to a certain extent. So I think inevitably if you look at it from a consumer point of view that if you're looking at it, whether it's consumable from the food aspects of it or if it's durable, it's from the furniture aspects of it. You do want to give the power to the <b>consumer on making wise decisions</b> , so you would want to give <b>them information about all those products</b> , whether it's either of these two broader categories on what's your <b>carbon footprint</b> , where was it sourced, is it ethically sourced, etc. So I think it would cover a lot of it and not just from the specific products, but also from a packaging point of view and so on from a recycling perspective, upcycling. So from all those perspectives, I think it's going to be very helpful.	<b>KU</b> <b>KSH</b>
4.15	<b>During the product design and manufacturing stages, what kind of information is vital to gather for understanding the usage of Materials in producing the products?</b>	
4.16 P4	Again, I think this is more an *** question, the franchiser who's making the products but I think it's again a general point of view on this is that from all the raw materials that you're procuring to even the factories where you would be putting these <b>raw materials together and how much water you're using, how much electricity is being consumed, all of the associated Taxes on the environment</b> . I think that kind of knowledge, if it's made <b>available, I think it's relevant to provide on how you are, giving transparency into how that product is actually put together from a circular economy point of view.</b>	<b>KSH</b>

4.17	<p><b>Let us imagine that the product is at the Consumer's end, what kind of information the Consumer expects to have access in supporting their buying decision, then once the product is at Consumer end then what information they expect for the prolonging life of product.</b></p> <p><b>(i) Who needs to generate this information?</b>  <b>(ii) How does this information contribute to the Circular Economy?</b></p>	
4.18 P4	<p>The kind of information like- How do you need to remove your products separate from each other from a recycling point of view? I think it kind of connects both from consumer and the recycler side of things. So even from the consumer end, I think having information not just yeah now that you are done with the product go straight away and recycle it, I think is not the connection that you want to give to them. I think first communicate- are there opportunities to upcycle it to repurpose it? Where would you go for that? What kind of inspiration can you get for doing that kind of activities, and the last resort should be now that you cannot think of anything else. Now, please go and recycle it. So I think helping the customer through that maturity of thinking I think would be helpful information to give the customer as well. So it's not just information on making wise purchase decisions, but it's even the after-purchase decisions that they need to make and how you can help them in that maturity curve as well. And then what's the grave end of the decisions? I think this kind of information is helpful.</p>	KSH
4.19	<p><b>Let us imagine that the product is at the Recycler end, what kind of information Recycler expects to have access to better extracting and recycling the materials.</b></p> <p><b>(i) Who needs to generate this information?</b>  <b>(ii) How does this information contribute to the Circular Economy?</b></p>	
4.20 P4	<p>Because I think then on the recycling end, I think the recycler would also need to have information that this specific kind of material. What is the best way to recycle it and they will of course have guidance on the recycling points from like in Sweden, you have specific products which need to be recycled in a specific way. So depending on how your product has been assembled together based on the raw materials, you might need to disassemble it when you're taking it to your recycling station.</p>	KU  KSH

	So I think having that kind of insight at the recycler end, but also on the consumer end.	
4.21	<p><b>Let us imagine that government authorities need to have access to product information from Compliance and Safety aspects, what kind of information they expect Retailers should provide when asked for information.</b></p> <p><b>(i) Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future?</b></p>	
4.22 P4	<p>I actually don't know about this too much, but again, this is interesting. I would again imagine over here when it comes again, it touches a little bit on the recycler and consumer end. I don't know when you're putting your products together if there are certain chemicals that might be used that maybe the government would need to have access to information on that from a safety point of view that maybe it's not just the wood that you're using, but maybe the chemicals that used in how you're putting it together, I don't know, but I'm assuming over here that information like that from a security perspective is relevant for the government to know because they then need to kind of relate back to the retailer saying, but then from a consumer side you do need to make this kind of information transparent to them and it's not falling under the category of this is patented information. It's a safety issue that you do need to do. I think you can see this mostly in the food-related industries that maybe certain chemicals that you're using when you're processing your product materials, they don't always make that transparent and that does have a health implication on the consumer. So a similar thing applies also for the furnitures or again, I don't know, I'm assuming over here, that if you're using certain chemicals, how does that chemicals kind of then leach into the atmosphere or I don't know things like that I think are relevant to share from a safety aspect of it, for example. And so I think the government authorities do need to make that kind of clear. What is the kind of information that they would need to collect, which I think DPP would make it easier for them to get access to that information and help the company side of it to understand when it comes to patented information, how do they need to handle that versus if it's a safety compliance information, then how does that need to be made accessible?</p>	<p>KST</p> <p>KST</p>

4.23	<b>Does your organisation have the necessary digital technologies already in place to support DPP? If Yes/No, then please elaborate.</b>	
4.24 P4	I'm not the best person to answer that because I don't have direct interactions on this side of the company. But again, by theory of association, I think we would because as a company we have put ourselves out there all the way at the CEO level. As I mentioned that this is something that's important for us.	
4.25	<b>What are the key drivers and challenges you see while implementing DPPs? For the challenges, what could be the best practices to overcome?</b>	
4.26 P4	<p>I also wanted to emphasize, is that in itself digital product passport is really good. But as in all cases, the tool does not mean you are going to suddenly become a driver for the circular economy. If, for example, there's too much information put over the consumer, just be like, OK, I don't know what's all this and he never looks at it. It's not going to drive anything of the intent of the circular economy forward. So I think the challenge here is that information is powerful, but how you are making it available in a way that people can digest that information is even more important. Take for example, if you look at, I don't know when was the last time you bought some food and you looked into the ingredients list and said wait, this is really not good for my health. I'm not gonna buy it because when you look at the information that's provided, it's not put in plain and simple English words or in a common language. It's put in a very scientific terminology that you would never understand. So yes, compliance-wise, the companies doing what's expected but in helping the consumer make decisions, no, it's not.</p> <p>So I think we have to be cautious when it comes to how we are implementing this new product, passports that it's not enough that you are compliant, but it really needs to be looked at from the perspective that if you want a truly circular economy then you need to make the information available in a way that the decision makers can understand it and enable them to make those decisions. And I think that's where the challenge, is that, yes, they can be compliant. And they'll be like, yeah, I've done what you asked, but nobody can do anything about it. So then where, who is gonna take that side of the things, and who's accountable for that? That's, I think, a challenge they'll have to think about.</p>	CHN

4.27	<b>How do you envision the future of digital product passports and the circular economy? What potential benefits and drawbacks do you anticipate as this concept continues to evolve?</b>	
4.28 P4	<p>Yeah, I think that's kind of connected with question 12 that I think this is the bigger challenge. So I don't think technology in itself is going to be the challenge, I don't think.</p> <p>The benefits would be, something that people don't understand. I think it's more the seriousness in terms of how they convert the obvious benefits and the technologies in a way that it actually is enabling the circular economy because the enabler is not the technology in itself. The enabler is not in the realization of the benefits, it's more. <b>How are you actually enabling the decisions associated across the value chain and unless people nail that part, nothing else is really going to be the driver of the circular economy? It's how do you enable the decision makers?</b></p>	CHN
4.29	<b>What are your thoughts about securing protection to Patents, Information security and data privacy for the information DPP collects and manages?</b>	
4.30 P4	<p>Again, <b>here it's more a question of how that information is, made available and who is given access to contribute to that information on the DPP. So example, I think if the blockchain is where you are updating all the information, so who is defining and what are the guidelines given by the industry on how that information needs to be recorded?</b> Because if you have different stakeholders both from you as a company and the stakeholders or the suppliers associated with your value chain, what is the guideline to follow are the formats to follow on how this information needs to be recorded, and this needs to be standardized across the industry so that the government doesn't have to be like, OK, what is *** talking about now? What does *** talking about now? What are these people talking about? So how that information needs to be recorded needs to be kind of standardized first of all. And then the point over here about patented information, how do you secure in the blockchain that you don't put yourself at risk that somebody else can come and steal that information and take it and set up their own company or whatever? I think there is also a key to understanding the guidelines that if there's certain content that should be part of the DPP, maybe it's only relevant for the government. How do you lock that kind of information depending on who that information</p>	KST

	<p>is relevant for there? I think there are other technologies like Verifiable credentials. How you can use verifiable credentials to make sure that the right person who is accessing information is given access to that information. So if I'm a person from the government and I need access to information to make an assessment, that is this from a safety perspective that we need to go back to the company and say that, yes, you need to make this publicly available. But at this point, it should be only accessible to the government person. So how can you utilize and leverage other technologies to safely share that information with the relevant stakeholders at the relevant points in time? So it is still part of the digital product passport. But it is locked in the context that who should have access to that piece of information. So how can we leverage other technologies together with this to make sure that that's secured as well? I think that also kind of goes hand in hand with the standardization of the information, how it should be presented across the industry, and what kinds of information from a pattern safety. Who should have access to that information and how? Again, it plays into. How does that enable decision-making? So if the government official decides that yes, this piece of information shouldn't be locked, it should be made public, then it should be easy to make sure that yes, this is just now made public information. So you're now at risk also that your competitor has access to that information and then you are doomed as a company. So how can you leverage other technologies together with this?</p>	<p>KST</p> <p>BNF</p> <p>CHN</p>
<p>4.31</p>	<p><b>What role do you see government and policymakers play in the adoption and implementation of DPP for enabling the Circular Economy?</b></p>	
<p>4.32 P4</p>	<p>I think here again it's going back to how can we look at all the different stakeholders who are involved in the value chain and consult them to make sure that you have together looks at how do you need to standardize this information and what guidelines then you need to give to different companies because it really is heavily dependent on the standards. That's put out there because it is not for one industry, it's for all industries. And it's not just from what's in the control of the company itself. It requires then that you engage with your suppliers as well on your product. So having a standard is very key over here. I think that's the stepping-in key success factor or the key driver I think we're here that you do need to have standards Otherwise, it's gonna be</p>	<p>KC</p>

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	<p>very complicated if I as a company, and then I will have a challenge on how my supplier needs to update the information then how the government would need to review that. It starts to complicate things. So I think starting in with the guidelines is something I think that's very key. And involving the right stakeholders in that decision of how do you need to standardize is important because everyone has their different point of view on that.</p>	
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## Appendix 8 - Interview Transcript - P5

**Company:** Anonymous

**Interviewee:** P5

**Job Title:** Sustainability Strategy Manager

**Date and Time:** 04:00 PM to 05:15 PM on 1st May, 2023

Knowledge Management codes = (Light Magenta color)

- (KC) - Knowledge Creation
- (KST) - Knowledge Storage
- (KSH) - Knowledge Sharing
- (KU) - Knowledge Utilization

Benefits (Light Green color) and Challenges (Light Blue color) codes

- (BNF) - Benefits
- (CHN) - Challenges

Speaker	Transcribed Text	Code
5.1	<p><b>Introduction of Interviewee</b></p> <p><b>If you can please go through your role in your company and what is your contribution towards the sustainability and circularity ambitions of your company?</b></p>	
5.2 P5	<p>I work as a sustainability strategy manager and advise organisations on strategies related to sustainability on circularity. I have been now working on *** related to the manufacturing sector and also related to circularity data sharing.</p> <p>Just maybe before I dive into the questions one comment on the topic, I think it's a very important topic and super relevant for the time being. It's quite also important to outline the scope when we talk about digital product passports is very much an EU directive. So, it goes across the EU and the direct impact is of course what we see is industries sitting within the EU, but they could also impact further on through their values across the geographies. So that's just one thing, I also want to point out that for now, yes, the stakeholder or direct stakeholders at European</p>	

	companies are companies basing the EU, but we also see the potential impact that extended beyond you given the industries value chain or supply chain.	
5.3	<b>Could you please walk us through your understanding about Digital Product Passport and how it plays a role in the Circular Economy?</b>	
5.4 P5	<p>At least, now what I understand is one of the most important regulations of a regulatory perspective as a driving force for circular economy within EU and the extent or let's say the extent they will touch on product, it's actually quite revolutionary. So the way we see that, it covers both or let's say most obvious ones about that disclosure. But in order to gather that disclosure, it actually touched on the whole ecosystem collaboration. So we see this is a regulation or regulatory driving force that is going to drive quite at least or speed up accelerate circular economy in EU and of course in between when we also speak with the countries such as different authority bodies in Denmark and all the Nordic countries, we also understand that there are two sides of effect of this digital product passport in it. On one hand, it will accelerate but on the other hand, it also requires companies to input resources to get prepared and get ready, and small and medium-sized companies may be impacted in not always positive way because they may lack resources to face this challenge to collect like that to disclose. So they're also concerned about how to enable SMEs to cope and face or absorb the shock of this regulation since it's given quite an also sharp timeline for companies to comply. So yes, it comes with both no, the positive force, but also the concerns about how industries actually deal with it.</p>	<p>BNF</p> <p>CHN</p>
5.5	<b>Do you believe that lack of digital product passports is hindering the Circular Economy transition? If yes/No then please elaborate your thoughts.</b>	
5.6 P5	I think a digital product passport is <b>one tool or one of many enablers</b> that will enable us to accelerate circular economy transition. So it has been, I mean circular economy has been a concept existing way longer than the digital product passport. So what I see is that a circular economy can happen and the transition can happen without a digital product passport. But of course, we also see this as a driving force that will potentially accelerate, so the lack of digital product passport is what, the	

	<p>industry has been experiencing in the past, whether it is hindering or not, I don't see it as a major like barrier without it will hinder. But I do see that digital passport alone will not fully unleash the potential of the circular economy if it does not pair up with other driving forces in the industry such as collaboration in the network such as the value chain and also together with the data disclosure and what we see that if we say yes it will hinder, I think what we might refer to not sharing data, no transparency that will hinder the circular economy transition and digital product passport is a vehicle to push forward the sharing of that increasing of transparency increasing collaboration of supplier manufacturers and consumers. So that is what we see that it alone will not drive, but lack of it may hinder in certain aspects but it's more because of the other fundamental infrastructure behind the product passports.</p>	<p>KSH</p> <p>KSH</p>
<p>5.7</p>	<p><b>How DPPs support the decisions or actions of various stakeholders (Material/Component Suppliers, Manufacturers, Retailers, Consumers and Recyclers etc.) in the Circular Economy?</b></p>	
<p>5.8 P5</p>	<p>This is a very broad question and we are also just laying our eyes on it. And I would say that since the value chain is so diverse and the stakeholders are very different and how DPP is playing or bringing the effects on these different stakeholders are yet to be studied. From what I see, since I talked to manufacturers most and I will say that for manufacturers, what it really supports a decision or requires action is exactly on this data disclosure part, and previously manufacturers are on the other discussion, there are two sides of it. One is the availability of that, so previously some of the manufacturers do not have like granularity level of data that is required by DPP for example the lifetime of components, the recyclability of parts, and for example, the lives of a battery, etc. So those information or granularity levels of information were not existing. So it actually poses manufacturers and urge to collect those data. And then the other layered and that is even when you have those data, some of the data are considered business sensitive. For example your design especially your pattern design and in order to fully compliant DPP, sometimes you may need to even disclose some of previously considered business sensitive data. So how industries are? And now both in the need of complying and at the same time want to protect their competitiveness. This also</p>	<p>KSH</p> <p>CHN</p> <p>KST</p> <p>CHN</p>

	<p>has been a debate internally, and this is only for one type of stakeholder that I can speak to, and I haven't yet been able to speak from, for example, a consumer perspective. I could speak a few words from a material supplier and recycler perspective because this is also a group of people we have spoken to our material supplier actually when it comes to recyclable contents, especially artistic ability in upstream material, this has been a more established practice. So many of the industries they have their traceability and in only comes to recycle material in the secondary market. They also have some type of material more material than the other. So for example fiber, metal, plastic, the secondary market is so mature that you can actually get those data and they are possible to provide you with recyclable content. It's not such a concern of disclosure or not, it's considered actually less sensitive, or I consider them lower-hanging fruits from a material composite perspective. And the same thing with the recycler. Many of the recyclers are operating in the markets, in the markets material domain. So the existing system where recyclers can sort, can quantify, can even trace up stream on where do they get those specific secondary material from. So yes, I just want to share that from that domain when we talk about recyclability and the secondary material part, I have more confidence compared to other areas such as lifetime of components, repairability. The usability of the specific products, the left part of like a connected to echo design part is more of a Gray area that companies still yet to find ways how to tackle that.</p>	
5.9	<p><b>What will be your thoughts on your organization's level of understanding about the information DPP should carry to meet EU guidelines?</b></p>	
5.10 P5	<p>For manufacturers on the information that DPP should carry, that you guideline and as I see this information or data, we consider <b>several layers of data.</b> So one we consider them, we call it the product information. So <b>it's everything related to products including your material composites including your components and Lifetime, etc. And then the other part of that, so we consider them product performance data.</b> So on one hand it's what is in it and the others in on the other hand is how product perform and especially related to be to be segments, the performance that is even more crucial because you also need to know which part we're out most</p>	KST

	<p>in order to design the product to be more durable. You also need to know that specific lifetime of that specific part if you want to provide, for example, service as a known component and sometimes manufacturers are even looking into proactive maintenance and for that you need even more data together, including simultaneous performance. Basically, be able to track how the motors are running while you know in a use space and which part will break down. At first, in order to predict where the maintenance will come in, so we see that, these two main kind of categories of informations that needs to establish at least as a kind of data infrastructure for organizations to get ready for future reporting.</p>	<p>KU</p> <p>KST</p>
<p>5.11</p>	<p><b>Do you believe that your organization is prepared to consider and implement DPPs?</b></p>	
<p>5.12 P5</p>	<p>I would say that the maturity levels are different from companies to companies and sometimes, it's actually regardless the size, sometimes even the big firms are not big companies and not entirely ready since they have been running in a more linear way and the main revenue is still from selling product as usual way. And when we spoke with also stakeholders within large firms trying to establish more circular business model, because like as a service within that firm. But typically those initiatives are happening at a small scale compared to their main business or very, very small business scale compared to their main business. And it is also stakeholders we spoke to also facing a journey or difficulty to convince the main business to take on that route because some of the business models are disrupting their own mainstream business. And then also this is one hand, business model may disrupt their own business. And the second thing is that the revenue is usually not as straightforward as the main business, so it takes longer payback time. It has a higher initial cost and let all put in the big companies, even the big ones hesitant to scale up their circular initiative. And versus. We are actually seeing some smaller companies or smaller medium sized companies where they are younger and they come in into <b>the market with digitalization</b>. So some of the companies we spoke to already have the building connectivity in their parts, so they automatically in their first generation of product layer less than 10 year old first generation of product, they're already able to check the performance of their product and the client side customer side constantly and they are also able to provide those</p>	<p>CHN</p>

	<p>data as a new service or analyze the data as a new service for their customer. Data as a service or product as a service is kind of building into their DNA, so we see different materiality that's happening in the industry and it truly requires. I would say that the first movers to showcase that you have the business value, you can actually make positive revenue in order to mobilize and encourage more followers to scale up. And in this industry it's all about scaling up because the more you scale up. The more you drive the cost down and the more your business become vegetable. Yeah. So it's a bit of chicken and egg, but we do see the first movers as setting good examples right now.</p>	KST
5.13	<b>Which product groups of your organisation need to comply with DPPs?</b>	
5.14 P5	<p>I think as you are correctly defined from the beginning, you also defined prioritized list, right? And that's ICT lesser packaging, material, textile, etc. So all those products are very important and I can maybe speak from a Nordic perspective since we spoke mostly to Nordic companies. One area that many companies will both lack of information and need stronger collaboration is around battery. At least battery use is now also with the product digitalization. It goes everywhere from smaller batteries that are part of the big machine or smaller electronics all the way to big batteries, for example the big ones for EVs are medium ones for electric vehicle and the big ones for mobile working station like lose the heavy vehicles. And they are different outside. There are different use cases. Again, even if you just looking into battery for small batteries, it's a lot about recyclability or take back right. You want to have your extended producer responsibility like extend all the way to take care of end-of-life batteries.</p> <p>And versus for mid size and big-size batteries. It's a business case where a lot on how you extend the product lifetime because many of them know after they are drained for driving a vehicle or do the actual work. Let's still have the second life the storage capacity that they carry is still quite considerable. And if you're now then send them to end of life. It's such a waste of resource for all society. So there are different use cases both you know, either you, go to recyclability or you go to extending product life. You would then define that use cases in order to build your consortium, build the network of stakeholders to start collaborating Because your end products could be another</p>	KSH

	<p>industry's resource and this goes everywhere, in circular economy and taking extending battery lifetime. For example, your end of life battery from workable device or vehicles could be energy storage for utility company.</p> <p>So yes, you need to find stakeholders sometimes across industries to collaborate together in order to make the use case.</p>	
5.15	<p><b>During the product design and manufacturing stages, what kind of information is vital to gather for understanding the usage of Materials in producing the products?</b></p>	
5.16 P5	<p>What we know is that on ecodesign or when we design, the usability of material is one thing, but the usability of the product is another thing. So I encourage everybody when we talk about DPP to think beyond material. It's important to think about what information needs to gather on material, but, as I said, I think upstream material traceability is an easier task to achieve. Many companies within their own value chain already build this kind of traceability for the material like put in the products and in the equal design phase, I see the most difficult part or most information that many companies do not have and which is also crucial to make eco-design truly makes sense, is it's user behavior, it's how your product is used in space and that information goes beyond material, and that information is crucial together in order to make your product truly circular.</p> <p>So yeah, here we're talking about two things, and our material part it is so much about both the origin of your material is to be sustainably sourced, but then also the recyclability, we see the packaging industry will have this new regulation just tackling packaging industry, on recyclability rate and then material wise. It's also about you know compliance or alignments with other EU directives such as REACH basically, as safety part and the chemical regulation part and then of course there's another element when it comes to material is lost critical materials that we will run out now such as especially now talk about battery. There's so many critical materials that goes in it in vehicle manufacturing, aerospace, a lot of critical materials are there and you really want to increase the recyclability of losing material, being able to reclaim them and reuse them. So this is our materials, but on the equal design as a whole concept, I would say the information about use phase is crucial. And it hasn't been generally a good practice as we now see in other companies have full visibility or no they don't.</p>	<p>KST</p> <p>KU</p> <p>KU</p>



5.17	<b>(i) Who needs to generate this information?</b>	
5.18 P5	<p>I think now like a material side, many major industries that we talked to have already taken action and it typically it's through their procurement. So the company, the downstream customer as a company in B2B segment send this requirement to their upstream material supplier and push the disclosure or material transparency. So this can be done and it's already happening and when it comes to collecting downstream user information, it is still laid within the producer's responsibility, so we see the manufacturer still is in the center of collecting this information, however, that users need to be incentivized in order to give this information. So the dynamic between if it's B2B, so their customer as a user, or if it's a consumer goods like, you sell to customers, consumers like kind of user behavior and how user connect back to the manufacturer or retailer telling them how they exactly use this product after product has left the shelf when they enter if it's customers home and it's B2B customer ends up in B2B customers workshop - How are they used? Those information needs to look back and how to look back today, less a a lack of incentive. As consumers, we buy a furniture, for example, we bring it home. We wouldn't think about it on. Now I need to let's say, take it. If I buy a furniture from IKEA, I wouldn't have the need of sharing how my furniture is used at my home to IKEA. However, if a brand is serious in designing a circular product, they need to collaborate much more with the users and build this whole. Visibility and insight on how their end of life product or how their product has been used throughout the lifetime.</p> <p>So I think it's a dynamic then users and manufacturers or retailers need to build this relationship and need to build a mutually beneficial incentive system to have a feedback system. Users are more kind of motivated to share this information or care more about information. For example, a diary we have an example of working with the infant formula, so the baby powder milk powder. Users really want to know where is my milk powder coming from, so they would scan all the QR code you provide. If you say now through QR code, you will know the traceability of this product. User want to do it and in return you may get some user information including maybe your infants eating habits, and your infant's development stage. Those information if you want to collect, you can get through this exchange to get the user information in order to feed in into your</p>	<p>KC</p> <p>KSH</p> <p>KSH</p> <p>KSH</p> <p>KSH</p> <p>KU</p> <p>KSH</p>

	<p><b>product design.</b> And of course it is formula is 1 particular example, but what I mean is sometimes they incentive needs to be created is not just like monetary. You know you give certain percentage of discount to customers etc. It's not necessarily so, although that is one of the most straightforward way. But it can also be an <b>information exchange</b>. You provide information that users care or customers care in return, you gather the information that you need in order to implement your circular design, and then the intention and the purpose of your data collection needs to be transparent. You need to communicate why you need that information from.</p>	
5.19	<p><b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future?</b></p>	
5.20 P5	<p>I think we touched base on this question, right regarding both material part and then also regarding the user information. But in general, since I'm not sitting in that particular product category, I would say you will need to evaluate it also case by case which industry is maybe more mature or material information and less mature on user information where some maybe more mature in product performance information or use faced information but less transparency in their sourcing stage. So typically we look into upstream and downstream, but of course essentially you want to close the loop. So to become a circle rather than a linear wave. But,, in the analysis we typically do not look into upstream and downstream and how those maturity lays.</p>	
5.21	<p><b>How does this information contribute to the Circular Economy?</b></p>	
5.22 P5	<p>We know that environmental impacts of the product, let's say in general sense, <b>80% of the environmental impact is already locked at design phase.</b> So, I think the design phase can never be overlooked, right? This is one of the most important phases where you would actually want to <b>enable the circularity.</b> And therefore I think, in what we all discussed the material information really decides on whether you go for sustainable or replaceable material and then going downwards towards the performance you really want to know <b>how users are interacting with your product in order to know which parts that you want to build in to extend like the starting point</b> is to extend productive</p>	<p>KC</p> <p>KU</p>

	<p>time by replacing repairing parts or components. And then you also want to design the product towards end of life. So in the battery for example, there's a lot of discussion now on no whether building the product into easy dissembling. So if you have a more standardized production protocol, you'll be able to disassemble the end of life product and reclaim or take back some of the metals, especially more heavy metals to reuse them. So the design phase consideration goes all the way from material choices to the use phase and to the end of life. And so the list is never overlooked. So it should be the most important phase.</p>	
<p>5.23</p>	<p><b>Let us imagine that the product is at the Recycler end, what kind of information Recycler expects to have access to better extracting and recycling the materials. Who needs to generate this information? How does this information contribute to the Circular Economy?</b></p>	
<p>5.24 P5</p>	<p>This is interesting because I've been recently talking to some recyclers and it depends on really How you want to treat this end of life product? Do you want to use them or like resembling them for remanufacturing. Or do you want to just simply like - tell them to end of life. Thats totally different approach and from recyclers that we spoke to is that they actually serve the needs of their customers so that customers being those people who send the material to the recycle center or those people who need to buy secondary material from them, so I think they really want to serve the industry, so they work around their customer needs, both upstream customer and downstream customer for upstream customer themselves they have needs of what I call it identify the list extended producer responsibility. So they want to be able to identify which products end up recycling center belong to me, belong to my company and sometimes only it's many of them. The two challenges in it, one is that. Well, that being homogeneous, it's the same type of products you can get from company ABC and D like battery for example. You cannot really tell which company does this battery belong to, especially in only and not the original manufacturer sourcing it from their suppliers. They all look the same. The battery is, so let's needs of identifying these more detailed responsibilities by tagging and having full traceability of these parts. All the way to the recycle center and this is often not the responsibility of recyclers. It's more the responsibility of the manufacturers. Yeah. So this is 1</p>	<p>KU</p> <p>CHN</p>



	<p>after, for example, the data collection is extensive. You collect your scope 123, you go all the way to your upstream and downstream. And this task alone is not always feasible for smaller size companies.</p> <p>So we also on the one hand need to think about how those regulations is going to accelerate, facilitate the transition towards sustainability for the society from the other hand <b>also need to consider how this adds cost and how the industry can adapt, and absorb those costs to really provide those data and compliance,</b> right? So, in this domain we work a lot with the companies about like digital platform and how you streamline your data collection- How you automate your reporting, etc. And to be honest, it still comes with quite a high cost. So it's, the big ones that have the advantage to get themselves more future-proof. But the impact on small ones. I see that the government also needs to have a further evaluation and help those small companies to cope to get ready.</p>	CHN
5.27	<p><b>Does your organisation have the necessary digital technologies already in place to support DPP? If Yes/No, then please elaborate.</b></p>	
5.28 P5	<p>I mean there are various digital technologies already in place. For example, we talk about blockchain and some companies have a tested blockchain to trace their upstream value chain and to increase their transparency. That's quite possible and we also know that the cloud technology will enable companies to share that a large volume, because I think talking about data sharing there will be the granularity level that is required now in new regulations, both ESRT, DPU, taxonomic, it's very expensive and in the conventional way where if you work offline on Excel, it's not possible. <b>But we have a cloud technology that can aggregate that can run large number of data calculation.</b> One on top of each other and we also allow you know the system to set different access credentials for different users. So all those <b>technologies are enabling data sharing</b> as we can see today and it will be even more so tomorrow. And of course there's another domain when it comes to digital technology that is about the security that ownership. How do you also you know in the meantime encouraging sharing but also make sure that.It's in a safe domain so so a common data space for example is also something being discussed and EU has.</p>	KST

	<p>I'm invested in the couple of big project in testing this common data space so there's a lot going on in this area and we see that Yes, <b>digital technology is maturing and they are enabling all this reporting and data sharing</b> and companies are individual companies can really evaluate which technology that is most suitable for them, which platform they want to be in. I think soon there will be more choices coming up.</p>	
5.29	<p><b>What are the key drivers and challenges you see while implementing DPPs? For the challenges, what could be the best practices to overcome?</b></p>	
5.30 P5	<p>When it comes to drivers and challenges of implementing DPP, I think we did just touch base on that, right? The drivers as I mentioned is important to see the circular business model to see how you can gain. And explore new business opportunity. Meanwhile, implementing DPP and not only see it as a constraint, if you only see that as a constraint is simply adding up administrative cost and also you will see that the adding up your risk of disclosing your design pattern, losing your competitiveness much more than the value that you will bring if you are embracing the change. If you really see that the circular product is the future right you I think every company. You're already in the game. You can run away, so you have to embrace this change and turn the challenge into opportunity. And then when it comes to challenge, I really see that the <b>biggest challenge is for the small and medium sized companies. How to handle the data collection? How to absorb those redundant administrative cost and how to maintain competitiveness because you know?</b> A majority of our economy in Europe, and especially in Nordics are medium sized companies. They're not big corporate big corporates, only a handful of them, but medium size companies composite with a large number and creating jobs and contributing to GDP. And these companies need to continue, maintain their competitiveness, need to survive. So I think the bottom line is that those regulations should not be like a killing factor to totally rule out them, but needs to be given enough timeline, enough enablers for them to make the transition to catch up. And so that the whole economy is more circular and green and prosperous in the meantime.</p>	CHN
5.31	<p><b>How do you envision the future of digital product passports and the circular economy? What potential benefits and</b></p>	

	<b>drawbacks do you anticipate as this concept continues to evolve?</b>	
5.32 P5	<p>I see as I mentioned, in future, the transparency will increase. Data sharing is inevitable and therefore I see the digital product passport, this kind of regulation or practice become a norm in future. Everybody will start to disclose and this will become. And ordinary thing to do, hopefully and circular economy. I do, of course, as someone working in sustainability, more optimistic, I think this is the only way to go. I mean if we talk about climate, Climate pressure that we have four, we are facing now and we're talking about biodiversity loss, resource deficiency always, you know, cannot be tackled let's say from decarbonization alone. They have to be paired up with the circular economy. But what is more challenging is circular economy is that it's a concept, it's not a one single solution. It's many solutions that adding up from different parts of the ecosystem or industrial. The stakeholders to actually composite the solution together.</p> <p>So it's, I think it's a concept that is gonna be constantly evolving, so it will not be as just OK today if I share my product information and that's enough, that's not enough. That's just starting point the more as I said the purpose is to turn this DPP and as an opportunity for you to actually see business circular business case in it and activate the whole network, including your supplier, supply chain, your consumer, your customer to swift, the change together or to change your behavior how you use the product, how you interact with the product together, then that's the angle.</p>	<p>BNF</p> <p>KSH</p>
5.33	<b>What are your thoughts about securing protection to Patents, Information security and data privacy for the information DPP collects and manages?</b>	
5.34 P5	<p>I don't have a deep insight on this. Yes, unfortunately, but all I think I share with you is that companies do express concern on sharing business sensitive information. And when it comes to how to secure securing this information and I mentioned, I think briefly, I guess summarize maybe two points. One is start with more common knowledge and information, less business sensitive information you can already do a lot with those non business sensitive information or sharing. The product manual for example, even like a fashion industry, for example, the how you maintain, how you, wash those clothes, those tags can</p>	<p>CHN</p> <p>KSH</p>



	<p>already tell you a lot on how you can better maintain the product and pass on to second hand or to the next user. So you don't really need to disclose all sensitive information in order to kick off this circular business model. So you can start with very minimum the start with less sensitive information. That's one key point, the other point is that with the technology maturing you are able or we will be as a collective society more and more able to protect our sensitive data and and better security while sharing information. So blockchain is being an example where we see. Aluminum Company who is able to basically check every single gram of their material from different recycle centers from all the way to different resources they come from right. So this kind of technology is not yet mainstream, but we know it's possible. And then on cloud technology also, you are able to set different level of access. You can grant access to maybe your Tier 1 suppliers but not Tier 2. You can ground access to maybe some of your most important customers to feed in the use phase data. So those practices are in place and we also see that it will become it will become more and more mainstream once you start sharing data.</p>	<p>KST, KSH</p> <p>KSH</p>
<p>5.35</p>	<p><b>What role do you see government and policy makers play in the adoption and implementation of DPP for enabling the Circular Economy?</b></p>	
<p>5.36 P5</p>	<p>I also touch on this in our previous conversation. I can summarize 2 main points. One is to give a good transition period of time. A give like transitional ground, and provide enablers such as knowledge sharing and such as guidance for especially SMEs. To be able to adopt this new new directive. So, it's not just about issuing a directive, it's also about providing support. And then the second thing I see is a government and policymakers are sitting in amazing network for continuous sharing and collaboration, and least sharing could go on know for example, knowledge sharing and could go on as demonstrating the successful use case. But as a circular economy is a concept that requires collaboration from whole society from whole value chain, sometimes the policy makers or even like industrial associations sitting in the unique position to bring these different actors together and also provide more kind of a trusted third party angle for these different players to plug in their solutions, so I see. On one hand it's an enabler to help the</p>	<p>KSH</p> <p>KSH</p> <p>KSH</p>

	<b>transition. On the other hand, again enabler, but more as a catalyst to nurture the ecosystem.</b>	
5.37	General Comment by interviewee	
5.38 P5	<p>I would say that it's really good for you to use the word information, not just data. Because in the DPP we see is a lot that is actually for example general information. <b>How you know product is to be used or is used like kind of even product manual or instruction can be part of the information</b> that's actually quite important for establishing circular business model and as I mentioned previously, there are two types of informations that we are kind of structured them right product related and product performance related and then on top of that there's also like what I just mentioned the general information how you written even the instruction of the product manual of the product and then they are also may be business sensitive questions like how your product is designed, which parts are put together, what material is for that particular part and what part worn out most and least gradually goes more and more business sensitive because some <b>manufacturers they do have like design pattern and they also want to keep that as their cutting edge competitiveness, so the requirement of disclosure information such as repairability, reusability may contradict with what they previously see as business sensitive.</b> So in this I see a staircase or a ladder to start with, less business sensitive and more general information disclosure and then gradually increasing the transparency because since if the industry or industry is doing the same, it's following this common practice, there's no such thing as a business sensitive anymore because you are borrowing on each others expertise and you are basically more and more centralized in the way your product should be designed and should be produced.</p> <p>Now that's just about that kind of role map. <b>But on top of that, even before you design the data road map and what information to be gathered and to be shared and one element is super important or precondition is super important is to define your business case. Meaning that knowing what purpose, for what I'm sharing this data,</b> I mean DPP is a regulation, right? It just tells you that you need to disclose for example material composite you need to declare your components lifetime. You need to state your repairability and if you say it's repairable, you need to provide the pair the parts that are now available so those</p>	<p><b>KST</b></p> <p><b>CHN</b></p> <p><b>KC</b></p>

	<p>informations are there. But I think for an individual company when they make decisions they have to be the 1st to identify what is indeed. For me there are so many parts or so many points in DPP like could be relevant, but to identify what is the business case, what is the use case? that I would like to focus on is the most important first step. And fundamentally what we want to see is that as advisor, what we want to see is that this is a <b>tool or regulation that will eventually enable circular business model</b>. So what we do is we started by identifying business model. So whether it list is <b>for example a contribution to increasing recyclability</b>, this could be one use case. Whether this is to promote product as a service. This is another business case. Whether this is a contribution to, for example, <b>repairability or reusability, extending product lifetime</b>. This is another use case. So after defining like the most relevant and most urging and business case there we will be able to know, or at least as a company you will be able to know where to put your resource to focus on because, yeah, I think that's a fundamental step for most companies, and then you will turn that kind of and you know, we have the carrot and stick right? Otherwise you will see this DPP regulation as a stick. You will turn the stick into a carrot. You will turn that as a constraining force into an incentive once you identify your business case unable to combine or translate your business case into how you comply with DPP.</p>	<p>BNF</p> <p>BNF</p>
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## Appendix 9 - Interview Transcript - P6, P7

**Company:** PEAB

**Interviewee:** Embla Winge (P6),  
Fredrick Berg (P7)

**Job Title:** Embla Winge: Development Manager - Climate  
Fredrick Berg: BIM Business Developer

**Date and Time:** 01:00 PM to 02:10 PM on 2nd May, 2023

Knowledge Management codes = (Light Magenta color)

- (KC) - Knowledge Creation
- (KST) - Knowledge Storage
- (KSH) - Knowledge Sharing
- (KU) - Knowledge Utilization

Benefits (Light Green color) and Challenges (Light Blue color) codes

- (BNF) - Benefits
- (CHN) - Challenges

Speaker	Transcribed Text	Code
6.1	<b>Introduction of Interviewee</b> <b>If you can please go through your role in your company and what is your contribution towards the sustainability and circularity ambitions of your company?</b>	
6.2 P6	Yes, my name is Embla Winge, and I work as a Climate Development Manager in, regarding Climate change and effects on our company. So I work for the whole company of PEAB with 16,000 employees and work only with climate change and climate mitigations. That's my role.	
6.3 P7	And my name is Fredrik Berg. I work as a BIM business developer at PEAB, focusing on standards that specify, identify and describe the built environment. And when it comes to sustainability and circularity, there are a lot of standards that	





	circle or in economy to to get the right decisions and right directions.	
6.10 P7	<p>I think for manufacturers this is a business opportunity for them and perhaps if they have a good product with low environmental impact, it's beneficial for them and their product will sell more if it's and if you compare it to different products and one has less environmental impact, you will probably as a consumer choose that one.</p> <p>And but it all depends on the data that you have the right data and the right quality of the data. And you have systems that may make it easy to compare different products and so if you have a good product, it's beneficial for the manufacturers. But for the consumers it's also helpful with this kind of product passports since you can actually compare products based on the data and it could be global warming potential, but it could also be all different kinds of properties that you can compare. So I think there are many stakeholders that will benefit from these product passports, but. I guess the consumers Or the society or the globe is perhaps the biggest winner in this, But we see that many different stakeholders and gain different They have something to gain from this, but for different purposes perhaps.</p>	<p>BNF</p> <p>KU</p> <p>BNF</p>
6.11	<b>What will be your thoughts on your organization's level of understanding about the information DPP should carry to meet EU guidelines?</b>	
6.12 P6	<p>If you should measure it so important that the quality of the data and that we all measure the same that all products have the same way of setting the frames for the data and this is a problem, I can see as if you know the environmental product declarations EPDs they are using different standards. So if you have one product and one another, they can use different types of EPD, because of the certificate that was used. So I think the most important for DPPs to follow EU guidelines on a large novel is that the framework is more is it a rigid framework for the data from the EU so that every project designer has the same data that they shared shall have in the DPP but in our organization I think, we have an on a larger level. When we order things when we have our supply chain, then we can set the demands on what product data should be on the products that are the frame for consuming things in our product. So in a bigger picture organizations don't have to understand what they're buying because somebody else has already set the standards of what to buy, using a data</p>	<p>KC</p> <p>CHN</p>



	<p>framework this is what the product we want. We want this data on a product and then the product is just buy these things and so the level of understanding is higher up where we set the supply chain and where we buy in a big contract or agreement. We have a whole department that is <b>setting the rules</b> of what to buy and from which producer. So those who have that power in our company are the ones who have to know about how to address digital product passport for the product that we buy. Most of our organization will not know because they only buy what somebody else is as they should buy. So if you understand that there's different levels of how you much, you have to understand and Fredrick is down in the data and working for the whole company to set address what data should we buy, what data should we demand from a product those we buy our products from and give this input through to that organization so. I think there's very few people in our organization that will understand everything about digital product passport, but then they will serve it for all the others too. Just buy the right things. I hope that is something that was understandable.</p>	<p><b>KST</b></p>
<p>6.13 P7</p>	<p>Yeah. I think that everyday users within our organization will not have that deep understanding about DPP but I think they will use the DPPs, whether or not they know about it. Like if we take for example in the future I guess <b>all the manufacturers will deliver DPPs and that will give you the data templates or data sheets that you could compare products on property level and I guess, that type of data will give us opportunity to make optimize and choices or a purchase</b> and based on perhaps different criterias as I mentioned before, if we see that we have two products that are almost about the same when it comes to technical properties and but one with less environmental impact, we will probably use the one that is the best for the environment and I guess we have high level purchases that Embla mentions and then perhaps it's not done in high level purchases as well and the people we have in the constructions perhaps don't have that much of a choice. What kind of product they can choose or buy. But if <b>we have more low level purchases like purchases that you do within the project or on the construction site, then you perhaps have portals where you can compare your product from different suppliers and then you can have informative purchases based on the data.</b></p>	<p><b>KST</b></p> <p><b>KU</b></p>

6.14	<b>Do you believe that your organization is prepared to consider and implement DPPs?</b>	
6.15 P7	Yeah, we are prepared to explore and we try to get a better understanding on the DPP, but perhaps not really ready to implement it, but I guess It's a broader question for the whole industry as a whole we're not there yet in Sweden and not what I haven't seen the piece yet at least, but, I don't know if you have seen some DPP unblock.	
6.16 P6	I've heard this about textiles that they have implemented it because it sets that we are there, we are ready to explore data and we're almost not digital product passports. But they are coming. So the best way is that we have the systems for handling orders and getting materials and collecting all that data because that hasn't been the way that we have been building before. We were just picking up the phone and getting some materials and maybe you have the money you used. How much money did you spend on this material but not as much kilograms because you got it in meters and you bought it. So everybody has always been showing how much money it costs and now the issue is with how much kilo to then set the CO2 on every kilo and I think that is the one issue that is taking from the digital product passes force because they want to know how much everything that is being used in every industry. And See how because before you can call before, you can't measure. If you can't measure anything, you can't say that you have developed in a direction, so. I think it's very good that we are more digital and more aware of what we are, the amounts we are buying and what is in it, the products.	KST
6.17 P7	Yeah, we are as Embla mentioned before in the middle of a digital transition right now. And one big trigger has been the climate declaration that we are legally bound to do and that has really pushed the industry forward and we see the need for good data. Especially environmental data when it comes to climate declarations. But in the future, if we have digital product passports, we will have other sorts of data as well, not just environmental data.	KC
6.18	<b>Which product groups of your organisation need to comply with DPPs?</b>	

6.19 P6	<p>Maybe it's our producing companies, so, the part of our company that our producing materials. Because it's the material who needs that is a product and I don't think that the end product like a house which includes all the products is the one that is having a digital product passport because they will be some of thousands of digital product passports because of every rock you know. But everything in it is in the house. So I think we have a company that's called Swarek that is taking out stone and making concrete I think in every Recipe of every concrete. That is going out to the product line is going to have a DPPs I think. So that's what I think we also have a prefabricated element that has to have a product pass because this is the product that is going out .So sorry Or do you see anything else Fredrik?</p>	
6.20 P7	<p>No, I guess that those companies are within the business unit PEAB industry and I guess they are the one that will produce on DPPs, but we as a PEAB contractor in the audience other end is a consumer of the data gets and we could use that data for different purposes.</p>	<p>KC</p> <p>KU</p>
6.21	<p><b>During the product design and manufacturing stages, what kind of information is vital to gather for understanding the usage of Materials in producing the products?</b></p>	
6.22 P6	<p>At first, I think that energy as what kind of energy and how it's produced is 1 main factor of understanding how the product was developed and produced and is setting the environmental issue on that product that will not issue but the contents, because energy is the key to everything. Because you use energy to produce your product and of course, chemicals are not energy because chemicals are something else, so no need to produce something. But so the impact of how much chemicals you're using and how much energy the product is being developed from is the information you need to be aware of to get a date as a part of passive and I think also this is the information as when you're aware of how much energy something is using then you might be prepared to use it again in a circular way to reuse it because you don't want to produce a new material again because it was so environmental impact on developing it from the first time. So maybe the knowledge of a product passport that when you know the energy, then you listen, you make a contribution to the circular economy because you don't want to produce it once more. You'd rather use the old material and use it again. And</p>	<p>KC</p> <p>BNF</p> <p>KU</p>

	that was my first. Do you have anything Fredrik there to I missed?	
6.23 P7	<p>Yeah. No, I think you covered it in a good way I guess and when we talk about product data today, we'll usually say that the manufacturers are the ones responsible for creating the data, sort of or fill in the data template into a data sheet, but I guess perhaps product passport is tracking data along the supply chain, so perhaps more stakeholder should contribute to the sum. I'm not completely sure, but I think the manufacturer has a big role in this and I think, except for energy, juice and chemicals, I think it's very important to also keep track of how many or other resources you have been using, how much water that you have used or other types of resources that was needed to manufacture the product, and all, of course that the environmental impact when it comes to greenhouse gasses and touch and I guess much of the data is probably already available, but I think it's not always available in a machine readable format. It could be non-readable like in a PDF or some other type of format. And so I think the whole industry within the whole supply chain has a big task in front of us to convert data from non-readable machine format into machine readable format and mentioned that when you have all the data you can make better decisions if it should be reused or recycled and such you always Or in favor with good data if you have access to it. now? Or it's my lack of knowledge when it comes to product passports. If it's supposed to be that we or all the stakeholders within the life cycle, if they are If they are supposed to add information, or if it's just the manufacturer, I'm not completely sure if we are the contractor. For example, if we should Perhaps add information about where we built the product within a building or bridge or whatever.</p>	<p>KC</p> <p>KSH</p> <p>CHN</p> <p>BNF</p>
6.24	<p><b>Let us imagine that the product is at Consumer end, what kind of information Consumer expects to have access in supporting their buying decision, then once the product is at Consumer end then what information they expect for the prolonging life of product.</b></p> <p><b>Who needs to generate this information?</b></p> <p><b>How does this information contribute to the Circular Economy?</b></p>	
6.25 P7	Mentioned this in the previous question when it comes to what kind of data, and as we mentioned, it did the energy or the use of	

	<p>resources such as energy or water and other resources, the greenhouse gases or the emissions overall and perhaps also technical information or technical data that you are in need of and it could be and this strength, I am bending strength or shear strength or something that you need to know when you make a decision to when it comes to this structural system, And I guess we mentioned it in the previous question when you need or what you do with this data and how it contributes to the circular economy, I guess all the data gives you good foundation to make good decisions, if you see the opportunity to reuse or recycle a product, for example, how should it be recycled? Or are there some hazards materials within the product that needs to be treated in a special way or? It would be good data. You can make good decisions again.</p>	<p>KU BNF</p>
<p>6.26 P6</p>	<p>Yeah, if we take a situation from real life there, everybody when we when we build for states everybody says that using wood on the facade is better for the climate because wood is having lower climate impact they say and it's renewable and if you look at it in a long term but before everybody was saying the tiles. And its better because then you, the consumers, don't have to do anything. They don't have to maintain. They don't have to paint the facades. But still when you looked at the life cycle you you could change the facades from if the facade was in wood and you have to paint it a couple of times you could change the facade three times on the death life cycle and still the impact on this CO2 impact. Slower on the one with the woods. Even if you change all the things but still the breaks was more heavily use of energy when there were produced so the old truth that it's easier to get the breaks and you don't have to do anything was completely wrong because when you got the data and you can see that you could change the whole facet three times and the same time and still it was lower and get packed on the climate. Then, so what we know now is not certain that we know this on about 5-10 years that the knowledge is increasing all the time and I think this is the same thing, if a consumer has a DPP he can more easily look and see but between two products what if I buy this product, the product will last for 10 years but it's a very low impact. But I have to change to a new product again about 10 years maybe then I will choose a product that has higher climate impact on the producing level. But I will know that it will last for much longer and that is better not for a circular economy if we only think about the money because then we</p>	<p>KU KU</p>



	<p>was the recycler, the producer has to know how to recycle the product to manufacture a product from the start. So you can use the ketchup thing to see that this won't have to burn, we can't reuse it. The other one we can recycle it's better for the environment.</p>	KU
6.30 P7	<p>And one thing that relates to this, but I'm not sure if it relates to the digital product passports in such. As a contractor, we need to have a log book where we specify, what kind of product we have been using and where they are built in, and in what amounts or quantities, and so we need to specify that and that type of information, it is very useful for recycler when you should demount the building or rebuild or such And that information could be very useful, but I'm not sure if that's something for digital product passports. Perhaps you set up a digital product passport for a whole building as well? I'm not sure.</p>	KST, KU
6.31	<p><b>Let us imagine that government authorities need to have access to product information from Compliance and Safety aspects, what kind of information they expect Retailers should provide when asked for information.</b></p> <p><b>Is this information already available? If yes then how this is captured in today. If not then do you have any views about how it will be in future.</b></p>	
6.32 P7	<p>Information is needed I guess if it's for material then you have in. You should have a safety. I'm not sure if it's called safe sheet or safety. You need to specify all the chemicals or the hazard. Information that the product contains, I guess that's already regulated on EU level. But as I mentioned before, many of these or much of this information is today only available in non-material, non-machine readable format and this also needs to be transformed or converted into machine- readable formats. So some work to do even if the data is available today, but it's a non-machine readable And, I'm not sure if it will come, the new regulations or follow that concerns compliance and safety. But I think this area is quite regulated already today.</p>	KST  CHN
6.33 P6	<p>Yes, you can see it's in plastic for children, they can't have that BPA as there are already so many regulations on the product. But I think that there could be more regulations because it's as we can see when the climate declaration comes in Sweden as a law demand. Everybody was making this change, so I think it's better that the regulations come. I don't think that the companies</p>	



	<p>will do the biggest impact first because they will go on as usual before there is a government demand on change. Not everybody, and not all everything, but I think the biggest impact is when the government is coming too. Say that, this isn't this? So you'd have to have in your product or you should not have in your product. So the information is not already available in all the things in a digital product passports, but I think in what's in safety and stuff like that, dangerous chemicals. This is regulated already so some parts, yes, some parts.</p>	
6.34	<p><b>Does your organisation have the necessary digital technologies already in place to support DPP? If Yes/No, then please elaborate.</b></p>	
6.35 P7	<p>Yes and No. I would say we have systems within PEAB that can collect data if it's structured and machine readable but, we haven't configured it based on the standards of DPP. So we need to get a better understanding about the DPP and the standards behind it.</p>	KST
6.36	<p><b>What are the key drivers and challenges you see while implementing DPPs? For the challenges, what could be the best practices to overcome?</b></p>	
6.37 P6	<p>The challenge are that the knowledge about DPPs and what the frame is for the demands is not clear. So maybe it's as you said it maybe in textiles but not in the products that I use on building constructions. So, we have to overcome this. We have to know more about what the framework and the data sheets that are demanded to address this. Do you agree Fredrick?</p>	CHN
6.38 P7	<p>Yes, I do.</p>	
6.39	<p><b>How do you envision the future of digital product passports and the circular economy? What potential benefits and drawbacks do you anticipate as this concept continues to evolve?</b></p>	
6.40 P6	<p>And maybe that was what I was talking about before. But when you have the knowledge, then you make the right decisions so the future that machine readable data on every product is the future and then the more knowledge every consumer product owner get on their products the more you will take the right decisions to change because of climate change. This impacts everybody else and also about money, I think that people will</p>	BNF KU BNF

	<p>see that it's better to use product longer and have more quality than consuming, consuming, and consuming and get the newest thing. Because I think that everybody has to agree soon that this has to stop.</p>	
6.41	<p><b>What are your thoughts about securing protection to Patents, Information security and data privacy for the information DPP collects and manages?</b></p>	
6.42 P7	<p>Yeah, that's a good question and I'm not completely sure how you can protect that. It depends on what detail you need to. I mean, the detail of the data that you're supposed to add to the digital product passports. I mean, if we take concrete, for example, you as a manufacturer of concrete, you don't want to give you our recipe of the concrete to the whole industry that's something you want to protect there and but when it comes to the data templates and data sheets based on ISO standards they are not going into that level of detail. It's more about the preps, what type of cement you are using and what type of aggregate and such, but perhaps not you. You cannot from a data sheet, you cannot read the whole recipe. And I think the industry will need to agree upon the level of detail that would be within the digital product passports. So there are agreement from the whole industry. Yeah, that's the only way of the how- it should be done, or at least work. Otherwise, the manufacturer will not sign up for this so or they will.</p>	<p>KC</p> <p>KST</p>
6.43 P6	<p>They will lose all their integrity, if they lose their recipe on you can take it in the baking world if you have a cupcake that is special and everybody's buying that cupcake and you have to give the recipe for that cupcake in detail so that everybody can do that, then you don't have a product that you will sell because you're secret recipe is out and open. So it's the same for concrete. I'm joking now but. Because you have to have maybe you could say flour, but you don't say that amount of flour in the, but you have to. You have to get this. Maybe the data for the whole product and have the product owner have to have some integrity. So, the level of the data that Fredrick was talking about. This is why you have to have some integrity left for the product manager. So patterns and too much details the level must be the same for every manufacture.</p>	<p>CHN</p> <p>CHN</p>
6.44 P7	<p>Yeah, and they should I hope the stakeholders, those the authorities that prep or those that create the standards for, the</p>	<p>KC</p>

	<p>data template for the digital passport, that they have a dialogue with the industry and so they have a broader agreement. So they communicate so they not just put out the standard that with a very high level of detail and they should include the industry. And in the dialogue, when they create these digital product passports or the templates of them.</p>	
6.45	<p><b>What role do you see government and policy makers play in the adoption and implementation of DPP for enabling the Circular Economy?</b></p>	
6.46 P6	<p>A very high role as I was talking before. I think when the demands come on a high level, everybody's following them. So as it's important that not every company is making their own implementation of DPP's and in their own way. And then you can't compare it with other companies, so it's very important that the direct direction from the government and then the end. Also policy makers is the same and follows the same rules for everybody. So that everybody is following and showing their data in the same way. So that you and me and everybody else can. That's absolutely the biggest the basic and the biggest thing for implementing at the digital passport I think.</p>	<p>BNF KU</p>
6.47 P7	<p>Yes, I agree!</p>	

## Appendix 10 - Consolidation of KM Codes across participants responses

The four stages of the knowledge management framework are shown in the table below and are listed against each interviewee. The keywords mentioned here during the interviews helped us in categorizing these into the four phases of our framework.

Participant	Knowledge Creation (KC)	Knowledge Storage (KST)	Knowledge Sharing (KSH)	Knowledge Utilisation (KU)	Information Ownership
P1	<p>Product information -&gt; durability, reusability, recyclability, upgradability (1.14)</p> <p>Product components data (1.14, 1.20)</p> <p>Audits &amp; self assessments (1.38)</p> <p>Certificates &amp; Verification Results (1.18)</p>	<p>Digital Twin (1.4)</p> <p>Data access in common way across stages (1.26, 1.46)</p> <p>Accessible in Standardised language &amp; neutral standards (1.42, 1.44)</p> <p>Standardised solutions in common way (1.42)</p> <p>Data confidentiality and access (1.48)</p>	<p>Climate footprint (1.22)</p> <p>Replacement and Repair instructions (1.22)</p> <p>Materials usage (1.30)</p> <p>Climate footprint (1.36)</p> <p>Reusability, Recyclability and Durability (1.36)</p> <p>Chemical content (1.36)</p> <p>Hazardous and Conflict materials (1.36)</p>	<p>Purchasing decisions by consumers (1.26)</p> <p>Repair, Reuse (1.20)</p> <p>Loop back of Product and materials (1.28)</p> <p>Recycle of Materials (1.30)</p>	<p>Retailer - Accountable (1.16)</p> <p>Producer &amp; Retailer - Responsible (1.16)</p>
P2	<p>Materials used (2.4, 2.26)</p> <p>Sustainability of Materials (2.4)</p> <p>Location/Source of Materials (2.4, 2.8)</p> <p>Product components &amp; parts information (2.8)</p> <p>Recyclable &amp; Renewable content of Materials (2.16)</p> <p>Repair and</p>	<p>Data access in common way (2.10, 2.12, 2.28, 2.38)</p> <p>Digital twin (2.32, 2.42)</p> <p>Digital technologies (2.42)</p> <p>Granularity and level of product data (2.42)</p> <p>Data access</p>	<p>Materials usage (2.24)</p> <p>Climate impact (2.24)</p>	<p>Materials selection in Production based on Sustainability (2.16)</p> <p>Purchasing decisions by consumers (2.24)</p> <p>Repair, Reuse &amp; Repurpose (2.22, 2.34)</p> <p>Recycle of Materials (2.34)</p>	<p>Retailer - Accountable (2.26)</p> <p>All stakeholders - Responsible (2.26)</p>

	<p>Replacement instructions (2.16, 2.22, 2.24)</p> <p>Assembly instructions (2.16)</p> <p>Disassembly instructions (2.22)</p> <p>Certificates &amp; Safety guidelines (2.38)</p>	<p>through QR code (2.46)</p> <p>Data confidentiality to protect patents (2.48)</p> <p>Data access based on stakeholder type (2.48)</p>		Competitive advantage (2.44)	
P3	All product data (3.22)	<p>Granularity and level of product data (3.6, 3.10, 3.16, 3.34)</p> <p>Data confidentiality to protect patents (3.16, 3.22, 3.34, 3.46)</p> <p>Data traceability (3.16)</p> <p>Data aggregation for bigger perspective (3.42)</p>	<p>Materials usage (3.24)</p> <p>Climate impact (3.24, 3.42)</p>	Overall climate footprint (3.42)	<p>Retailer - Accountable (3.18)</p> <p>All stakeholders - Responsible (3.18, 3.26, 3.32, 3.38)</p>
P4	<p>Tamper-proof Product Information (4.4)</p> <p>Standardized Information(4.32)</p>	<p>Record of information (4.6)</p> <p>Blockchain Technology (4.8, 4.30)</p> <p>Security Perspective, Patented information (4.22)</p> <p>Verifiable Credentials (4.30)</p>	<p>Information flow across value chain (4.6)</p> <p>Carbon footprint (4.14)</p> <p>Sharing relevant information (4.14)</p> <p>Transparency (4.16)</p> <p>Developing maturity in thinking (4.18)</p> <p>Assembling and Disassembling the product (4.20)</p>	<p>Wise and better decisions by consumers (4.6, 4.8, 4.14)</p> <p>Best way to recycle, Recycling points (4.20)</p>	<p>Retailer - Accountable (4.22)</p> <p>All stakeholders - Responsible (4.6, 4.30, 4.32)</p>
P5	Collecting downstream user information by manufacturers (5.18)	Importance of gathering the data (5.8, 5.16, 5.26)	<p>Transparency in network (5.6)</p> <p>Increasing</p>	Proactive maintenance, Simultaneous performance	Retailer - accountable (5.18, 5.26)

	<p>Importance of Design Phase (5.22)</p> <p>Designing the data road map (5.38)</p>	<p>Product Performance Data (5.10)</p> <p>Need of data infrastructure, Cloud technology (5.10, 5.28, 5.34)</p> <p>Data or a product as a service (5.12)</p> <p>Product manual (5.38)</p>	<p>collaboration of supplier, manufacturers and consumers (5.6, 5.18, 5.32)</p> <p>Data disclosure (5.8)</p> <p>Resource identification in consortium (5.14)</p> <p>Mutually beneficial incentive system or feedback system (5.18)</p> <p>Retailers and manufacturers need to share information (5.26)</p> <p>Sharing common knowledge and information (5.34)</p> <p>Blockchain, Cloud (5.34)</p> <p>Knowledge sharing as an enabler (5.36)</p>	<p>(5.10)</p> <p>Eco-design (5.16)</p> <p>User Behaviour, User Interaction (5.16, 5.22)</p> <p>Recyclability, Reuse (5.16)</p> <p>Traceability of the product (5.18)</p>	<p>Manufacturers - accountable (5.8)</p> <p>All stakeholders - Responsible (5.8, 5.32)</p>
P6	<p>Environmental product declarations (6.12)</p> <p>Understanding about product development and production (6.22)</p> <p>Companies, manufactures producing information (6.29)</p>	<p>Setting regulations (6.12)</p>	<p>Data and knowledge for retailers, consumers (6.9)</p>	<p>Contribution to the circular economy (6.22)</p> <p>Assessment of the product (6.26)</p> <p>Compare in an equal way (6.46)</p>	<p>Retailer - accountable (6.9)</p> <p>Manufacturers - accountable (6.29)</p> <p>All stakeholders - Responsible (6.9)</p>
P7	<p>Need for good, environmental data (6.17)</p> <p>DPPs tracking data along the supply chain (6.23)</p> <p>Information to be</p>	<p>Data dictionary, data templates, data sets(6.6, 6.8, 6.13)</p> <p>Log book (6.30)</p> <p>Safe sheet and Safety (6.32)</p>	<p>Different stakeholders and different needs of data (6.8)</p> <p>More stakeholder contribution (6.23)</p>	<p>Right quality of the data (6.10)</p> <p>Informative purchases based on the data (6.13)</p> <p>Utilization of</p>	<p>Manufacturers - accountable (6.23)</p> <p>All stakeholders - Responsible (6.23, 6.42)</p>

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	added by stakeholders (6.28)  Detail of data (6.42)  Creation of the standards (6.44)			data by customer and making better decisions (6.20, 6.23)	
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## Appendix 11 - Consolidation of Benefits and Challenges codes across participants responses

The below table depicts the benefits and challenges mentioned by the participants while answering the interview questions and are captured against each participant. This information enables us to summarise the overall benefits which can be realised once DPP becomes a reality and the DPP journey needs to address the challenges described by the participants for effectiveness of DPP implementation.

Participant	Benefits to perceive	Challenges to face
P1	<ul style="list-style-type: none"> <li>● Traceability and transparency (1.4)</li> <li>● Sustainable production and consumption (1.4)</li> <li>● Circular business models (1.4, 1.20)</li> <li>● Service and repair based business models (1.4)</li> <li>● Informed purchasing decisions to consumers (1.4)</li> <li>● Products complaint with legal regulations (1.4)</li> <li>● DPP is an enabler for Circular Economy (1.6)</li> <li>● Competitive advantage for business (1.8)</li> <li>● Informed decision making support (1.8)</li> <li>● Prolong products life span (1.22)</li> <li>● Easy access of product information to all stakeholders (1.26)</li> <li>● Good support for taking care of products (1.28)</li> </ul>	<ul style="list-style-type: none"> <li>● Lack of support to trace where and how product is produced today (1.4, 1.6)</li> <li>● Lack of understanding about DPP (1.10)</li> <li>● Lack of product data availability today (1.26)</li> <li>● Without standardisation, there will be lots of solutions that will not be compatible with each other and become messy (1.44)</li> <li>● Heavy burden on administration to manage the data (1.44)</li> <li>● Reliability, accuracy and authenticity of data which feeds into DPP (1.46)</li> <li>● Granularity and extent of data to expose while protecting confidentiality (1.48)</li> <li>● The required support to provide by European Commission while implementing DPP (1.50)</li> </ul>
P2	<ul style="list-style-type: none"> <li>● Promotes Eco-friendly products (2.4, 2.24)</li> <li>● Prolong products life span (2.4, 2.22, 2.30)</li> <li>● DPP is an enabler for Circular Economy (2.4, 2.6)</li> <li>● Easy access of product information to all stakeholders (2.10, 2.20, 2.40, 2.46)</li> <li>● Informed purchasing decisions to consumers (2.24)</li> <li>● Good support for taking care of products (2.30)</li> <li>● Circular business models (2.30)</li> <li>● Service and repair based business models (2.30)</li> <li>● Products complaint with legal regulations and brings more safer</li> </ul>	<ul style="list-style-type: none"> <li>● Granularity and extent of data to expose while protecting confidentiality and patents (2.12, 2.42, 2.48)</li> <li>● Without standardisation, there will be lots of solutions that will not be compatible with each other and difficult to maintain (2.20)</li> <li>● Requires heavy investments in building the solutions and maintaining data so adoption requires some incentives from governments (2.44, 2.50)</li> <li>● Brings counterfeit products to markets if data access rules are not governed and entire information is exposed (2.48)</li> <li>● Requires good collaboration with all stakeholders while designing DPP guidelines (2.50)</li> </ul>

	<p>products (2.38)</p> <ul style="list-style-type: none"> <li>● Competitive advantage for business (2.44)</li> </ul>	
P3	<ul style="list-style-type: none"> <li>● Traceability and accuracy of product information (3.20)</li> <li>● Promotes Eco-friendly products and saves planet (3.28)</li> <li>● Products compliant with legal regulations (3.34)</li> </ul>	<ul style="list-style-type: none"> <li>● Reliability, accuracy and authenticity of data which feeds into DPP (3.4)</li> <li>● Granularity and extent of data to expose while protecting confidentiality and patents (3.6, 3.10, 3.12, 3.44, 3.46)</li> <li>● Traceability of data across tiers of supply chain (3.16)</li> <li>● Requires heavy investments in building the solutions and maintaining data (3.8, 3.32)</li> <li>● Lack of product data availability today (3.30)</li> <li>● Reliability, accuracy and authenticity of data which feeds into DPP (3.46)</li> <li>● Requires good collaboration with all stakeholders while designing DPP guidelines (3.50)</li> </ul>
P4	<ul style="list-style-type: none"> <li>● Secure in the information that's provided about the product (4.4)</li> <li>● Digital product passports as an enabler for a circular economy (4.6)</li> <li>● Standardization of the information (4.30)</li> </ul>	<ul style="list-style-type: none"> <li>● Lots of information can be difficult to digest (4.26)</li> <li>● Enabling the decision makers (4.28)</li> <li>● Information and data access concerns (4.30)</li> </ul>
P5	<ul style="list-style-type: none"> <li>● Regulatory driving force to speed up accelerate circular economy (5.4)</li> <li>● DPP and as an opportunity to actually see circular business case (5.32)</li> <li>● A contribution to increasing recyclability, reparability or reusability, extending product lifetime (5.38)</li> </ul>	<ul style="list-style-type: none"> <li>● SMEs can find it difficult to cope up or absorb the shock of this regulation (5.4)</li> <li>● Sharp timeline for companies to comply (5.4)</li> <li>● Manufacturers having lack of granularity level of data (5.8)</li> <li>● Business sensitive data and the organisations protecting their competitiveness (5.8, 5.34)</li> <li>● Difficulty to convince the main business to establish Circular Business models (5.12)</li> <li>● Difficulty to trace the original manufacturer (5.24)</li> <li>● Higher costs involved for smaller size companies to meet compliance (5.26, 5.30)</li> <li>● Requirement of disclosure of information (5.38)</li> </ul>
P6	<ul style="list-style-type: none"> <li>● To know about data brings many benefits (6.9)</li> <li>● Utilization of resources in more circular way (6.22)</li> <li>● More knowledge leads to better decision</li> </ul>	<ul style="list-style-type: none"> <li>● It a rigid framework for the data from the EU (6.12)</li> <li>● Knowledge about DPPs and what the frame for demands is not clear (6.37)</li> <li>● Maintaining the data integrity (6.43)</li> </ul>

	<p>making (6.40)</p> <ul style="list-style-type: none"> <li>● Prolong use of product (6.40)</li> <li>● Standardized format of data (6.46)</li> </ul>	
P7	<ul style="list-style-type: none"> <li>● Important in the circular economy for different stakeholders (6.6)</li> <li>● Good business opportunity for manufacturers (6.10)</li> <li>● Consumers can actually compare products based on the data (6.10)</li> <li>● Lead to better decisions (6.23, 6.25)</li> </ul>	<ul style="list-style-type: none"> <li>● Data is sometimes in a non machine readable format (6.32)</li> </ul>

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