Textiles in the Digital Age: Navigating the Integration of the Digital Product Pass within the Fab City Framework

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***Abstract* – This paper critically explores the challenges surrounding the implementation of the Digital Product Pass (DPP) within the context of a Fab City model, focusing on the textile industry exemplified by the use case Fab City Hamburg. The DPP, initiated by the European Union as part of its Circular Economy Action Plan, aims to enhance product traceability and promote sustainable consumption by providing detailed information about a product's lifecycle. However, its adoption in a Fab City setting, characterized by local production, community-based practices, and a focus on reducing consumption, encounters several obstacles. Financial constraints, particularly affecting small and medium-sized enterprises, pose a significant barrier to DPP implementation. Standardization of data models is another critical issue, given the diversity of products and manufacturing processes in Fab Cities. Ensuring transparency and accessibility of product information, influencing consumer behaviour towards sustainability, and addressing the scalability of upcycling processes are also major challenges. Critics argue that the DPP's emphasis on recycling may undermine efforts to prevent waste generation and that it lacks focus on systemic changes needed for genuine sustainability. The potential for greenwashing and the need for a user-friendly solution that accommodates the unique characteristics of Fab City production are also highlighted. This exploration underscores the complexities of integrating digital technologies with sustainability goals in a Fab City model, emphasizing the need for supportive policies and innovative approaches to overcome these challenges.**

Keywords – Cosmo-localism, commons-based future, digitalisation, digital product pass, textile industry

NOMENKLATURA

DPP	Digital Product Passport
EU	European Union
CEAP	Circular Economy Action Plan
ESPR	Eco Design Sustainable Products Regulation
CSDDD	Corporate Sustainability Due Diligence Directive

I. INTRODUCTION

In a world with finite resources and growing environmental issues, the traditional linear consumption model is unsustainable. The circular economy, which relies on reuse and recycling, offers a regenerative solution. This approach aims not only to reduce harmful products but also to establish systems that benefit the environment and society. This text explores two digital concepts addressing the sustainability crisis: the Digital Product Pass (DPP) and the Fab City initiative. It critically examines their feasibility in the context of a Fab City exemplifying a case study from the research project Fab City by dtec.bw in Hamburg. The project part dedicated to textiles is carried out by Sarah Prien, her company House of All and her team Through qualitative research methods they endeavour to figure how Hamburg could become a Fab City in the textiles sector and evaluate local manufacturing capacities and the local scene.

II. CIRCULAR ECONOMY AND SUSTAINABLE PRODUCT LIFECYCLE MANAGEMENT

The circular economy emphasizes keeping products and their components in circulation through reuse and recycling. Sustainable product lifecycle management is central to this approach, aiming to minimize environmental impacts while promoting economic viability and social justice. In the textile industry, significant challenges exist. Currently, only about 1% of textiles are converted into new textiles, and 26% are recycled, leaving a substantial "Circularity Gap" [1].

III. DIGITAL PRODUCT PASS (DPP) BY THE EU

The European Union's Circular Economy Action Plan (CEAP) [2] includes implementing the Digital Product Pass (DPP) to address the Circularity Gap. The DPP is a structured collection of product-related data with a unique identifier, designed to enhance industry digitalization, regulatory frameworks, business opportunities, and circular economy efficiency.

The DPP aims to influence consumer behaviour towards sustainable purchasing by making sustainability aspects of a product lifecycle visible. Traceability of product information is crucial for maintaining products in a circular economy. Without consistent and precise flows of information about resources, products, and processes, lifecycle gaps cannot be closed.

A. Technical Structure and EU Requirements for DPP

A DPP consists of three components: the DPP system, the digital twin of the product, and the DPP data. The system integrates standards and protocols into the IT architecture, covering data carriers, unique identifiers, access rights, interoperability, data transmission, storage, processing, authentication, reliability, and security. It must be referred to as a Digital Product Pass Ecosystem as pointed out by King et al. (2023) with intense implications [3]. The European Commission has adopted amendments to the EU Regulation for Ecodesign Sustainable Products (ESPR) in April 2024 to facilitate this [4]. Article 5 sets out the requirements for the design, from which the information requirements for the DPP should contain.

The textile industry has been working on a proposal for the Digital Product Passport (DPP) that meets the requirements of the European Commission. The overarching project for textiles DPP associated with this is CIRPASS. This initiative aims to identify the most suitable proposal, which then paves the way for defining the next steps in the entire industry. Especially the textile industry, one of the most environmentally harmful industries, plans to implement DPP regulations by 2027 and complete implementation by 2030.

B. Application

The product is entered into an existing database along with all information about the material, manufacturing instructions including relevant processes and required resources, instructions for recycling the product, and ideally usage instructions, such as care tips for textiles. The full list of requirements is shown in Figure 1. Target groups are therefore varied, so different access rights must be configured. This database, usually maintained by the brand, must now be linked to a DPP system to make the data accessible via a unique identifier, the physically affixed data carrier, when the product "travels".

C. Challenges and Market Solutions

The Digital Product Pass (DPP) emerges as a critical tool within the European Union's Circular Economy Action Plan (CEAP), aiming to bridge the gap between linear and circular economies, notably within the textile industry. This initiative is part of a broader regulatory framework that includes the Corporate Sustainability Due Diligence Directive and the Extended Producer Responsibility Act. These regulations mandate companies to identify and mitigate adverse human rights and environmental impacts across their global value chains, signalling a shift towards more sustainable and responsible corporate behaviour. However, the implementation of these regulations requires time and systemic changes that cannot occur overnight, highlighting the complexity of transitioning from established systems to more sustainable practices.

The DPP is envisioned as a mechanism to influence consumer behaviour towards sustainable purchasing and responsible product ownership by making sustainability aspects of a product lifecycle visible. Yet, the directive's effectiveness is contingent upon the ability of sustainability criteria to motivate purchases, a factor that studies suggest are secondary considerations for many consumers [5]. This raises concerns about the potential for greenwashing, where only specific, positive aspects of a product's lifecycle are highlighted, omitting critical information that could influence consumer choices.

Extract from Ecodesign Requirements Framework (December 2023)

Regulation establishing a framework for setting ecodesign requirements for sustainable products and repealing Directive 2009/125/EC

In order to address environmental impacts which arise in any of the stages of products'life cycle, and based on the product parameters in Annex I, the Commission shall establish ecodesign requirements to improve the following product aspects when relevant to the product group concerned

(a) durability;
(b) reliability;
(c) reusability;
(d) upgradability;
(e) repairability;
(f) the possibility of maintenance and refurbishment;
(g) the presence of substances of concern;
(h) energy use and energy efficiency;
(i) water use and water efficiency;
(j) resource use and resource efficiency;
(k) recycled content;
(l) the possibility of remanufacturing;
(m) recyclability;
(n) the possibility of the recovery of materials;
(o) environmental impacts, including carbon footprints and environmental footprints;
(p) expected generation of waste.

FIGURE 1: REQUIREMENTS TO BE INSERTED IN THE DPP

Moreover, the scope of the Corporate Sustainability Due Diligence Directive is specifically targeted at large EU companies (with more than 1,000 employees and a worldwide turnover of more than €450 million) and non-EU companies doing significant business in the EU (with a turnover of more than €450 million in the EU). This targeted approach underscores the directive's intention to leverage the influence of larger corporations to drive systemic change towards sustainability. However, it also raises questions about the inclusivity of such measures and the potential for smaller companies to navigate the complexities of compliance without significant resources.

The directive also introduces obligations for companies to undertake risk-based due diligence, adopt a climate transition plan, and report on their implementation and effectiveness. These requirements are designed to ensure that companies actively engage in identifying and mitigating adverse environmental and human rights impacts throughout their supply chains. However, the practical implications of these obligations, particularly for smaller companies, remain unclear, highlighting the need for further guidance and support to ensure widespread compliance.

In the realm of product passports, the market currently offers various solutions, each designed to address different problems. This diversity leads to inconsistencies in data and standards, complicating the understanding of benefits and the establishment of global standards for international product distribution. Current solutions are proprietary, adding to their cost, and their implementation requires high-capacity processes that

may not be affordable for smaller entities. Notably, only one solution met sustainability criteria using the Higgs index, as evaluated by Teresa Dianelly Flores Ramirez [6] in her thesis. Her work underscores the necessity for standardization of data models to render the DPP feasible.

IV. Fab City Initiative: A Bottom-Up Approach

A. Concept and Vision

The Fab City [7] initiative represents a global movement aimed at transforming urban environments into self-sufficient entities by 2054 that are locally productive and globally connected. This concept is called cosmo-localism and holds the promise of shifting towards a more sustainable future [8]. Originating from the global Fab Lab Network, Fab City seeks to address social and environmental challenges within cities by empowering citizens and shifting the urban paradigm towards sustainability. This involves a significant cultural shift, requiring collaboration among local government, civic organisations, startups, universities, and other entities.

1) Key Components of the Fab City Initiative [9]:

- **Fab City Network**: A federated network of cities committed to becoming Fab Cities, facilitating knowledge sharing and best practices.
- **Full Stack**: Represents the comprehensive framework that guides cities in implementing the Fab City challenge. It outlines the systemic change from centralized production and consumption to distributed production and self-sufficiency, emphasizing the importance of data in driving urban transformation.
- **Manifesto**: Defines the principles and values that underpin the Fab City Global Initiative. Commitment to these principles is essential for cities seeking to become part of the Fab City movement [10].

2) Principles and Implementation

At the heart of the Fab City concept is the transition from a linear economy to a circular one, where more production occurs within the city, along with recycling materials and meeting local needs The g local inventiveness. This shift is encapsulated in the transition from "Products In Trash Out" (PITO) to "Data In Data Out" (DIDO), indicating that a city's imports and exports would predominantly consist of data, including information, knowledge, design, and code.

B. Fashion Localism in a Fab City

Fashion holds universal appeal, making textiles indispensable in our lives. The prevailing model of mass production, however, creates a disconnection between consumers and the manufacturing processes. Clothing becomes a mere commodity, detached from its cultural significance and basic necessity status. When individuals engage in designing and crafting their own attire, they acquire profound insights into the materials, processes, and labour involved. This intimate relationship fosters a deeper appreciation for clothing, encouraging practices such as mending and adapting garments to suit evolving preferences or requirements. Such behaviours not only conserve resources but also instil a sense of ownership and pride in one's wardrobe, underscoring the emotional value of clothing [11]. Consequently, this approach contributes to enhanced sustainability.

Personal involvement in creating or altering clothing empowers individuals, granting them autonomy over their fashion decisions and diminishing reliance on mass-produced, single-use items. This empowerment resonates with broader sustainability objectives by advocating for a culture of reuse, repair, and reduction, diverging from the fast-fashion ethos of unceasing consumption and discarding. Future production strategies could markedly lessen dependence on cotton and fibres from the Global South by repurposing existing garments and employing locally sourced fibres for upcycling, repair, and redesign. Community-based mending not only carries social worth but also cultivates social solidarity through collective responsibility for garment care, potential style transformations, and sustainable wear [11].

C. Case Study: Textile Manufacturing in Hamburg

Hamburg's textile manufacturing sector stands at a crossroads, facing significant challenges and opportunities in its quest to evolve into a Fab City model. This section delves into the current landscape of textile manufacturing, shedding light on the digital capacity gap and the intricacies of upcycling.

1) Research Methodology

House of All collaborates with Helmut Schmidt University/University of the Federal Armed Forces on the Fab City project to evaluate the opportunities and challenges of transforming textile manufacturing in Hamburg into a Fab City model. House of All runs the living lab Open Lab Circular Textiles where aforementioned practices of care and local manufacturing are explored on an experimental scale. The study employed qualitative methods, including semi-structured interviews with 15 tailors from various ethnic backgrounds. Over six months beginning in December 2022, qualitative interviews were conducted with local craftsmen and designers to gauge current practices [7] and gather insights into their daily practices, challenges, and perceptions of sustainability and digital tools. Additionally, observations were made during visits to tailor workshops and designer ateliers to complement the interview data.

2) Current Practices and Capabilities

The interviews underscored the pressing need for digital capacity building and highlighted the absence of circularity in the daily routines of most tailors. The majority of tailors, focused on community-centric production, lacked familiarity with sustainability or circular design, prioritizing mending and on-demand garment production.

- **Digital Literacy and Sustainability Awareness**: Most tailors demonstrated limited knowledge of sustainability concepts and circular design, focusing instead on traditional garment repair. The concept of circular design seemed to be perceived as a luxury, reflecting broader issues of access to sustainable education and resources.
- **Analog Processes in Garment Production**: The production process remained largely analogue, with minimal use of digital tools beyond basic communication devices. This was attributed to a lack of training and the perception that digital tools are unnecessary for their work. Many designers still make the patterns by hand and prefer this way of working, stating that they have greater control over silhouettes.

3) Non-Scalable Upcycling: A Challenge Explained

Upcycling, a cornerstone of circular economies, faces scalability challenges. As highlighted by two of the interviewed designers, the process of upcycling is time-consuming and requires a tailored approach, making it less amenable to large-scale production and digitization [13]. The complexity arises from the need to handle cuttings individually, often necessitating one garment at a time, which contrasts sharply with the efficiencies of traditional production methods. Additionally, the variability in fabric remnants complicates the upcycling process, making it more akin to an artful, manual task rather than a scalable industrial operation.

V. Comparative Analysis of DPP and Fab City

The Digital Product Pass (DPP) is intended to complement the existing global system of brands and mass manufacturing, including the fast-fashion industry, through recycling mechanisms. However, there is a recognized need for a system that encourages local ecosystems to produce and manage their own values. Despite its potential advantages, the DPP infrastructure presents challenges for small and medium-sized enterprises due to financial constraints, especially in implementing these systems.

A. Ecodesign Regulation and Recycling

The Ecodesign Regulation focuses on the enduring durability of products, with recycling considered only as a final resort. However, starting from January 2025, the expectation is that the internalization of recycling costs will make recycling the preferred option, potentially accelerating mass production.

1) Critique of the Current Overproduction-Centric Model

The prevailing fashion system is criticized for generating excessive demand for disposable goods, prioritizing production over consumption reduction. The DPP's emphasis on recycling overlooks the initial 'R' of the 9R model — Refuse — and fails to challenge the production of new clothing. The efficacy of technological advancements remains uncertain, as demonstrated by Renewcell's bankruptcy despite significant investment, underscoring the limitations of technology alone in addressing sustainability challenges. Thus, according to De-Growth models, reducing consumption becomes essential. As Kate Fletcher argues, we have a limited timeframe to halve the impact of resource consumption by 75% [14].

2) Fab City Initiative and Local Production

In contrast to the EU's top-down approach, the Fab City initiative supports a bottom-up strategy that starts with "Rethink" to tackle sustainability issues. It advocates for local textile production using available materials, promoting proximity between production and usage. This approach suggests extended product lifecycles and potential for consumption reduction and enhanced resource efficiency through community-based practices like mending and Do It Together (DIT). Many local designers' unique selling point is the personalized touch of their products, offering bespoke options. Implementing a DPP in this context would require entering information on a case-by-case basis, posing challenges for transparency. Determining necessary, available, and helpful information becomes crucial. If production scales down to meet local needs, the complexity of system implementation versus labelling basic information, such as materials and recyclability, may be reconsidered. Technologies like Infrared Scanning could replace RFID tags, improving recycling efficiency.

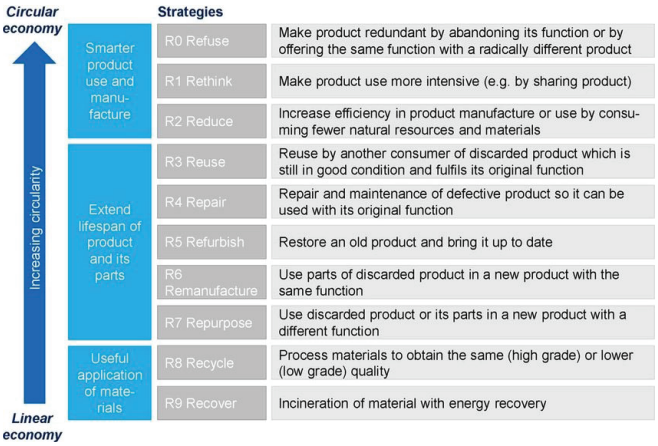

Figure 2: The 9 R Model [18]

The debate on fashion sustainability contrasts analogue and digital processes. While digitalization, exemplified by the DPP, aims to streamline operations and increase transparency, it also raises concerns about increased consumption and environmental impact. Analogue processes, such as sewing, mending, and personal clothing creation, are advocated for their potential to reduce consumption, conserve resources, and foster a deeper emotional connection with clothing. This approach aligns with the principles of the "craft of use," emphasizing engagement with clothing to extend its lifecycle and minimize waste [15].

VI. Challenges and Considerations

The Digital Product Pass (DPP) endeavours to optimize the fashion supply chain and augment transparency, albeit potentially exacerbating consumption and complexity. Furthermore, it perpetuates the existing global system reliant on unstable supply chains, which are underpinned by the exploitation of workers in the Global South and Far East. Enhancing working conditions in these contexts is a formidable challenge, given the current stability of these conditions.

Conversely, rendering the sustainability facets of a product's lifecycle discernible to consumers might sway their purchasing behaviour. The DPP equips consumers with information to select more sustainable alternatives, catalysing demand for environmentally friendly products and practices within the fashion industry.

In juxtaposition, the Fab City initiative advocates for local production, mitigating consumption through communal practices, thereby fostering resilient supply chains. The Fab City model, grounded in a bottom-up approach, seems more viable for sustainability by cultivating sustainable local ecosystems. The proliferation of Fab Cities is evident, with a recent addition of a Fab Region in Germany.

The concept of upcycling, involving the design and manufacture of clothing in small batches or singular pieces, primarily executed by independent labels, though challenging to scale, would likely dominate in a Fab City. Prioritizing waste prevention generates both economic and social benefits [16]. Engaging in the commons implies the existence of alternative economic models that eliminate brand rivalry and involve

individuals in the design and production of clothing through community-supported concepts [17]. The extent to which a digital product pass could be beneficial and implemented within these newly formed commons-based infrastructures, inherently sustainable [8], remains to be determined.

Future endeavours should bolster research and community-driven initiatives aimed at constructing a digital ecosystem compatible with the specific demands of textile-centric cosmo-local production. Implementing a Digital Product Pass in harmony with Fab City principles offers numerous prospects but also presents hurdles. These include the necessity for uniform data models to ascertain the viability of the DPP, the imperative for digital capability enhancement among designers, manufacturers, and consumers, and the need for supportive policies to surmount financial and logistical obstacles to local production. Crucially, it demands a user-friendly solution that is dynamic, openly accessible, and provides an index of materials available in the Fab City, ensuring compatibility with extant systems. Moreover, transitioning to a more sustainable and localized fashion industry necessitates a fundamental systemic overhaul, accompanied by substantial incentives for local craftspeople, whose numbers have dwindled in recent years.

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