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DIGITAL PRODUCT PASSPORTS IN CONSTRUCTION – BARRIERS AND OPPORTUNITIES AT PEOPLE, PROCESS AND TECHNOLOGY DIMENSIONS

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Abstract

Digital Product Passports (DPP) will be inevitable as they pursue objectives aligned with the Sustainable Development Goals (SDGs). DPP is grounded in digital data, enabling integration and traceability throughout life cycles and value chains. DPP can play a central role in accomplishing twin transitions in construction. A People, Process and Technology (PPT) dimensions study aimed to fill the knowledge gap between strategies and sector visions—the mixed methods integrated approach collected data focusing on barriers and opportunities at each dimension. Focus groups analysed and clustered the results. Despite relevant barriers, construction stakeholders see opportunities and recognise the need, demonstrating eagerness towards adoption.

Introduction

Digital Product Passport (DPP) means a set of data specific to a product that includes, at minimum, relevant information for performance, environment and waste dimensions and is accessible via electronic means through a data carrier defined under the EU Ecodesign Regulation (European Parliament and European Union Council, 2022). EU legislation on the Green Deal and Data Act will make DPP a reality for different areas of activity in Europe and worldwide (Commission, 2022).

The construction sector is often labelled as highly resistant to change (Lines *et al.*, 2015). However, when awareness and a concerted change effort are made, the sector can behave and perform as one of the best. Stakeholders' realisation and perception of barriers and opportunities are crucial to anticipate implementation problems, better tune the support actions, and provide valuable and aligned contributions, fostering smooth transitions. This work stems from these assumptions, collecting impressions to forecast and support streamlined DPP implementation in the construction sector.

Despite some uncertainties on how the passports will be mandated, the objectives they aim to achieve are known, especially those concerning environmental targets and Sustainable Development Goals (SDGs) (United Nations, no date). According to (Munaro and Tavares, 2021), product passports are generally seen as a mechanism to influence consumer behaviour concerning sustainable purchasing and responsible product ownership. However, to accomplish this objective, many other aspects must be handled, enabling a broad range of services, businesses and possibilities and establishing a relevant ecosystem that should be anticipated (King, *et al.*, 2023).

Although recent, the DPP results from continuous work that has been ongoing for decades. The stakeholders' capacity for new requirements, more digital methods, and abilities related to products have been tested with EU-scale developments in areas such as energy efficiency and chemicals. However, there is the intuition that product passports might raise some fear across sectors due to the introduction of significant changes in how trade is processed and how product information is managed among all involved in the different value chains.

Several researchers have devoted their efforts to detailing and anticipating implementation challenges surrounding DPPs or associated concepts (Byers and De Wolf, 2023; Ducuing and Reich, 2023; King, *et al.*, 2023; van Capelleveen *et al.*, 2023). However, none have approached the topic from a People, Processes and Technology (PPT) dimension and grounded in visions from industry stakeholders. The motivation for this work is based on previous studies where the same research design was used to generate an improved understanding of the positioning of specific stakeholders regarding the use of construction technologies.

The research topic is the DPP for Construction Products. A survey is used as the ground for a mixed methods approach collecting quantitative and qualitative data from respondents in PPT dimensions. As part of the qualitative approach, specific questions for each dimension focus on identifying barriers and opportunities. A focus group involving the authors and experts analysed and clustered the answers and thoughts shared via open questions. The results aim to answer the following Research Questions:

- From the different PPT dimensions, how mature is the construction sector for DPPs?
- What ideas do stakeholders have regarding the opportunities and barriers raised by DPPs, considering the same dimensions?

This research comprises this Introduction followed by the research design and methods presentation. A brief overview is drawn on the origin and motivations for product passports, ranging from several sector perspectives to the specific features of the subject under investigation: Construction DPP. The survey structure and an overview of the quantitative data are presented. To end, the analysis of the qualitative results and overall discussion point to the conclusions section, where answers to the research questions are provided and summarised, endorsing the contributions, limitations, and paths for future works.

Research Design and Methods

The design for this research is inspired by previous studies (Mêda *et al.*, 2020). The reason for using PPT dimensions is associated with the imperatives for Integrated Design and Delivery Solutions (IDDS), where the use of collaborative work processes and enhanced skills, with integrated data, information, and knowledge management, aim to minimise structural and process inefficiencies and to enhance the value delivered during design, build, and operation, and across projects (Owen, 2013). As it will be detailed, this definition aligns with what Digital Product Passports aim to achieve. Complementary to this is the intuition that DPPs' accomplishment contributes to IDDS goals.

The integrated-use approach for mixed methods, according to (Cresswell and Poth, 2018), was chosen to perform simultaneously the qualitative and quantitative data collection using a survey.

After receiving the answers (the sample), the authors gathered a focus group formed by the authors and four experts to discuss the results, assess maturities, and analyse the most relevant barriers and opportunities identified from the PPT dimensions. Figure 1 illustrates the research design detailed above.

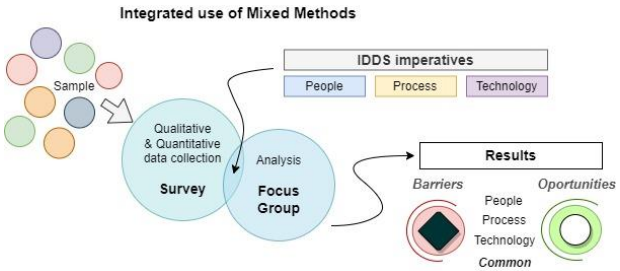

Figure 1: Research Design and method adopted in the study

Why Passport for Products?

When addressing a passport, most people understand it as a travel document issued by a determined country containing relevant information about the person who owns it. That information is secured and curated through time by authorities and individuals. This experience is based on a global standard that facilitates the understanding of passport information by all countries (Torpey, 2018).

Free trade and a single market of products and services constitute the EU's foundational principles. Over the last decades, rules and standards were developed to break down barriers to open trade across member states. Focusing on the free trade of goods, one of the key elements was the definition of a common framework of principles and procedures for marketing products (Official Journal of the European Communities, 2008). This set of rules was summarised on the CE conformity marking or "CE mark", indicating that a product meets the applicable requirements and has undergone the relevant conformity assessment procedures. This label has been working as a sort of passport "facilitating the understanding" between manufacturers, distributors, importers, and other relevant stakeholders across the EU and worldwide.

Performance characteristics were prioritised above all others. This was essential for confidence across markets and not to overcomplicate, ensuring feasibility and widespread implementation. Despite some shortcomings, in the construction sector, the process can be recognised as a successful (Ecorys, 2018), creating the needed background and opening paths to new interests and requirements.

Sustainability and environmental concerns command most 21st-century agendas (United Nations, no date). The product's characterisation imperatives regarding chemicals and energy consumption led the EU to increase the requirements and develop tools to disclose energy efficiency labels and track and disclose chemicals and substances of high concern (Agency, no date; Energy, no date). In this respect, and to improve the legal framework, the EU proposed a new Ecodesign regulation (European Parliament and European Union Council, 2022). The objective is to repeal rules currently in force, mainly concentrated on energy-related products, broadening the scope to a broader variety of products and making them more durable, reusable, reparable, upgradable, recyclable and less harmful to the environment (European Parliament and European Union Council, 2022). The proposal establishes performance and information requirements, supported by a digital instrument to streamline and facilitate data access, management, exchange, and traceability throughout the product lifecycle: the DPP. The proposal sets the link to specific product delegate acts to determine which information should be included and the accessibility rules to different stakeholders (European Parliament and European Union Council, 2022). For the case of most products used in construction, the Delegate Act will be the new version of the Construction Products Regulation (CPR) (Commission, 2022).

One of the most challenging aspects of this process is balancing the requirements with a successful and widespread implementation. In this respect and following the work developed by (King, *et al.*, 2023), it becomes clear for the European Commission that DPP objectives must be made more explicit, the administration costs for businesses must be anticipated, supported or limited, and requirements must be generated on a product-by-product basis, being determined in the construction products case, by harmonised standards.

DPPs must be perceived as an industry symbiosis enabler, given the amount of data that can be collected and managed and the viewpoints and stakeholders that can engage. (King, *et al.*, 2023) envisages an ecosystem for DPPs detailing the abovementioned aspects without focusing on a specific sector or delegated act. Among the many challenges identified is the awareness that such an ecosystem will operate within constraints (such as commercial interests, data quality and data ownership, a

variety of sustainability metrics, privacy concerns, legacy systems, cost, skills, and current capacity) to achieve the sustainability values and goals of societal stakeholders (King, *et al.*, 2023).

In what respects the construction sector, DPPs should be additionally envisaged as Digital Twin (DTw) enablers at building scale (Mêda *et al.*, 2021), being a relevant part of the information structures being prepared to characterise built entities (Mêda *et al.*, 2022). Other initiatives originating from data-driven and waste perspectives, such as data templates, ISO standards, and material Passport initiatives, increase the complexity of this already delicate ecosystem (Honic, *et al.*, 2024). Formalising the discerning concept of passports is crucial, supporting decision makers' understanding and stakeholders' awareness of the full potential and realising the benefits together with the surrounding challenges (van Capelleveen *et al.*, 2023).

The first passport was designed to introduce changes in people's identification for the purpose of travelling across borders. By doing that, many services and business opportunities opened, most of which were not realised initially. DPPs are envisaged to pursue similar intentions and, most importantly, to enable a transformation in the product value chain supported by digital tools. The challenges for this endeavour in the construction industry are as broad as the opportunities, therefore justifying a multidimensional approach such as PPT (Derenzi *et al.*, 2009).

Development

Structuring the Survey

The survey was structured to suit a wide range of respondents. The initial objective was to share it via LinkedIn social media. Due to the number of lectures given to postgraduate students in different universities on DPPs' origin, main characteristics, and objectives according to the regulations, it was included as part of the teaching material. Google Forms was used as the support tool. An account subscribed to by the University of Porto was used to fulfil data protection requirements. Fifteen answers were obtained from the lectures that engaged a universe of sixty professionals. In this respect, respondents represent several areas of the construction value chain, from the primary sector (raw materials) to real estate and facility management, including architecture and engineering practice, manufacturing, wholesale, and owners. The answers range from six different European countries, and, in terms of professional practices, one-third has between 5 and 10 years, 26,7 and 20% has between 10 and 15, and 15 and 20 years, respectively. Lastly, 13,3% answered more than 20 years of practice. The survey is organised into five sections, promoting a brief explanation and capturing different types of respondents regarding DPP knowledge.

The Introduction and the Data management, positioned at the beginning and end, frame the study objectives, and collect relevant information regarding the respondents' professional experience, background, and geographic location. The three middle sections focus, as previously framed, on the PPT dimensions, setting a series of open questions with short answers and multiple-choice questions, where personal evaluations are to be provided considering four maturity levels, "Emerging", "Basic", "Advanced" and "Expert", with variations on the definitions depending on the dimension being questioned.

Table 1 presents the Process dimension questions as an example, as the changes are minor for the People and Technology dimensions.

Table 1: "Process" dimension questions used in the survey and presented as example

Question	Type of answer
How do you envisage the PROCESSES involving DPPs? (provide an answer based on a meaningful example from your perspective: awareness on how DPPs are to be structured and how they should be used as data providers for different outcomes throughout the construction life cycle; providing U-value of products for energy performance certificate issuance, among others)	open question with short answer
Can you provide an example of a process or outcome/deliverable that could benefit from the data set in a DPP?	open question with short answer
In your opinion, what might be the biggest CHALLENGES/BARRIERS at the PROCESS level regarding the implementation of DPPs?	open question with short answer
What might be, in your opinion, the biggest OPPORTUNITIES at the PROCESS level regarding the implementation of DPPs?	open question with short answer
How do you assess the existing PROCESSES for STRUCTURING and DELIVERING DATA for DPPs.	multiple-choice
How do you assess the routines' maturity for the DPPs to STREAMLINE PROCESSES during the Design, Construction and Use phases?	multiple-choice
How do you assess the routines' maturity for the DPPs to support PROCESSES contributing to the SUSTAINABLE GOALS (LCA, Level(s), others)?	multiple-choice

Quantitative Results

Different multiple-choice questions were prepared for each dimension to understand better and assess the respondents' maturity and their perceptions of daily practices.

Starting with the People dimension, when asked about their impressions of the level of knowledge regarding DPP, 42,9% pointed it as "Emerging", 50% as "Basic", and 7,1% as "Advanced". The same results were achieved for the questions focusing on awareness of the changes in EU Regulations that will make DPPs mandatory and how different stakeholders realise DPPs' benefits for the value chain.

A different landscape of answers was obtained for the Process dimension. When asked to provide a personal assessment of the existing processes for structuring and

delivering data into DPPs, 42,9% classified them as "Emerging", 35,7% as "Basic", and 21,4% as "Advanced". Regarding the maturity of the routines to streamline DPP processes during the Design, Construction and Use phases, 50% considered these as "Emerging", 28,6% as "Basic", and 21,4% as "Advanced". When the question focused on the routines' maturity to support sustainability assessments and goals, 35,7% considered them "Emerging". The same result was obtained for "Basic", and 28,6% classified it as "Advanced". These results demonstrate higher maturity at the Process level if the scope is sustainability-related deliverables.

Concerning the Technology dimension, and when asked to provide a maturity assessment for existing tools to support and deploy DPPs, 21,4% considered these as "Emerging", 35,7% as "Basic", and 42,9% as "Advanced". Regarding the existing technology frameworks enabling information exchange for DPPs, 35,7% considered them as "Emerging", 35,7% as "Basic", and 28,6% as "Advanced". The last question impacted the data ownership and security topic, namely assessing the extent to which these concerns are being anticipated. 42,9% of the respondents considered them "Emerging" and the same percentage as "Basic". 14,3% considered them to be "Advanced".

From the overall view of the results for different dimensions, it is possible to state that higher maturity was achieved for the questions under the Technology dimension. This is not surprising compared to previous PPT studies (Mêda *et al.*, 2020). It is relevant to stress that interesting maturity levels are observed for some questions under the Process dimension.

Analysis and Discussion

Quantitative Analysis

Focus group participants were involved in previous PPT studies, meaning there is a knowledgeable but eventually biased view of the results. Given the topic's novelty and, more importantly, the absence of final decisions on its framework and contents, it was already expected to have low or 0% answers in all dimensions for the "Expert" maturity level.

It is worth noting that the lowest result obtained for "Advanced" in the Technology dimension is associated with data ownership and security, revealing stakeholders' concerns about how these issues are being safeguarded and explained. Still, in this dimension, it is interesting to observe the differences between the results of existing tools supporting and deploying DPPs and those enabling the exchange of DPP information. Respondents recognise that improvements must be made on the second.

From the dimension results, it is impossible to clearly state that Processes and People are falling far behind. When questioned on the routines' maturity to provide outcomes at the sustainability level, a relevant percentage of inputs was given for "Advanced". This situation may indicate that respondents recognise how the processes are aligned to provide these outcomes. In contrast, it might raise concerns about the inability to see how processes will handle others. Associated with these results might be the knowledge of systems and processes to deliver this type of outcome and how they need to be adjusted to accomplish the aimed integration. The people dimension lies behind all questions, namely if we look at the percentages obtained for the "Advanced" level. However, this confirms how awareness is needed. Complementing the legal picture of DPPs, such actions should focus on increasing the stakeholders' maturity where the lowest results were obtained.

Focus Group - Qualitative PPT Analysis

The first exercise consisted of grouping and clustering the answers for each dimension according to barriers and opportunities. At the Process and Technology levels, additional questions were made to improve how respondents see DPP implementation outcomes. These will be described as additional elements.

Starting with the People dimension, the lack of skills is identified as a constraint, confirming results from quantitative data collection. The absence of clear guidelines, reaction to change, the perception of the resources needed to systematise data, and concerns about data overflow can be highlighted as relevant bottlenecks. On the other hand, respondents clearly perceive how productivity can be raised with DPPs. As well as opportunities for business and innovation with a strong focus on sustainability. It is interesting to note that, from a professional perspective, DPP skills are envisaged as a relevant knowledge asset.

Looking at the Process dimension from the barrier's perspective, several concerns are raised regarding the cost of deploying and curating DPPs. Aside from the cost of technology (development/acquisition), respondents expressed concerns about the cost of changes at the process level and the human resources competencies needed. The requirements in terms of new processes, compliance with legacy systems and innovations and processes to ensure data quality and validity are also pointed out. On the opportunities side, the productivity gains, the timing for integrating processes, and the vision of how transactions and comparability can be streamlined are the topics respondents demonstrate higher confidence.

From the Technology dimension, the investment costs needed for new tools, the adaptation, when possible, of legacy systems and the management and update over time raise concerns. Interoperability, data security, and ownership are also aspects pinpointed as hurdles. From the opportunity's perspective, the data access, continuity, and the recognition of a data-driven approach as the background for digitalisation are the most recognised. Some respondents already forecast Artificial Intelligence (AI) developments to bring added value. In contrast, others strengthen how this can constitute an unparalleled

opportunity to improve and widespread information management systems in construction.

These results prove that some barriers and opportunities range from more than one dimension; in some cases, they are common to the three. This vision steered the focus group discussions to produce the answers to the research questions.

Discussion on Barriers

Figure 2 clusters the main barriers framed within the dimensions and their overlap. From the core to the boundaries, the main concerns expressed by respondents, ranging from the PPT dimensions, are those associated with the costs, data collection and quality assurance. This aligns with some of the issues raised by EU entities regarding the final text for the regulations, where improvements are needed. However, their implementation should be feasible, scalable, and widespread at all levels. When looking at the overlap between People and Process, the perception of DPPs' value and the development of guidelines, standards, and supporting documentation are identified as the main barriers. In this respect, it is recognised that awareness actions and real use cases are needed as demonstrators and facilitators of the potential contributions of using DPPs. The idea is that these must, in the first moment, concentrate on the already identified goals, namely the ones associated with sustainability.

Notwithstanding, other topics should be presented, namely those that use the same data. This will provide an improved perception of the DPP value, not just for new requirements but also for the long existing ones, such as structural resistance or thermal behaviour. When looking at the identified potential constraints targeting the Process and Technology dimensions, the systems curation through time, hosting resources, update requirements, lifelong operation, and integration with legacy systems stand out. As all respondents have a professional practice, this result may derive from past experiences with systems replacement. This was pointed out in some answers. Establishing the framework and systems for DPPs must consider the objectives and all the relevant legacy tools and processes to accommodate the integration needs as best as possible. In addition, the framework should assume an incremental vision to accommodate more requirements and evolutions through time.

When looking at the aspects set in a single dimension and starting with Technology, interoperability, security, and ownership management constitute the main barriers. Respondents expressed the need to consider all the existing knowledge and systems architecture devoted to interoperability issues. When looking at DPPs from a multi-sector perspective, this aspect raises many concerns

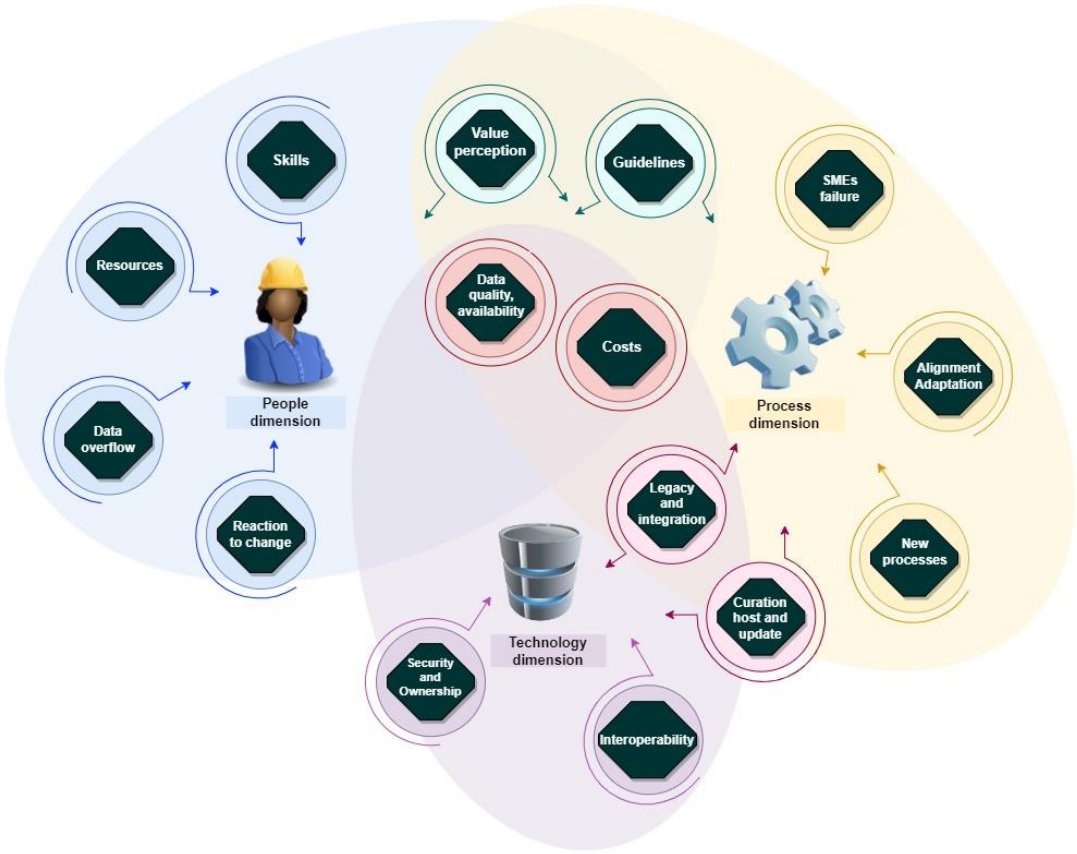

Figure 2: Main barriers clustered at People, Process and Technology dimensions

as several stakeholders are developing tools in silos. In construction, the topic is more safeguarded due to Building Information Modelling (BIM), meaning that developments can be built from the prescriptions set in BIM standards. This link and consensus favours overcoming the ownership and security of data issues. However, the DPP case will need new stakeholders, profiles, and restrictions. From a Process dimension, respondents pointed out three main barriers associated with the need to establish new processes or adapt existing ones, as well as the potential for failure from SMEs, given the dimension and demand underlying this transformation. The capacity to transform, keeping as much as possible or introducing effortless innovations, is a critical challenge common to most endeavours. In this case, and considering that most construction product manufacturers are SMEs, where some are very small, it is necessary to be aware of ways to support these structures to deliver successfully.

Finally, when looking at the People dimension, respondents identify some barriers when discussing innovation, namely reaction to change and lack of skills. The data overflow concern, the incapacity to collect and manage all properties for various products, is part of a data challenge that deserves in-depth research. This topic is associated with the lack of resources. In the present practice, many resources are wasted searching for data and keeping it in the head for some time to avoid getting lost during the processes. This somewhat "mental traceability" must be shifted by improving the ability to search faster and knowing where to access data or where it is stored in larger quantities. This is to say that, despite data overflow being a reality and an issue to prevent, misjudgements can, to some extent, blur this topic.

Discussion on Opportunities

Following the approach used for barriers, Figure 3 presents the landscape of DPP opportunities. Data integration, trust, and transparency stand out by ranging all dimensions under discussion. From the answers, it is observed that respondents understand relatively well the role of DPP and, more importantly, the transformations that it can bring to the construction sector if well implemented. Aligned with this are productivity gains and efficiency, also mentioned as joint opportunities. Only two aspects were identified as sharing two dimensions, one for People and Technology and the other for Technology and Process. Starting with the first case, an ample opportunity is imagined for the sector from data-driven developments, with many answers detailing the importance in having tools that manage and exchange data with a common understanding. Somewhat related is the

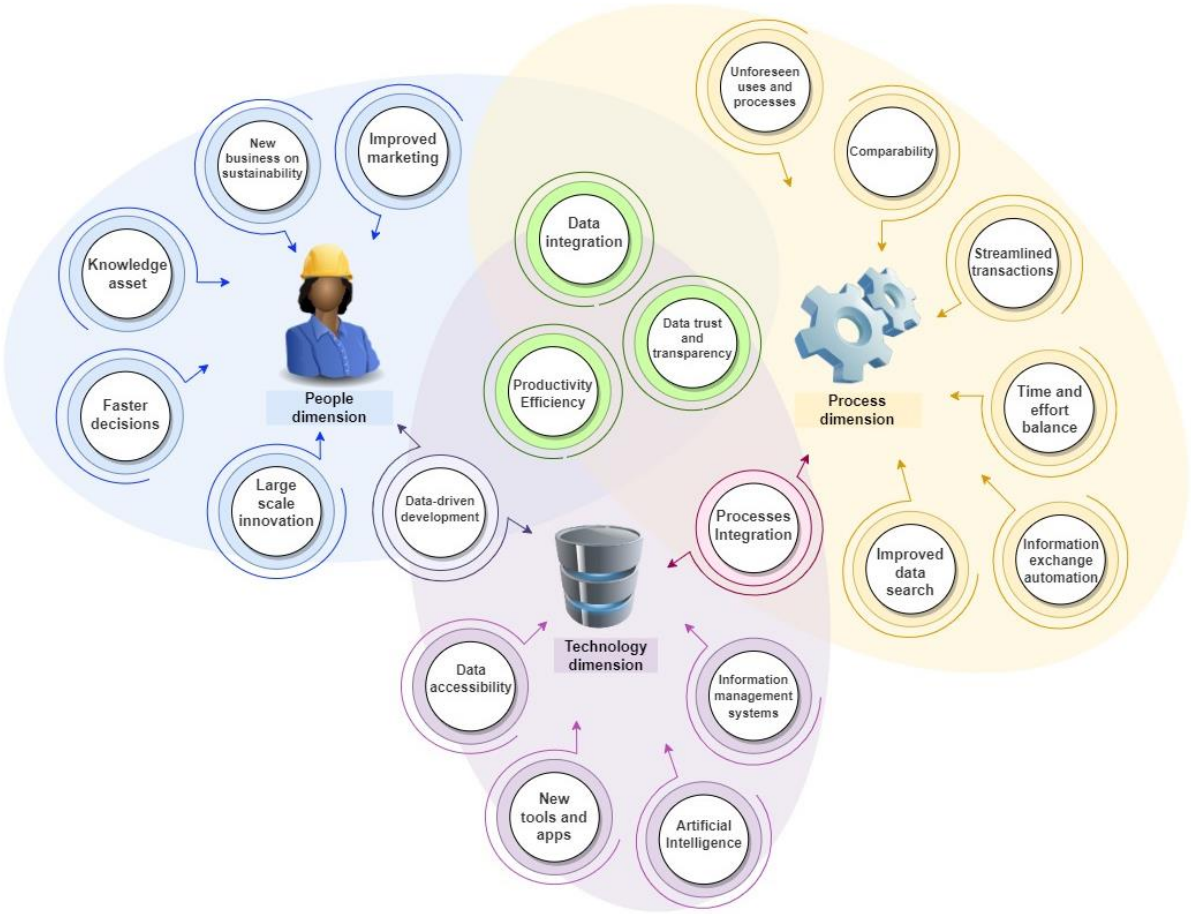

Figure 3: Main opportunities clustered at People, Process and Technology dimensions

other aspect, where respondents highlight the process integration as a game changer.

From a single-dimension vision, the identified opportunities are related to developing new tools and applications, namely information management systems that can support and efficiently administrate rich data environments. In this respect, many respondents pointed out the prospects in AI as essential to speed up and support data management. The last aspect mentioned by respondents reinforces the topic by highlighting the opportunities deriving from access to more organised and broader amounts of data. In the Process dimension, many answers focus on how the DPP-associated processes constitute an opportunity to find data better, increase comparability capacity, streamline transactions, and automate information exchanges. The results are very interesting because examples supporting these topics are provided, including all the construction process phases and the life cycle value chain. The expressed changes envisaged for the comparability opportunity from design to construction or during the bidding process were highlighted. The other topic mentioned is the unforeseen uses and processes. These answers reveal, to some extent, how the DPPs motivate and engage stakeholders. This enthusiasm must be used to tackle barriers previously addressed in the People dimension. Respondents state that improved marketing and faster decisions can occur in this respect. Some pointed out that new businesses can be built based on sustainability. Large-scale innovation is an opportunity deriving from the perception of how DPPs can work in terms of data integration. Finally, more than one respondent identified DPPs as a knowledge asset and an opportunity, supported by the idea that proficiency in this subject will become a competitive advantage in the short term, allowing more competitive professional possibilities.

Conclusions

From applying mixed methods and the People, Process, and Technology dimensions, it can be concluded that regarding Construction DPPs, the Technology dimension is more mature. It is also possible to note that a significant push should be made at the People dimension to provide awareness, guidelines, use cases and training to tackle erroneous value perceptions and reactions to change. DPPs are not a complete novelty. So, in the first moment, there should be a focus on what already exists and how DPPs can be built from it. Working on the outcomes deriving from the existing data is critical, making it part of DPP's information structure. The next step will be understanding the new requirements and the data needed for a comprehensive accomplishment. There are still unknown details on the passport framework and functionalities. The new regulations will bring about clarity. Despite the infancy of the concept and the absence of a full realisation, a solid background should be built using the known facts, fostering the conditions for a concerted change effort for the transformation to be consistent.

The research outcomes constitute relevant contributions, namely on how professionals engaged in the construction processes perceive DPPs and how their thoughts align with the strategies. When detailing the barriers, relevant bottlenecks were identified, targeting a single dimension from PPT, or ranging more than one, with cases comprising the three. The landscape of clustered barriers presents topics that are well-known and labelled as transversal to most innovation initiatives, whereas others can be recognised as specific from the DPP. As presented in Figure 2, the vision of the barriers can be paramount to tackle the main concerns in the short-medium time. Regarding the opportunities presented in Figure 3, it is relevant to stress that DPP seems to motivate stakeholders given the wide range of issues pinpointed and the associated comments. Relevant advantages can be taken from this enthusiasm, namely by establishing strategies to ensure a positive environment for the transition, engaging a high number of stakeholders and working on the most meaningful outcomes for each role. From this overview, it is relevant to highlight the similarity, in terms of pattern, achieved for the barriers and the opportunities.

The research is limited to the questions set in the survey and the sample, which can be classified as above average concerning DPP knowledge. The number of respondents could be more significant. However, it can be recognised that, due to the infancy of Construction DPP, few professionals can provide inputs such as the ones obtained. One of the objectives was to fill the gap in the existing studies by providing an overall perspective on the passport ecosystem for the construction sector when collecting insights from a multidimensional perspective. With the mentioned limitations, this was accomplished. Future research will focus on amplifying the sample and extending the number of questions and topics. A deep understanding of the motivations and reasons for the identified barriers and opportunities is also part of future actions. From the DPP perspective, future research will incorporate new elements as they become public, namely, the EU Regulations, when published, and discussions on the roles and implementation of Construction DPPs.

Digital Product Passports are inevitable in the EU as they are the cornerstone instrument of the digital and green transitions supporting industrial and carbon-neutral strategies. Despite the novelty, stakeholders identify the benefits and opportunities, expressing positive impressions towards a widespread implementation. Many answers state that what DPPs aim to accomplish was long expected, given the inefficiencies derived from manual work that is still mostly needed when using digital tools. This means the novelty is more on the concept than the features and enablers. However, given the push from the sustainability side, concerns are raised regarding the data overflow and the data priorities for the aimed goals. The situation is particularly relevant to SMEs as more support may be required to keep pace. To conclude, the

impressions point to an easy understanding of the DPP and to a positive environment for its adoption in the construction industry.

The Construction DPP seems well-positioned to create a concerted change effort across the industry. Therefore, the capacity to set clear guidelines for this to occur is critical.

Acknowledgments

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References

Agency, EC (no date) ECHA - SCIP database. Available at: https://echa.europa.eu/scip (11 December 2023).

Byers, B.S. and De Wolf, C. (2023) 'QR Code-Based Material Passports for Component Reuse Across Life Cycle Stages in Small-Scale Construction', Circular Economy, 1(2), pp. 1–16. Available at: https://doi.org/10.55845/iweb6031.

van Capelleveen, G. et al. (2023) 'The anatomy of a passport for the circular economy: a conceptual definition, vision and structured literature review', Resources, Conservation and Recycling Advances, 17(May 2022), p. 200131. Available at: https://doi.org/10.1016/j.rcradv.2023.200131.

Commission, E. (2022) EU Construction Products Regulation proposal, COM(2022) 144 final. Brussels.

Cresswell, J.W. and Poth, C.N. (2018) Qualitative Inquiry and Research Design: Choosing among five approaches. 4th edn. Thousand Oaks: SAGE Pub Ltd.

Derenzi, D. et al. (2009) 'A successful approach in integrating people, process, and technology inside collaborative environments: A practical view of challenges and lessons learned', Digital Energy Conference and Exhibition 2009, pp. 268–277. Available at: https://doi.org/10.2118/123287-ms.

Ducuing, C. and Reich, R.H. (2023) 'Data governance: Digital product passports as a case study', Competition and Regulation in Network Industries, 24(1), pp. 3–23. Av. at: https://doi.org/10.1177/17835917231152799.

Ecorys (2018) Survey on users' need for information on construction products. Brussels. Available at: https://doi.org/10.2873/87907.

Energy, D.-G. EPREL - European Product Registry for Energy Labelling: (11 December 2023) https://eprel.ec.europa.eu/screen/home.

European Parliament and European Union Council (2022) Ecodesign requirements for sustainable products, COM(2022) 142 final. Brussels.

Honic, M., Magalhães, P.M. and Bosch, P. Van Den (2024) 'From Data Templates to Material Passports and Digital Product Passports', in C. De Wolf, (eds) A Circular Built Environment in the Digital Age. Springer. Springer Cham, pp. 79–94. Available at: https://doi.org/10.1007/978-3-031-39675-5_5.

King, M.R.N., Timms, P.D. and Mountney, S. (2023) 'A proposed universal definition of a Digital Product Passport Ecosystem (DPPE): Worldviews, discrete capabilities, stakeholder requirements and concerns', Journal of Cleaner Production, 384(Nov. 2022),. Av. at: https://doi.org/10.1016/j.jclepro.2022.135538.

Lines, B.C. et al. (2015) 'Overcoming resistance to change in engineering and construction: Change management factors for owner organizations', International Journal of Project Management, 33(5), pp. 1170–1179. Available at: https://doi.org/10.1016/j.ijproman.2015.01.008.

Mêda, P. et al. (2020) 'People, Process, Technology in Construction 4.0 - Balancing Knowledge, Distrust and Motivations', in S. Toledo, Eduardo (ed.) 37th CIB W78 Information Technology for Construction Conference, São Paulo, Brazil, pp.218–231. Av. at: https://doi.org/10.46421/2706-6568.37.2020.paper016.

Mêda, P. et al. (2021) 'Incremental Digital Twin Conceptualisations Targeting Data-Driven Circular Construction', Buildings, 11(11), p. 554. Available at: https://doi.org/10.3390/buildings11110554.

Mêda, P. et al. (2022) 'A Process-Based Framework for Digital Building Logbooks', in EC3 (ed.) 2022 European Conference on Computing in Construction. Ixia: EC3, p. 8. Available at: https://doi.org/10.35490/EC3.2022.183.

Munaro, M.R. and Tavares, S.F. (2021) 'Materials passport's review: challenges and opportunities toward a circular economy building sector', Built Environment Project and Asset Management, 11(4), pp. 767–782. Available at: https://doi.org/10.1108/BEPAM-02-2020-0027.

Official Journal of the European Communities (2008) 'Decsion 768/2008/EC: common framework for the marketing of products', OJEU, p. 768/2008/EC Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008D0768.

Owen, R. (2013) Integrated Design & Delivery Solutions (IDDS). Rotterdam.

Torpey, J.C. (2018) The Invention of the Passport: Surveillance, Citizenship and the State. 2nd edn. Edited by CS in L. and Society. Cambridge: Cambridge University Press.

United Nations (no date) U.N. Sustainable Development Goals. Available at: https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (Accessed: 17 May 2022).