TOWARD DEVELOPING A DATA MODEL FOR A DIGITAL PRODUCT PASSPORT TO ENHANCE CIRCULARITY IN FASHION

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Abstract

In the context of a transition to sustainable fashion, a Digital Product Passport could support the circular economy and inform consumers about the sustainability conditions of the products they intend to purchase. This paper presents our methodology to develop a data model of a DPP for the textile industry through a Grounded Theory approach. It results from the convergence of domains of expertise including the evolving legal context in Europe and France, the initiatives of brands to improve consumer information, the growing interest of academics in supply chain traceability and the evolution of stakeholders needs as they become actors of the value chain. The draft model we are presenting is gathering 16 areas of information that can be used by the stakeholders of the entire value chain.

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The Textile and Clothing Industry is transforming to regain consumer trust by increasing transparency (Jestratijevic *et al.*, 2021). In order to make informed purchases, consumers need information about the sustainability conditions of the products they intend to purchase (Granskog *et al.*, 2020). A result of a survey of 54 fashion brands found that most transparency information available is at a corporate level and information about specific products is limited (Ospital et al., 2021). A Digital Product Passport (DPP) associated with the label, referring to the specific item or its batch, could be the answer to this problem.

This paper presents our methodology to develop a data model of a DPP that could enhance circularity in the textile industry. The Digital Product Passport (DPP) is a recent development, arising from the convergence of four factors: the evolving legal context in Europe (section 1), the innovation of brands in response to changing consumer needs and the legal context (section 2), the growing interest of academics in supply chain traceability (section 3) and the evolution of stakeholders needs on all the value chain (section 4).This paper aims to construct a theoretical framework of the DPP through a Grounded Theory approach. This method uses an inductive approach, iteratively defining and refining the analysis of data collected through various forms and stages, using a constantly evolving coding system for categorization (Paillé, 2011).

1. The evolution of the DPP in the regulatory context in Europe and France

This section will provide an overview of the relevant legislation and regulations that have shaped the development of the DPP and its current legal framework. The aim of this section is to give a comprehensive understanding of the legal context in which the DPP operates and its evolution over time. The DPP concept is becoming more and more precise as European and National regulations are introduced.

The DPP is mentioned in 2013 in the Recommendation: *Improve resource efficiency in business-to-business relations* (European Commission, 2013),

In “The European Green Deal (European Commission, 2019) which is a roadmap with a set of measures to put the European Union on the path of ecological transition, with the objective of achieving climate neutrality by 2050. DPP was presented as: *“electronic product passport could provide information on a product’s origin, composition, repair and dismantling possibilities, and end of life handling”.* A new Circular Economy Action Plan (CEAP) was announced “*to guide the transition of all sectors, particularly on resource-intensive sectors such as textiles, construction, electronics and plastics”.* A package of measures proposed is Eco-design for Sustainable Products Regulation that includes a specification of the set of data that may be included in the DPP (European Commission, 2022a) and another focusing on the Textile and clothing industry *EU Strategy for Sustainable and circular Textiles* (European Commission, 2022b).

The CIRPASS project funded by EC (Collaborative Initiative for a Standards-based Digital Product Passport for Stakeholder-Specific Sharing of Product Data for a Circular Economy) is working on

defining a clear concept of the DPP with the definition of a cross-sectoral standard for the 3 sectors initially targeted: electronics, batteries and textiles (“CIRPASS”, 2023).

In parallel, in France, the AGEC (Anti-waste for a circular economy) law (Code de l’environnement, 2020) and the Climate and Resilience law (Code de l’environnement, 2021) share common visions with the European projects with a will to transform the French economy by favouring circularity, waste reduction and consumer information.

Since January 2023, companies whose annual turnover exceeds €50 million must make available to consumers a "Product sheet on environmental qualities and characteristics" for new regulated products intended for consumers. "(Code de l’environnement, 2022) : incorporation of recycled material, recyclability, presence of hazardous substances, geographical traceability and presence of plastic microfibres are mandatory for textile products for clothing, linen, and shoes.

This information must be made available to the consumer at the time of purchase and in an accessible dematerialised format, free of charge. This new measure will revolutionise consumer information which was previously limited to the composition of textile products. Some brands go further than the mandatory information by experimenting with forms of DPP.

When analysing both regulations, the categories of information shared on DPP are:

- Instructions for reparation, recycling, dismantling (European Commission, 2019).
- Information about composition, sustainable material content, origin of materials, sustainability conditions (Code de l’environnement, 2022).

The main objectives of DPP are to:

- Improve resource efficiency and material flow (European Commission, 2013)
- Allow consumers and all stakeholders to make informed choices with transparency about the life-cycle impact of products (Code de l’environnement, 2022).
- Improve circularity (dismantling possibilities, end of life handling) (European Commission, 2019)
- Help public authorities to better verify and control. (European Commission, 2019)

Stakeholders identified are:

- Consumers
- Companies in the supply chain and throughout the product life cycle
- Public authorities

2. DPP in 2022 in the textile industry

This section aims to present the results of a field study of 13 initiatives from brands and technology providers in 2022 aimed at communication of environmental information to consumers. The study focuses on the information companies are making available to consumers through their products, with a focus on the specific data provided and how it is presented. The objective of the study is to understand which information companies are communicating to consumers and to highlight the latest innovations in this field. The initiatives studied are TBS & Fairly Made, Made in Green by Oeko-tex, Residus & Trust Trace, Sorga, Eram & e-SCM, Gabriela Hearst & EON Circular.ID, Myrka Studios & Circularity ID, Hopaal & Clear Fashion, Reformation & Fibertrace, H&M, Etam, Saint James & Crystalchain, Aigle & Tilkal Footbridge.

They vary on the level of details communicated to consumers: some solutions are comparable to augmented labels with online information whereas others give in-depth details from material provenance. Some brands have implemented their solution to most of their products while others only used it for a capsule collection. Finally, some technological providers only share demonstration versions that remains theoretical proof of concepts.

We classified the type of information into 9 topics to build our model. This classification allows the information to be categorised into broad themes, each of which may include information with different levels of detail. These categories allow the comparison of initiatives and to extract the most common themes in current projects.

- Product description: product type, size/measures, manufacturing technique, period, pictures
- Composition: Material and characterisation, colour, components
- Supply chain: companies participating in manufacturing and logistics, their identification and their processing step.
- Transportation/ Distances: localisations, distance traveled, means of transport.
- Brand information: presentation, contact details, commitments.
- Documentation/Certification/Verification: Social and environmental certificates (materials, products (transaction), companies (scope, supplier information), Verification (audits, tests)
- Environmental Impact: LCA calculations and impacts, responsible sourcing (recycled, dead stocks, on-demand)
- Circularity indicators: history of events after the sale (maintenance, purchase, repair, modification), and information regarding: maintenance, customer returns, resale (advertisement, selling price), repair (techniques and availability of parts), modification, recycling (material characterization and dismantling)
- Data carrier/Unicity/Granularity: Technology of data carrier, passport granularity (single identification or batch)

In addition to this, the study of the most transparent brands on the market leads us to add 3 topics not included in the DPP studied for more transparency (Asket; Loom; Nudie Jeans).

- Tests: safety and performance (pilling, twisting, shrinking, technical properties).
- Costs: cost price, raw material, fabric and components, manufacturing, transport.
- Quantities produced: this reference, whole brand.

3. DPP in the scientific literature in 2022

The emergence of DPP in scientific literature has been influenced by EU regulations, with a notable increase in the number of publications since the European Green Deal (European Commission, 2019).

Our study of 71 texts in the corpus showed that while several industrial sectors are mentioned, the majority of the texts (32) did not specify a specific industry as they were primarily theoretical and general in nature. The construction and building industry was the most represented with 10 articles, though the term "material passport" was more commonly used instead of "DPP". The textile industry is featured in 4 articles, while both industries 4.0 and 5.0 are discussed in 4 articles. The battery sector and electronics sector are each mentioned in 3 articles, while the waste and recycling industry, mining and extraction industry, and materials industry each appear in 2 articles. The automotive sector, plastic materials industry, aeronautics industry, additive manufacturing, metallurgy, agriculture, and renewable energy are each mentioned in 1 article.

From an academic perspective, the literature review highlights that the current research on the DPP carried from the perspective of the circular economy research field as the term "circular" is the most commonly used keyword, appearing 57 times in the corpus. It is often paired with "economy" (52 times) and related concepts such as "circular economy tool," "circular 4.0," "circular supply chain management," and "digital circular economy." Other related expressions that appeared include "circular business models," "circular innovations," "circular society," and "EU action plans on circular economy."

The most commonly cited definition of a Digital Product Passport comes from the European Commission and The Wuppertal Institute (Götz *et al.*, 2022), defined as *"a product-specific data set that summarizes the components, materials, and chemical substances in a product, and information on reparability, spare parts, and proper disposal instructions.".* Other purposes identified in the studied corpus include: track of material and product lifecycles at all stages to optimise resource management and promote circular business models; simplify quality controls, compliance and certifications for both authorities and brands, support standardised data exchange for all stakeholders.

These stakeholders are from the whole circular supply chain and include: Supply chain companies (raw materials producers, manufacturers, logistics, technology suppliers, distributors, brands, retailers, service providers), communities (citizens, authorities, certification organizations), consumers and users, investors, recycling operators.

All these different profiles require specific information that needs to be studied in more detail for our sector.

4. The evolution of stakeholders needs

In the next section, we focus on qualitative interviews with key stakeholders to gain insight into the needs and perspectives of all players in the value chain. While The needs of consumers are constantly evolving, and in the context of a transition to sustainable fashion they are becoming more involved as active participants in the value chain. it is crucial to have a clear understanding of these changing needs to effectively implement the Digital Product Passport. However, the value chain remains a complex socio-economic system, and introducing the DPP requires a comprehensive understanding of all stakeholders and their roles. This section aims to provide insights into these diverse perspectives to inform the successful integration of the DPP into the value chain.

Key users of the DPP were identified and the relevant areas of information were categorized through interviews with stakeholders across various stages of the supply chains and product life cycles. These profiles include after-sales service/repair, marketing managers, researchers on circularity, second-hand resellers, quality managers, CSR managers, and technology providers.

Semi-structured interviews were conducted to gather information on the availability and format of product information and to determine what additional data would be useful. The analysis of data collected from the semi-structured interviews is ongoing. To date, the interviews have provided valuable insights into the practicality of the field, revealing the limitations and fragmentation of existing information systems, particularly after-sales. The engagement with potential DPP users through these interviews has enabled us to gain a deeper understanding and accuracy beyond what theoretical research can provide. Our ongoing categorization and coding efforts aim to construct the most comprehensive model of the Digital Product Passport possible gathering 16 areas of information. On Table 2. a draft model of DPP summarises the categories we have identified.

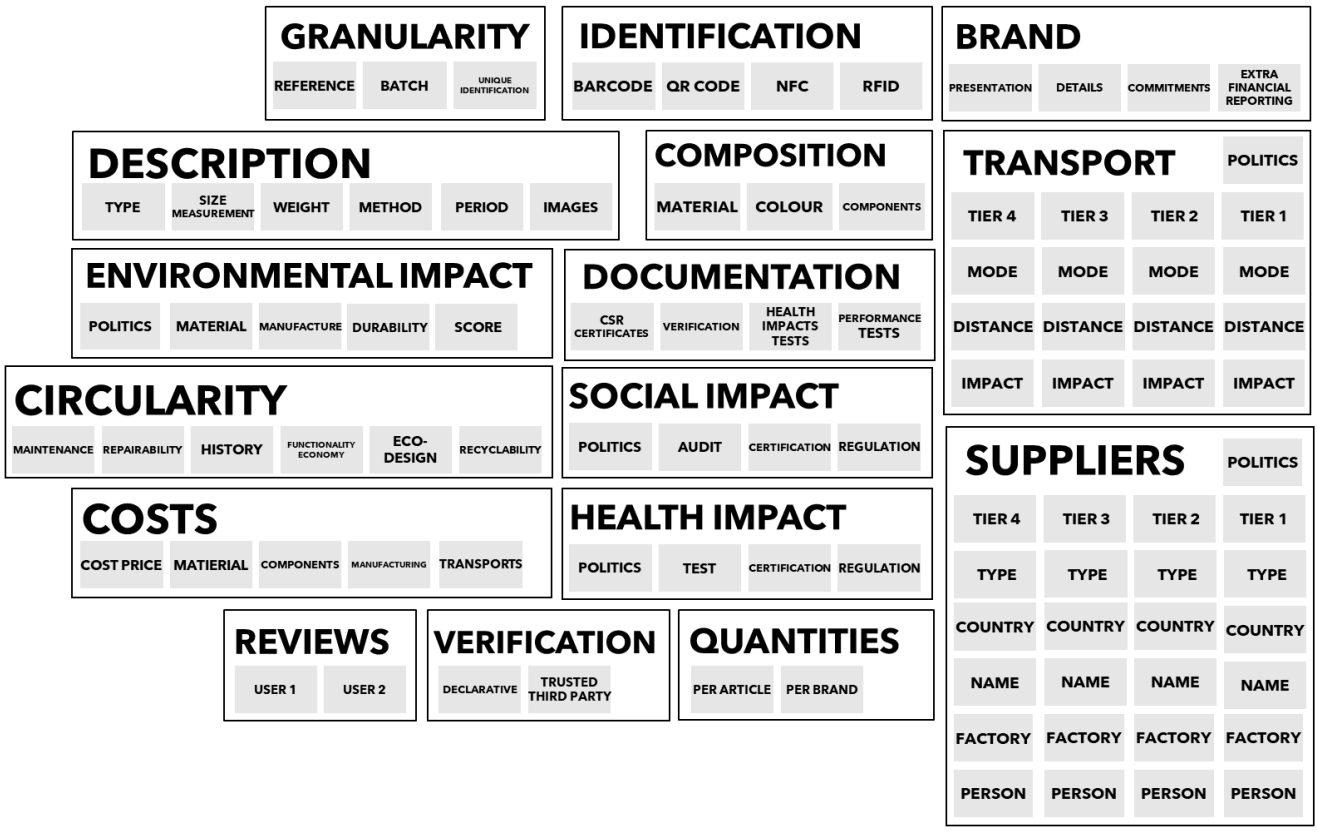

Table 2. Draft model of DPP for the textile industry

5. Conclusion

In constructing a DPP model for the textile industry, our focus has been on the provision of relevant information to users by identifying the attributes of significance to various stakeholders. These stakeholders include consumers, companies within the supply chain and throughout the product life cycle, and public authorities. The successful implementation of this model hinges upon the ability of IT systems to gather data in a standardized and trustworthy manner, as well as the willingness of these stakeholders to transparently share information. Ultimately, the widespread adoption of DPP throughout the value chain will only be achievable if all parties, including consumers, companies, and public authorities, view it not as a burden but rather as an opportunity to advance towards a more circular approach in the textile sector.

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Biographies

Pantxika Ospital is a PhD student at the University of Bordeaux and ESTIA Institute of Technology, France. She has an MA in Textile Design from ENSAD and has been working in the textile industry for ten years. She is researching how full traceability in the Supply chain, from the producer to the informed consumer, could support brands' CSR policies in the textile and fashion industry.

Dimitri Masson holds an engineering degree (BS, MS) in computer science from Grenoble INP Ensimag and a Master's degree from Joseph Fourier University in distributed, integrated, mobile, interactive, and parallel systems. He also has a PhD in computer science from the University of Grenoble, specialising in computer-assisted creativity. Since 2015 he has been a teacher, researcher, and engineer at ESTIA. Since 2018 he has been the head of the Mathematics & Computer Science teaching unit and the pedagogical coordinator of the Bali Chair. His field of research is at the crossroads of artificial intelligence, computational creativity and human-computer interaction. He

focuses on the design and development of computer tools designed to support design activities, creativity, innovation, and decision-making. He has contributed to the Incose HSI WG since 2020.

Cédrik Béler is assistant professor at ENIT (Ecole Nationale d'ingénieurs de Tarbes). His research is in the field of Social-Cyber-Physical Systems and Digital Twins and is related to data science and knowledge management. He is especially interested in the way information is organised in distributed networks of information systems with humans in the loop. Applications are developed in the context of industry 4.0 as well as the public space (local, regional and national authorities).

Jérémy Legardeur is a professor at ESTIA Institute of Technology. He graduated as a Mechanical Engineer from Montpellier University in 1997 and completed his PhD from Grenoble's INP (Institut National Polytechnique) in 2001. He is the founder of 'The 24h of Innovation®' event (www.24h.estia.fr) and the scientific head of the BALI Chair (https://chaire-bali.fr), a research programme with companies dedicated to fostering circularity for the textile sector.