



# Digital Product Passports for a Sustainable Furniture Industry: An Exploratory Qualitative Study

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**Abstract.** The furniture industry is increasingly compelled to adopt sustainable practices and transition towards a circular economy due to complex supply chains and significant waste generation. The Digital Product Passport (DPP) is presented as a critical tool at the nexus of sustainability and digital transformation, designed to provide accessible and trustworthy information about a product's lifecycle. This exploratory qualitative study aims to understand how DPPs can be successfully integrated into the furniture industry's digital transformation journey to enhance sustainability and lifecycle management. Thematic analysis of the gathered data revealed five key themes: the necessity of a digital strategy, the impact of regulatory compliance, the role in supporting the circular economy, challenges related to technical infrastructure, and the foundational importance of traceability. Findings indicate that successful DPP implementation is strongly linked to having a robust digital strategy and appropriate technological infrastructure, driven significantly by growing regulatory requirements, while actively facilitating circular economy principles.

**Keywords:** Digital Product Passport · traceability · furniture · sustainability

## 1 Introduction

The contemporary global landscape is increasingly defined by the imperative for sustainable practices and a transition towards a circular economy, necessitating industries to reevaluate their operational paradigms and product lifecycles [1]. The furniture sector, which is marked by complex supply chains, resource-intensive manufacturing, and substantial waste generation, is under increasing pressure to embrace more sustainable models in this paradigm shift [2]. Digital transformation, also encompassing the integration of digital technologies across all aspects of a business, offers a powerful avenue to address these challenges and unlock new opportunities for enhanced sustainability and lifecycle management.

The Digital Product Passport (DPP) is a significant new idea at the nexus of sustainability and digital transformation. As a digital version of a physical product, the DPP seeks to make information about a product's composition, place of origin, manufacturing process, repairability, recyclability, and overall environmental impact easily

accessible and trustworthy [3]. DPPs have the potential to completely transform how stakeholders, such as manufacturers, consumers, recyclers, and regulators, engage with and manage products over the course of their whole lifecycle by giving each one a comprehensive digital identity [4]. The implementation of DPPs is expected to improve resource circularity, reduce emissions, and strengthen supply chain governance [5].

Developments in emerging technologies are making it easier to implement DPPs. Immutability, transparency, and decentralized data management are all features of blockchain technology that make it a suitable platform for safely storing and exchanging DPP data across intricate value chains [6, 7]. In a similar way, the Internet of Things (IoT) can help automate the collection of real time data about the condition and usage of products, providing the DPP with useful information. This abundance of data can then be processed by artificial intelligence (AI) and data analytics to improve lifecycle management procedures, forecast maintenance requirements, and ease the recovery of end-of-life materials [8].

Even though the potential of DPPs is becoming more widely acknowledged, there are still unanswered questions, especially in the context of the furniture industry. While the theoretical advantages are frequently discussed, empirical research on the real-world applications of integrating DPPs into current digital transformation strategies is limited. Moreover, research examining their observable effects on sustainability and lifecycle management are still in their infancy.

By examining how DPPs can be successfully incorporated into the larger framework of digital transformation in the furniture industry, with an emphasis on improving sustainability and lifecycle management, this study aims to close this gap. Hence, this study intends to offer an understanding of the preparedness and adoption rate of DPP by furniture companies. By relying on the digitalization maturity framework, we envisage the challenges and implications that furniture companies face during the journey of DPP implementation. Moreover, this study seeks to bridge the identified research gap by mapping DPP functionalities onto organizational digital transformation pathways, ultimately fostering a more sustainable and resilient furniture industry.

## 2 Background

### 2.1 DPPs: Traceability and Sustainability Enablers

The furniture industry's drive for sustainability has led to a greater emphasis on lifecycle thinking, the circular economy, and the DPP, which allows for product information traceability and transparency. A foundational stream of research emphasizes the integration of sustainable design principles in furniture manufacturing, aiming to mitigate negative environmental impacts and extend product lifespans.

The DPP is increasingly seen as a backbone for circularity and sustainability ambitions, particularly within the context of the EU Green Deal. Authors in [9] highlight the DPP's role in aggregating lifecycle information, facilitating regulatory compliance, and driving informed consumer choices. They further assert that leveraging blockchain can reinforce the transparency, verifiability, and regulatory trustworthiness of such digital artefacts. Authors offer empirical insights from the electronics sector, identifying not only diverse drivers for DPP adoption including improved decisionmaking, transparency,

and customer engagement but also key barriers such as data standardization, interoperability, data intensity, and implementation complexity. These findings translate to the furniture sector, given shared supply chain characteristics and circularity ambitions, and describe a comprehensive research agenda for operationalizing DPPs [10].

Further advancement of the DPP discourse by integrating absolute environmental and social sustainability perspectives is emphasized in [11]. This work argues for the inclusion of social life cycle assessment indicators and environmental metrics based on the Planetary Boundaries framework, thereby promoting a more holistic and rigorous approach to DPP content and utility. Their proposed cyber-physical system framework signals the transformative potential of Industry 4.0 and Industry 5.0 technologies in dynamically updating and extending DPPs across product lifecycles. Moreover, operationalization of DPPs using decentralized identifiers and multi-blockchain infrastructure - specifically Hyperledger Fabric - to manage product data securely, ensuring scalability, efficiency, and interoperability for European circular economy initiatives is investigated in [12].

Methods such as lifecycle assessment (LCA) and user-centered design frameworks have been prioritized to ensure that furniture products remain aligned with both ecological imperatives and evolving user demands [13]. Similarly, the multifaceted benefits of embedding human-centered design approaches in collaborative university industry projects, revealing the importance of stakeholder engagement and end user feedback in the development of deployable, sustainable furniture solutions are explored by [14]. Complementing these perspectives, authors in [15] in their bibliometric analysis underline the emergence of themes such as LCA, carbon emissions reduction, supply chain integration, and digital innovation (including artificial intelligence and system-level design) as the next frontiers for sustainable furniture research.

A shift toward circularity in the furniture industry is increasingly enabled by the digitalization of product and service systems. An effort to conceptualize the integration of blockchain technology with product-service systems (PSSs) to create a blockchain enhanced information model for sustainable furniture, emphasizing the capacity of such frameworks to securely store and transmit lifecycle data, protect stakeholder interests, and quantify design contributions is given by [16]. Authors in [17] reinforce the argument for circular design strategies, highlighting the predominance of innovative materials, resource efficiency, and the development of service systems to extend product functionality and longevity. However, they also note a shortfall in the adoption of circular business models and the necessity for more systemic stakeholder engagement.

## 2.2 Understanding Digital Maturity in Furniture Sector

Despite the DPPs capabilities to offer transformative potential, their implementation exposes gaps in digital maturity, particularly for small and medium-sized enterprises (SMEs). Many lack the infrastructure to manage data across fragmented supply chains or meet evolving regulatory demands [18]. Existing digital maturity models often focus narrowly on IT adoption, neglecting lifecycle-specific competencies like data transparency and ownership or stakeholder collaboration [19]. For example, SMEs may struggle to integrate DPPs with legacy systems, hindering compliance with standards such as the EU's DPP requirements for furniture [3]. Furthermore, more research is needed to fully

comprehend the key components of DPPs, including the ideal degree of data transparency, systems for guaranteeing regulatory compliance in a variety of markets, and efficient techniques for lifecycle tracking in the furniture industry.

Mapping these essential DPP features to established digital maturity models can provide a structured approach for understanding the organizational competencies and technological capabilities required for successful implementation. For instance, basic data transparency might align with initial stages of digitalization, whereas sophisticated lifecycle tracking leveraging IoT and AI could correspond to higher levels of digital maturity characterized by integrated systems and data-driven decision-making [20, 21]. Even though digital information management for sustainable furniture has advanced significantly, there are still a number of unresolved issues, according to recent research [22, 23]. These include the creation and standardization of DPP frameworks tailored to the furniture industry, the incorporation of social sustainability metrics and stakeholder viewpoints. Additionally, there is a need for strong data security and interoperability solutions, and the development of systemic approaches that connect supply chain transparency, business modelling, and design. The synthesis of these interdisciplinary insights' points toward the necessity of exploratory qualitative studies, such as the present research, to shed light on stakeholder expectations, operational challenges, and best practices. These are crucial for the effective integration of DPPs in sustainable furniture ecosystems.

This research work, informed by the theoretical underpinnings related to digitalization maturity model, as established in [24] and endorsed by [25], aims to fulfill the following objectives:

- 1) Evaluating the main challenges in designing digital strategies for DPP implementation in furniture SMEs.
- 2) Analyzing the employees' skills and culture towards adoption of DPPs.
- 3) Organization flexibility, i.e., exploring how organizations adapt to new digital requirements like DPPs.
- 4) Investigating technological infrastructure and upgrades necessary to implement the DPP system in existing infrastructure.
- 5) Exploring the challenges encountered in data integration for DPPs across furniture company processes.
- 6) Analyzing how DPPs will impact customer relationships and experiences.
- 7) Understanding external environment to collaborate with furniture companies to understand the specific DPP requirements.
- 8) Analyzing the expectations for DPPs to contribute to organizations' overall business performance.

### 3 Methodology

This research investigates the adoption of DPP by furniture companies, using the theoretical frameworks of digitalization maturity. The study employs an exploratory single case study methodology [26]. With such an approach, the aim is also to better understand the phenomenological foundations of a digital representation of a product within the framework of digitalization of value chains.

### 3.1 Data Collection

A semi-structured interview guide was created for primary data collection, informed by the theoretical underpinnings related to digitalization maturity model, as established in [24]. The interview guideline<sup>1</sup> was based on semi-structured and open-ended questions and was sent to the respondents via email in advance. Participants for this study were recruited using convenience sampling [27], drawing from a pool of collaborators involved in ongoing innovation projects across Europe.

This research followed ethical guidelines in accordance with the norms outlined by Swedish Research Council [28]. The respondents were informed about the methodology for conducting and recording the interviews, along with the duration for which the authors plan to retain the recorded files. The informed consent emphasized that the findings of this research would be used only for scientific reasons. Interviews were conducted online from January 13, 2025, until February 25, 2025. Each interview had an average duration of 30 min. Table 1 gives the details about respondents in the study.

**Table 1.** Interview respondents in the study.

Participants	Organization	Job description	Date of interview
P1	IT company (Sweden)	Product developer	13.01.2025
P2	Furniture company (Sweden)	Sustainability manager	15.01.2025
P3	IT company (Sweden)	CEO	16.01.2025
P4	Furniture company (Spain)	Internationalization manager	29.01.2025
P5	Government agency (Sweden)	Eco-design expert	10.02.2025
P6	Furniture cluster (Italy)	Cluster manager	11.02.2025
P7	Furniture company (Sweden)	Quality and sustainability manager	21.02.2025
P8	Furniture company (Sweden)	Product and sustainability manager	25.02.2025

### 3.2 Data Analysis

The data collected from the interviews was recorded and transcribed verbatim. The data analysis of this study adheres to the thematic analysis approach, as outlined in [29]. Initially, the most relevant information is extracted from the gathered interview data.

Open coding was used for the analysis of interview material, facilitating the identification of various themes that arose in participants' discourse on their experiences with the implementation of DPPs in the furniture sector. The researchers analyzed the collected data and categorized it to identify themes for analysis. Subsequently, each theme was summarized by quoting one or more participants to illustrate the collective view-point of the participants. Throughout the process, we used the MaxQDA software.

<sup>1</sup> The interview questions can be accessed here: <https://tinyurl.com/DPPs-furniture>.

## 4 Empirical Findings

The thematic analysis approach resulted in the identification of five themes: *need for digital strategy*, *regulatory compliance*, *circular economy support*, *technical infrastructure*, and *traceability*. Each theme is examined comprehensively in the following subsections. Figure 1 presents excerpts from the data, illustrating how codes were identified and combined to form the five themes.

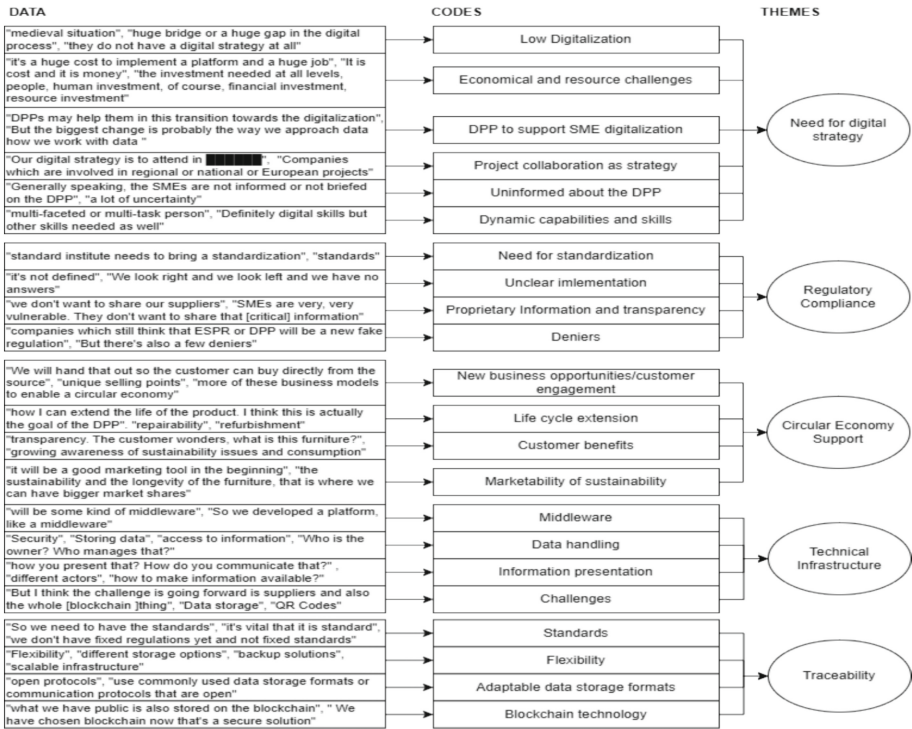


Fig. 1. Thematic map of main themes

### 4.1 Theme 1: Need for Digital Strategy

Understanding that a thorough digital strategy is necessary for the successful integration of digital product passports was a recurrent theme among participants. Respondents underlined that without a clear roadmap and organizational alignment, efforts to implement digital solutions risk becoming fragmented or ineffective. According to interview participants, a clear digital strategy guarantees that digital product passports are integrated into larger business objectives in addition to directing technology adoption.

*“And in many cases, unfortunately, they [SMEs] do not have a digital strategy at all in terms of product code, codification, ERP management systems. So, what the DPP is going to entail to these companies is that they’re going to have to start talking about*

*ERPs, product codification, and so on and so forth. So, the DPP may come to help them in this transition towards the digitalization and efficiency of the company” – P4.*

This strategic approach is echoed in industry reports, which highlight that companies adopting DPPs must rethink their digital infrastructure and data management practices to maximize value and achieve a competitive edge [30]. The persistence of the term “digital strategy” suggests that many firms in the furniture sector may still perceive digitalization as an “add-on” or a specialized track, rather than a core enabler of business transformation. At the same time, the call for a digital strategy can be interpreted positively, as an early sign of strategic awareness and an acknowledgment that digitalization requires deliberate planning, resources, and leadership commitment.

## 4.2 Theme 2: Regulatory Compliance

Participants regularly underlined the increasing relevance of regulatory compliance as a motivating factor for the use of digital product passports. Many furniture industry experts claimed that changing rules, especially those concerning sustainability and product traceability, are pushing companies to look for digital solutions. These solutions enable reporting and compliance. The changing regulatory environment is viewed by many in the furniture industry as both an opportunity for transformation and an obstacle.

*“Even if they’re [companies] quite ignorant about the topic [DPPs] that’s the first question, how are we then protected if we have to go further with all these regulations which are very demanding for us? There will be benefits from them, [...] but money is a burden, it’s a lot of resources and time spent [...]. How do we protect what we are against Chinese or any other country’s products” -P6.*

*“So, any requirements for SMEs to incorporate ways to manage, to control, to audit, to analyze is welcome because at the end of the day, they’re going to have to look at their balance sheet or the income statement from a different viewpoint. So yes, it is a way to have efficiency” – P4.*

The urgency to adapt to these requirements is reinforced by recent Swedish projects and industry-academia collaborations (APPEND<sup>2</sup>, STELLA<sup>3</sup>), which underscore the importance of standardized information and robust data governance to meet regulatory expectations.

## 4.3 Theme 3: Circular Economy

One of the main reasons for incorporating digital product passports was to support the circular economy. The participants explained how these digital tools can promote recycling and reuse, improve transparency, and allow material tracking across the product lifecycle. Digital product passports, according to several participants, are seen as facilitating circular business models and assisting organizations in showcasing their sustainability commitments to stakeholders and consumers.

<sup>2</sup> <https://www.vinnova.se/en/p/append---digital-product-passport-to-revolutionize-the-furniture-industry/>.

<sup>3</sup> <https://www.vinnova.se/en/p/stella---digital-transformation-of-swedish-furniture-industry-through-advanced-digital-value-chains/>.

*“So, I mean, there are benefits, [...], one of the main ideas behind the DPP is for the waste management or [...] for reuse, remanufacturing. And I think, [...] that hopefully in order to kind of make it easier to find new business models that function and that, you know, build up this ecosystem for the circular economy, that there the DPP is an interesting tool” – P5.*

These commitments are seen as a decisive step toward more sustainable business models.

*“I think one structure that we really need, like a marketing thing also in DPP is the whole refurbishment, spare parts, how we can extend the life of the products. This step is something we need to develop more here. And you want something like marketed more. And I think there’s a lot of profit in this as well” - P2.*

This quote emphasizes the need for closer collaboration with customers and user involvement when developing potential solutions.

#### **4.4 Theme 4: Technical Infrastructure**

The discussions on implementation difficulties revealed a clear emphasis on the theme of technology infrastructure. To enable digital product passports, both information technology experts and furniture industry professionals underlined the necessity of strong IT systems, interoperability standards, and data management skills. Participants underlined the need of investing in scalable and flexible infrastructure by pointing out that legacy systems and fragmented data might impede progress.

*“Ways to get that is to have a scalable infrastructure, so our infrastructure is built on, not microservices, I would say, but we try to create loosely connected components that can individually scale” – P1.*

Participants pointed to the need for seamless integration with existing ERP (Enterprise Resource Planning) systems, reliable data management platforms, and the adoption of technologies like blockchain and QR codes to ensure data integrity and accessibility. Recent case studies, such as the APPEND project, demonstrate how tailored content management systems and ERP integrations are being piloted to streamline DPP creation and management.

*“We have some data in our ERP, [...], where we have article numbers, not so much like intricate data. So, we figured, okay, we need to make something. We need to create something here that can “talk”, get this data from our ERP system. So, we developed a platform, like a middleware, so to speak [...]. But this, I feel like this platform is key because our ERP is not developed in this way so that it could support a DPP.” - P2.*

#### **4.5 Theme 5: Traceability**

Traceability emerges as a paramount theme in integrating DPPs within the furniture sector’s digital transformation, serving as the foundational capability for achieving robust sustainability and effective lifecycle management. For the furniture industry, this means having transparent and verifiable information about the origin of timber, the composition of fabrics, the glues used, and the geographical locations and environmental impacts of production processes. Such comprehensive visibility, facilitated by DPPs, empowers

stakeholders to make informed decisions. Consumers can choose ethically produced items, manufacturers can identify and mitigate supply chain risks, and recyclers can efficiently recover valuable materials.

The successful implementation of traceability relies on the synergistic operation of several key factors identified in our coding. The establishment of *standards* is crucial for ensuring that data from various suppliers, manufacturers and lifecycle actors can be seamlessly integrated and understood across disparate systems.

*“It’s vital that it is standard [...], we don’t want potential customers in the future to be stuck in a solution, and that’s why from our perspective and from our customers, independent of industry, need to have standards because there will be thousands of products handling DPP” – P3.*

Furthermore, *flexibility* in digital systems and an emphasis on *adaptable data storage* formats are essential to accommodate the diverse range of materials, production methods and the evolving regulatory requirements unique to this industry.

*“We try to use commonly used data storage formats or communication protocols that are open and standard. In that way we can adapt to whatever the next standard needs.” – P1.*

Finally, *blockchain* technology, as a robust and immutable ledger, provides the secure and transparent backbone for recording and verifying all traceability data, preventing fraud and building trust among all participants in the furniture value chain.

*“Our approach here is that we will leverage blockchain technology to store data that will be immutable and accessible long past the creation of the product, for the lifetime of the product” – P1.*

## 5 Discussion

The findings indicate that a comprehensive digital strategy is a foundational enabler for the successful adoption of DPPs. Without a well-articulated roadmap, organizations risk fragmented implementation and outcomes. The emphasis on regulatory compliance confirms the growing importance of external pressures in driving digital innovation. Circular economy goals, often cited as motivators, are shown to rely heavily on the technological readiness of SMEs. The themes of infrastructure and traceability highlight the critical role of robust digital ecosystems that can support data integrity, interoperability, and transparency.

The development of such digital ecosystems should be implemented by applying usercentered design principles to ensure customer inclusion [31]. Several quotes from interviews included references to customers and the need for closer collaboration with them. Such collaboration and user involvement will ensure user satisfaction and more importantly encourage acceptance of the proposed solutions. Involving users ensures greater sustainability by enhancing customer engagement, ongoing support and utilization.

Through the lens of the digitalization maturity model discussed by [32], our findings suggest that many firms are still in the early to mid-stages of digital maturity. The need for strategic planning, digital infrastructure, and organizational alignment reflects the “developing” phase of maturity, where firms recognize the importance of digitalization

but face implementation challenges. The work of [18] on the transition from analogue to digital passports in furniture, provides direct validation of the challenges noted by our respondents, particularly concerning legacy systems and the need for flexible digital infrastructures.

The strong emphasis on regulatory compliance, particularly concerning sustainability and product traceability, is prompting furniture companies to seek digital solutions that facilitate reporting and compliance. This suggests that while sustainability is a key objective, regulatory pressure acts as a significant catalyst for change and innovation within the industry. This finding resonates with the broader push from the EU commission for sustainable products, where the DPP is envisioned as a central tool for achieving compliance with future eco-design requirements [3].

The undeniable link between DPPs and the circular economy highlights their transformative potential. Respondents articulated how DPPs can directly enable recycling and reuse, enhance transparency, and facilitate material tracking across the entire product life-cycle [13, 14]. This extends beyond mere compliance, positioning DPPs as active tools for implementing circular business models and showcasing sustainability commitments to consumers and stakeholders.

The indispensable role of technology infrastructure is also well-supported in the literature of digital transformation of SMEs. The challenges of legacy systems and data fragmentation, noted by our respondents, are common barriers to digitalization across industries. Solutions involving blockchain for data integrity, as discussed by [9] for supply chain transparency, and multi-blockchain approaches for decentralized identifiers by [12], directly correlate with our respondents' emphasis on robust and interoperable systems.

Finally, the overarching theme of traceability is crucial to the very concept of a DPP and is extensively covered in the academic discourse. Authors in [5] conduct a structured review of DPP use cases, identifying traceability as a core function for sustainable supply chain management. Our findings, however, go beyond simply acknowledging traceability by empirically demonstrating its perceived relevance among industry experts within the furniture context.

## 5.1 Theoretical and Practical Implications

From a theoretical standpoint, this study contributes to the discourse on digitalization maturity in SMEs, particularly within traditional manufacturing sectors such as furniture. Firstly, the need for a cohesive digital strategy and robust technology infrastructure indicates that companies must be beyond initial stages of digitalization and possess capabilities in data management, system integration, and strategic planning. This implies that existing digitalization maturity models highlighted by [32] could explicitly incorporate "DPP readiness" as a benchmark for higher maturity levels, linking it to organizational capabilities in data governance, interoperability, and strategic foresight. Secondly, the research contributes to the growing theoretical understanding of digital ecosystems in circular economy transitions. By highlighting how DPPs enable traceability, regulatory compliance, and circular business models, the study emphasizes their role as a connective tissue within a broader digital ecosystem that supports circularity. This calls

for theoretical models that emphasize the networked nature of digital sustainability initiatives.

The findings of this exploratory study also offer several practical implications for furniture manufacturers, technology providers, and policymakers. Furniture manufacturers should not view DPPs as isolated IT projects, but as integral components of their overall digital transformation journey. This requires investment in strategic planning, fostering a culture of data-driven decision-making, and technology infrastructure upgrades. They should also proactively prepare for evolving regulatory compliance by implementing systems that can capture and report necessary data effectively. In light of our findings regarding highly flexible solutions that support adaptable data formats, technology providers must offer seamless integration with existing ERP and content management systems. Finally, the findings reinforce the effectiveness of regulatory mandates as a driver for sustainable practices. Policymakers should continue to develop clear and harmonized regulations for DPPs, providing incentives for early adoption and supporting the development of industry-wide standards. Industry associations can also play a crucial role in facilitating knowledge sharing, developing best practices, and promoting collaboration among members to collectively address infrastructure challenges and advance traceability within the sector.

## 5.2 Limitations and Future Research

This study is subject to several limitations. The qualitative nature and small sample size (eight interviews) limits generalizability and focusing on Swedish, Italian and Spanish professionals only, may not reflect experiences in other regions. The reliance on self-reported data also introduces potential bias, as participants may emphasize successes over challenges. Additionally, while thematic analysis provides depth, it may not capture all nuances, particularly in highly technical areas such as data standards and blockchain implementations.

Future research could benefit from triangulating qualitative insights with quantitative data. Future studies could also explore longitudinal case studies of DPP implementation to track evolution over time. Comparative research across different industries (e.g., textiles, electronics) would help determine whether challenges and enablers are sector-specific or generalizable. There is also a need for deeper exploration of the role of standards and how different stakeholders can co-develop interoperable solutions. Moreover, research could investigate consumer perceptions and responses to DPPs, particularly in terms of trust, sustainability claims, and buying behavior.

## 6 Conclusion

This exploratory qualitative study emphasizes the multifaceted nature of integrating digital product passports for enhanced sustainability and lifecycle management within the furniture industry's ongoing digital transformation. Our findings highlight that successful DPP implementation is intrinsically linked to a robust digital strategy, driven by the increasing demands of regulatory compliance. Furthermore, the research empirically confirms the critical role of DPPs in facilitating circular economy principles and highlights the indispensable need for a well prepared technological infrastructure.

Ultimately, traceability emerges as the foundational capability underpinning the entire DPP ecosystem, enabled by standards, flexibility, adaptable data formats, and blockchain technology. Acknowledging the limitations of an exploratory approach, this study provides valuable insights for industry practitioners, technology developers, and policymakers, offering a strategic roadmap for leveraging DPPs to build a more sustainable and transparent furniture value chain.

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