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INFORMATION NEEDS IN DIGITAL PRODUCTS PASSPORT – DISCUSSING DATA FRAMEWORK AND REASONABILITY

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Abstract

Digital Product Passports (DPPs) are cross-sectorial data containers with relevant characteristics of products aiming to enable the circular economy. The European Union (EU) ecodesign directive proposal sets the background for the study as it establishes the framework for DPP requirements and aligns with the construction products regulation (CPR) for that sector singularities. However, despite this streamlined vision, there are many challenges related to stakeholder engagement. The role of key stakeholders, such as manufacturers, must be considered. This study discusses their role, the DPP data framework, and the reasonability of data requirements considering the present knowledge related to developing and utilising DPPs. The sector's ability to accomplish sustainability goals relies heavily on effectively sharing product information across the entire value chain. However, due to the challenges, the outlook of DPPs remains unclear.

Introduction

The construction industry (CI) is one of the principal sectors of the world's economy (Ribeirinho *et al.*, 2020). Its significance and contribution to society's development and well-being go far beyond the direct and measurable indicators, such as its percentage concerning the globe's gross domestic product (GDP) (Europe, 2021) (Staff, 2021). As such, there is a need to overcome challenges in the daily CI tasks and activities at the individual stakeholder and project levels. In addition, high-level challenges related to the engagement and integration of the value chain need to be considered and addressed comprehensively.

At the beginning of this century, site health, safety and hygiene have become widely recognised in the CI. However, improving health and safety conditions in construction sites was only possible after several years of developments involving increasing requirements, training, surveillance, penalties, and incentives for change. Nowadays, most construction sites are safer, better performing, and can deliver improved built objects.

Recently, there has been increasing awareness and concerns about achieving sustainability outcomes in all sectors of the global economy. Specifically, concerns about the underperformance and sustainability credentials of CI have become mainstream discussions. Strategic documents have identified nine shifts to "radically change" the situation (Ribeirinho *et al.*, 2020). These involve a combination of "sustainability requirements, cost efficiency, skills scarcity, new materials, industrial approaches, digitalisation, and a new breed of player" (Ribeirinho *et al.*, 2020). Policies have been set, at the EU level, pointing roadmaps towards a circular economy and actions targeted at digitalisation and sustainability aiming to twin the transitions (Commission, 2020) (Staff, 2021). Significant changes are taking place, supported by these documents. It is worth highlighting the revision of several regulations, such as the Construction Products Regulation (CPR) (Commission, 2022) or the Ecodesign Directive (European Parliament and European Union Council, 2022), as well as the development of a widespread sustainability assessment methodology to be applied to all buildings; Level(s) (Díaz-López *et al.*, 2021). The new laws and tools aim to set the needed background to raise the bar of the construction value chain to improve sustainability performance in multiple dimensions. In this respect, adopting digital technologies, tools, and systems is critical to supporting and streamlining different processes (Çetin, De Wolf and Bocken, 2021).

Built assets consist of construction products produced and supplied on-site to be placed, assembled, or mixed during construction. In the EU, the products trading and on-site acceptance must be CPR compliant, meaning they should have a CE mark and/or a Declaration of Performance (DoP) (Ecorys, 2018). Sustainability trends will demand improved knowledge of product characteristics regarding environmental performance and reuse potential (Commission, 2022). Similarly, more characteristics associated with products will be needed and have been very challenging to obtain, compile, standardise and adequately disclose. Digital tools provide efficient ways to collect and manage product characteristics throughout their life cycle. Therefore, Digital Product Passports (DPP) are meant to be the crucial element in answering information management requirements, improving the situation observed until nowadays (European Parliament and European Union Council, 2022)(Commission, 2022)(Bernier, 2022).

This paper addresses DPPs, discussing their value proposition and the information framework considering the legal requirements, the stakeholders involved, future needs and the manufacturer's ability/willingness to deliver information. This discussion is imperative given the number of initiatives, concepts and existing tools that centre around this topic without a clear perception of the overall context (Soman, Kedir and Hall, 2022)(Adisorn, Tholen and Gotz, 2021)—likewise, the implementation of

strategies to engage manufacturers and to evaluate the requirements' reasonability.

This paper is divided into five sections. The following section introduces the main concepts supporting the research. The following section explains the research approach and chosen methodologies. The following explores DPPs from different perspectives, from the technological requirements to the information framework and features considering what is set on the regulation's proposal and other documents. In this respect, reflections are made considering actions occurring both within the sector and outside to obtain answers to the following questions:

- What are the basic datasets required for a DPP to be operational? And why?
- Which datasets are reasonable to demand, and which are not?

It is worth mentioning that due to the circular economy objectives (Commission, 2020a), a construction product should be able to be reused in other industries and vice versa. Therefore, DPPs must support multi-sector requirements to make a difference in the circular economy. The supporting technologies should be shared, interoperable, or at least compatible. Finally, the discussion and conclusions systematise the main findings, study limitations, and propose directions for future research.

EU Legal Proposals under discussion

Construction Products Regulation – CPR

The CPR is one of the core legal documents in the EU because it implements the free trade protocols that constitute the foundational assumptions for CEE establishment in the late 50s. Focusing on the product level, it sets the common technical language to describe characteristics across different countries and use the same label, the CE mark, to promote free trade and perform the compliance checking needed within the construction process value chain. Presently, the CPR addresses "essential characteristics" as "those of construction products which relate to the basic requirements for construction works" (European Parliament and European Union Council, 2011). The basic requirements are set in Annex I and are the following:

- Mechanical resistance and stability
- Safety in case of fire
- Hygiene, health, and the environment
- Safety and accessibility in use
- Protection against noise
- Energy economy and heat retention
- Sustainable use of natural resources

The ability to work for commerce and compliance with construction-related regulations has been a significant challenge, not always handled in the best way and often lacking to accomplish the aimed goals. The magnitude of different types of construction products, different characteristics applicable and the growing needs in terms of requirements for environmental-related analysis are presently becoming at the forefront. These evolving requirements have made it more complex to provide the same legal framework tools suited for the previously mentioned dimensions.

The proposal aims to work on several identified challenges and focuses on the last-mentioned basic requirement, which was mostly left behind in the 2011 version of the regulation. In addition, this links with the eco-design directive by stating in Article 78 that: *"The Commission is empowered to supplement this Regulation… by setting up a Union construction products database or system that builds to the extent possible on the Digital Product Passport established by... Regulation on eco-design for sustainable products"* (Commission, 2022).

Ecodesign Directive

The ecodesign directive proposal is meant to reduce the negative life cycle environmental impacts of products and improve the functioning of the internal market. It has a horizontal framework vision governing multiple products, setting the bridge with other specific regulations, such as CPR, when needed. In addition, DPPs are envisaged and detailed in this regulation on their dimensions, from technological aspects to lifecycle implementation, security, and information requirements. It is worth pointing out a proposal statement on DPPs:

"The proposal also includes the creation of a digital product passport to register electronically, process and share product-related information amongst supply chain businesses, authorities, and consumers. This is expected to increase transparency, both for supply chain businesses and for the general public and increase efficiencies in terms of information transfer. In particular, it is likely to help facilitate and streamline the monitoring and enforcement of the regulation carried out by EU and Member State authorities. It is also likely to provide a market-intelligence tool that may be used for revising and refining obligations in the future" (European Parliament and European Union Council, 2022).

Overview

As presented, there are very high expectations concerning DPP and the position of the new proposal as an essential new tool for enabling a holistic and comprehensive recording of product data sustainability characteristics in the future (Adisorn, Tholen and Gotz, 2021).

Methods

The main objective of this paper is to explore the datasets required and the perception of business value regarding construction product information and how it should be framed in DPP in line with regulatory requirements, stakeholder information and manufacturers' willingness to deliver it. Therefore, this study adopts an inductive research strategy to formulate the theory associated with

the DPP's overall data framework using background knowledge. Furthermore, this study utilises a use case and focus group approach to discuss the data framework and stakeholders' will and/or capacity to deliver data in a specific context.

Defining DPP's data Framework

Introduction

The EU ecodesign directive sets the framework for all DPP characteristics, associated definitions, and rules and regulations governing its development. This aspect is clearly stated in Annex III align (e). According to the proposal, DPP is defined as:

"a set of data specific to a product that includes the information specified in the applicable delegated act adopted pursuant to Article 4 (Empowerments to adopt delegated acts), and that is accessible via electronic means through a data carrier in accordance with Chapter III – Digital Product Passport" (European Parliament and European Union Council, 2022).

The DPP framework is extensively covered in Chapter III, which comprises: Article 8, Product Passport; Article 9, General Requirements for the product passport; Article 10, Technical Design and Operation of the product passport; Article 11, Unique operator identifier and Unique facility identifier; Article 12, Product Passport registry, and Article 13 Customs controls relating to the product passport. However, most of these provisions relate to DPP technological aspects, such as interoperability, unique identifiers, storage, responsibilities, and life cycle. In terms of the provisions for information requirements, Article 8 is one of the most relevant by making reference to Annex III, Article 7 Information requirements, and Article 5 number 1, where ecodesign requirements are defined as follows: (a) durability, (b) reliability, (c) reusability, (d) upgradability, (e) reparability, (f) possibility of maintenance and refurbishment, (g) presence of substances of concern, (h) energy use or energy efficiency, (i) resource use or resource efficiency, (j) recycled content, (k) possibility of remanufacturing and recycling, (l) possibility of recovery of materials, (m) environmental impacts, including carbon and environmental footprint and (n) expected generation of waste materials (European Parliament and European Union Council, 2022).

Therefore, the prescriptions in Chapter III provide essential insights into the general technological and information requirements associated with DPPs. At the same time, it raises some concerns about the implementation of the data framework and the technological and interoperability factors.

Cirpass project and its DPP definition

The EU is expected to have a new legal framework by 2024 to improve the knowledge and set the ground for the gradual adoption of DPPs across sectors. In this regard, the EU promotes the Cirpass project to develop cross-sectoral definitions, data models and open exchange protocol working stakeholder consensus (Bernier, 2022).

One of the outputs of the Cirpass project is the proposed definition of DPPs, mainly from the systems architecture and information requirements point of view. Defining DPPs are:

"a structured collection of product-related data with a predefined scope and agreed data ownership and access rights conveyed through a unique identifier", set on a "decentralised system with a central registry" with "Information related to sustainability, circularity, value retention for reuse/remanufacturing/recycling" (Bernier, 2022).

However, despite the significance of the CI, it was left out, and the Cirpass project approaches only DPPs for batteries, electronics, and textiles. Furthermore, considering the project's aimed outcomes, there is the risk of introducing constraints or providing guidelines that go against some standards and methods already implemented by the CI. Therefore, the impact of this oversight needs to be mitigated.

Building Information Modelling and Data Templates

Despite the well-known challenges, such as resistance to change in the CI, the sector has positively embraced the transition initiatives towards a more digital and sustainable way of delivering built assets (Ribeirinho *et al.*, 2020). Although not in its entirety, enhanced practices are evident in the CI, and organisations are continuously taking steps to improve their processes, which have increased their maturity and speed of adoption.

Building Information Modelling (BIM) is one of the most important components of digital transformation in the CI (Çetin, De Wolf and Bocken, 2021). BIM is a methodology that covers several processes and integrates critical elements of construction projects. Its increasing adoption and improved perception led to the development of guidelines several industry guidelines that would later become the ISO 19650 standards. The ISO 19650 standards define BIM assumptions and processes regarding information management across the project lifecycle. One of the most known elements of BIM is the 3D mode to facilitate information exchange between stakeholders. The ability to geometrically position most objects has been a game changer for stakeholders, as they can set an initial vision of the built environment and detect issues such as clashes and other types of geometric incompatibilities and non-compliances. The 3D model is relevant in DPP discussions as it allows stakeholders to link characteristics to objects, which constitutes a considerable advantage for achieving several sustainability deliverables. The 3D model can facilitate energy efficiency performance analysis, acoustic behaviour and fire resistance analysis, to name only a few conditions and compliance checks that need to be done and delivered as part of the design.

Machine-readable data is essential to provide a reliable exchange of information across an asset life cycle to

support the management and production of sustainability-related information in these business processes (Standardization, 2020a). For this to happen, Data Templates are the technological structures that can support all needed product characteristics to be linked to modelled objects. Data templates are defined by ISO 23387 standard, and the EN 17473 standard sets the link between BIM, Data Templates and the CPR (Standardization, 2020a). Consequently, the DPPs framework must consider what is already part of the innovative practices in the CI.

Construction Information Needs

Digital structures like Data Templates can collect and manage diverse datasets. However, several aspects, need to be considered if the aim is to have this properly and widely implemented:

- Relevant and comprehensive product information is supplied in a variety of formats (Adisorn, Tholen and Gotz, 2021)
- DPPs, although pushed from the ecodesign side, must support other types of data, namely the one set by the CPR (European Parliament and European Union Council, 2022)
- Product information can be relevant to different user groups but with different levels of detail/need (Adisorn, Tholen and Gotz, 2021)
- Manufacturers and suppliers are generally the main actors in providing specific product information (Adisorn, Tholen and Gotz, 2021)
- Proportionality of implementation. Following the EU Data Governance Act, the DPPs data framework should not go beyond what is necessary to achieve the objectives (Commission, 2020b)

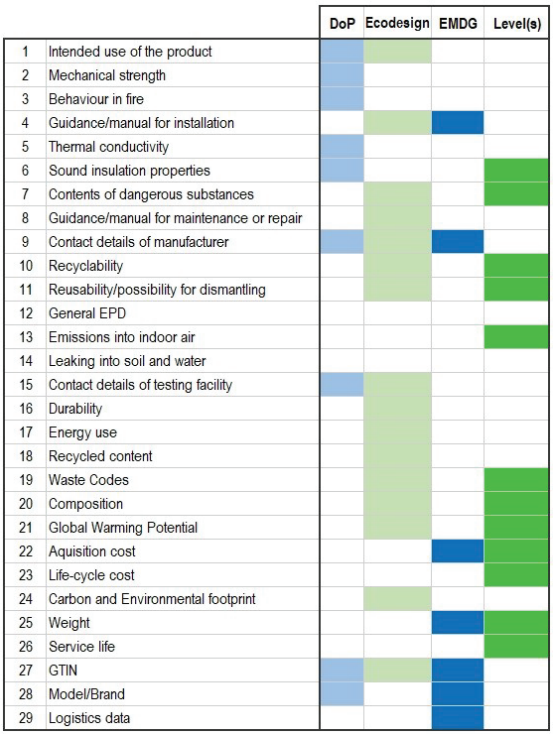
Considering the two first points, it is relevant to understand the present situation relating to construction product information. As part of the CPR update process, the EU launched a survey to better understand these, among other aspects (Ecorys, 2018). Although the survey is not exhaustive, it provides vital elements for the discussion. The significant changes identified in the regulations will highly influence the information needs. In addressing high-level results, it is interesting to observe that "Thermal insulating products", "doors and windows", "concrete, mortar & grout", "cement", "roof coverings", and "floorings" are among the product types where technical information is more required. This occurs mainly due to the systems defined in CPR for trading, the needed compliance checks, and the influence of these product types on the results. Looking at the more often requested information for an overall scenario of construction products and considering all types of stakeholders, it is observed that "Intended use", "Mechanical strength", and "Behaviour in fire" are the three more requested characteristics by the respondents, with a value of 40% or more. Elements such as "Manual for installation", "Thermal conductivity", "Sound insulation properties", "contents of dangerous substances", "Maintenance manual", "Manufacturer contact details", "Recyclability", and "Reusability" are requested by the respondents from 39 to 20%. Less than 19% of respondents identified "Environmental Product Declaration (EPD) data", "Emissions into indoor air", "Leaking into soil and water", and "Contact details of the testing facility" (Ecorys, 2018, page 36). Therefore, few characteristics overlap with the ones defined in the ecodesign directive when compared to Ecorys (2018), which highlights that the requirements in the regulations are far from being the ones requested by stakeholders. Also, the leading properties are the ones associated with performance.

It is not questionable that, once published, the ecodesign data requirements will gain relevance. From a practical point of view, the data framework supporting all requirements must be the same. Related to the formats where this information is presented, the survey evidence on page 65 is a clear graphic demonstrating that most of the contents are made available on the manufacturer's and/or supplier's website or in paper documents at delivery. Studies are yet to explore whether the datasets are provided .pdf documents, in metadata files or as part of BIM objects. As such, the exploration of this situation would be helpful in the development of DPPs for the CI. Also, the data environment will increase to serve a broader range of purposes. To support improved management of all this information, the construction sector, in combination with BIM standards, is working on the concept of Level of Information Need (LoIN). LoIN is meant to adjust the different dimensions of BIM to specific needs/requests from different stakeholders (Standardization, 2020b).

On the data framework, it is worth mentioning that there are two initiatives covered by the European Master Data Guideline (EMDG) (Arge, 2020) on the data side and the other related to the sustainability deliverables of future construction projects, the Level(s) methodology (Díaz-López *et al.*, 2021). The EMDG is led by the European Federation of the Sanitary and Heating Wholesale Trade (FEST), aiming to unambiguously define and uniquely identify the general master data attributes for the products (Arge, 2020). It is intended to be the common framework to which different systems can be mapped to communicate correctly (Arge, 2020). Most data are associated with the manufacturer and/or supplier, product brand and model, costs, and logistics data as packaging. Without overlapping entirely, they are some common points with the contents set by the CPR for the Declarations of Performance.

Furthermore, Level(s) methodology is a sustainability assessment technique to be implemented in European buildings. The objective is to assess the sustainability of the overall built stock. It comprises six macro-objectives built from a group of indicators (Díaz-López *et al.*, 2021). Previous research explored these indicators and the product data needed to perform estimations. Among the

needed data relating to products is the "Thermal conductivity", "Global Warming Potential", "Acquisition cost", "Weight", "Estimated service life", "Composition", "toxicity", "Waste codes", "possible outlets before deconstruction", "Sound insulation properties", "lifecycle cost", "end of life value" and "maintenance needs"(GrowingCircle, 2022). As such, Level(s) methodology uses a mix of more "traditional" characteristics of products together with others that are now gaining relevance with the ecodesign directive. The directive is meant to set requirements to enable Level(s), which will support stakeholders in defining a common language for macro-project objectives assessments. All elements previously presented address requirements and the data framework surrounding products in general and construction products in particular. This analysis was essential to gain an overview of the elements and characteristics to be considered, as summarised in Figure 1.



		DoP	Ecodesign	EMDG	Level(s)
1	Intended use of the product				
2	Mechanical strength				
3	Behaviour in fire				
4	Guidance/manual for installation				
5	Thermal conductivity				
6	Sound insulation properties				
7	Contents of dangerous substances				
8	Guidance/manual for maintenance or repair				
9	Contact details of manufacturer				
10	Recyclability				
11	Reusability/possibility for dismantling				
12	General EPD				
13	Emissions into indoor air				
14	Leaking into soil and water				
15	Contact details of testing facility				
16	Durability				
17	Energy use				
18	Recycled content				
19	Waste Codes				
20	Composition				
21	Global Warming Potential				
22	Aquisition cost				
23	Life-cycle cost				
24	Carbon and Environmental footprint				
25	Weight				
26	Service life				
27	GTIN				
28	Model/Brand				
29	Logistics data				

Figure 1: Data framework considering different requirements/deliverables/uses

Discussion

Product Information Business Value

Construction product manufacturers are stakeholders often not considered part of the core construction value chain (Staff, 2021). This restrictive vision must change because manufacturers and suppliers are vital players in the fabrication, supply and installation of construction products. Based on the empirical data analysed in this study, it is suggested that manufacturers should assume a leading role in terms of data provision and organisation. Furthermore, given the increasing requirements, stakeholders' business value need to be understood as it will drive their motivation and actions to produce and disclose those data requirements. As such, the discussion cannot be centred on what is or might become mandatory regarding datasets or product characteristics, as this aspect is still developing. Instead, the reasoning is to observe the stakeholder's perception and assessment when facing different data requirements. This is also critical to understand potential constraints and actions that need to be considered to tackle potential problems. Despite potential differences in product types, most manufacturers govern their business considering different dimensions. These were raised and validated in focus groups leading to the result summarised in Figure 2. Also, corporate strategies influence manufacturer decisions, leading to different behaviours related to delivering specific product information. Therefore, these patterns can affect aspects such as the cost of the product.

In terms of other dimensions, such as "Compliance" or "Safety and Security", these can be assumed as the basics for business, as they are highly regulated. Others are associated with quality patterns such as "Reliability" and services such as "Logistics" or "Maintenance". Several manufacturers use these dimensions to boost their products' reputation and/or competitiveness. Brand value is a significant factor that influences the perception of customers in any sector. For example, when considering the factor of "Reliability", some car or watch brands have achieved a level where it is implicit, and clients are willing to pay more to get it. Similarly, regarding products and services in the CI, clients might be more motivated to buy a product where they know they will have the needed support or are aware that failures in the supply chain will not happen. Other dimensions, such as "Data standards and governance", it is essential to state that this is closely related to the readiness and/or willingness of manufacturers to embrace digitalisation. There is a direct connection between the organisational strategy and the ability to produce and/or disclose data. Manufacturers are willing to demonstrate specific capabilities when implementing processes and following standards. They comply with requirements that translate into disclosing product data to demonstrate transparency and build customer trust. Usually, "Sustainability" would be part of this dimension. However, given the recent push, it is perceived as an individual dimension with high implications at processes and data levels.

Furthermore, although the 2011 CPR version mainly left environmental aspects behind, some innovative manufacturers considered it relevant to start producing EPDs for their products. At that time, this was considered part of the "competitive advantage", which has now been covered as of the basic and regulated requirements. Therefore, all the dimensions identified in this study are essential to characterising construction product manufacturers, perceiving their main concerns and

Figure 2: Products business value dimensions

strategies, and understanding the reasonability of the information requests in the short and medium term.

Following this vision, it is essential to stress that most manufacturers are willing to provide information if they have it or if, from a business perspective, it is affordable to provide without giving away any part of its competitive edge.

Reasonability exercise

According to Cambridge Dictionary, something is considered reasonable when it is "based on or using good judgment and therefore fair and practical".

Previously, an overview of the DPPs' potential data framework was set, looking at the analysed datasets and characteristics and forecasting future ones, as a result of newly established regulations and processes, such as Ecodesign regulation and Level(s) methodology of sustainability assessment. In addition, one example from field practice was explored, the EMDG, to represent the sector's initiative on identifying core datasets needed for improved trade and turned towards increased productivity. The datasets/characteristics, summarised in Figure 1, constitute the use case, assumed as the construction products data landscape. Several stakeholders from the products and manufacturers sub-sector were consulted and brought together to discuss two critical elements of the business strategy that influences data deliverables. These are the capacity to deliver the data and the will to deliver it. Both dimensions were scaled with six levels. Regarding the capacity, the first level was set as "easy" to deliver, and the last level was set as "very hard". Intermediate levels were set to perceive if the capacity for delivering data was more challenging due to cost or effort. The established levels were "with little extra work", "with some extra work", "demanding process", and "hard or costly to obtain".

Regarding the will, the first level aims to express datasets or characteristics that are "convenient" to be delivered. The last level seeks to translate a state where providing data is considered "stressful". As previously, four intermediate levels were set to express the following states of mind: "not so peaceful, but", "if asked, ok to provide", "not so comfortable in providing", "if pressured, I would provide". Figure 3 presents a matrix that aims to express the reasonability of the DPPs data framework requests considering the present situation. As it will be detailed, this is relevant because it marks a trend and can point directions relating to actions needed to overcome potential constraints on delivering specific datasets, even if they are set as mandatory.

Based on the focus group results, several aspects can be highlighted regarding which datasets are reasonable to demand from manufacturers. From the 29 characteristics identified, it is noted that most parts of the requirements are convenient to be delivered despite the high-level efforts assumed to produce them. In this respect, the ones marked as "very hard" involve specific product tests. However, as some are mandatory, they constitute no problem for manufacturers and are embedded as part of the basic needs of the business value dimensions, such as "Data standards and governance". In addition, some characteristics identified in this section as "easy and convenient to deliver" are part of the "new requirements". Some examples are "weight", "energy use", and "recycled content", among others.

Furthermore, looking at the "more stressful" side of the matrix, it is interesting to observe that "composition", although easy to disclose, it introduces stress and additional responsibilities on manufacturers. As such, the perception of a potential loss of competitive advantage by publishing "secrets of the business" is among the most relevant aspects. This factor holds as much significance as the characteristics associated with "cost".

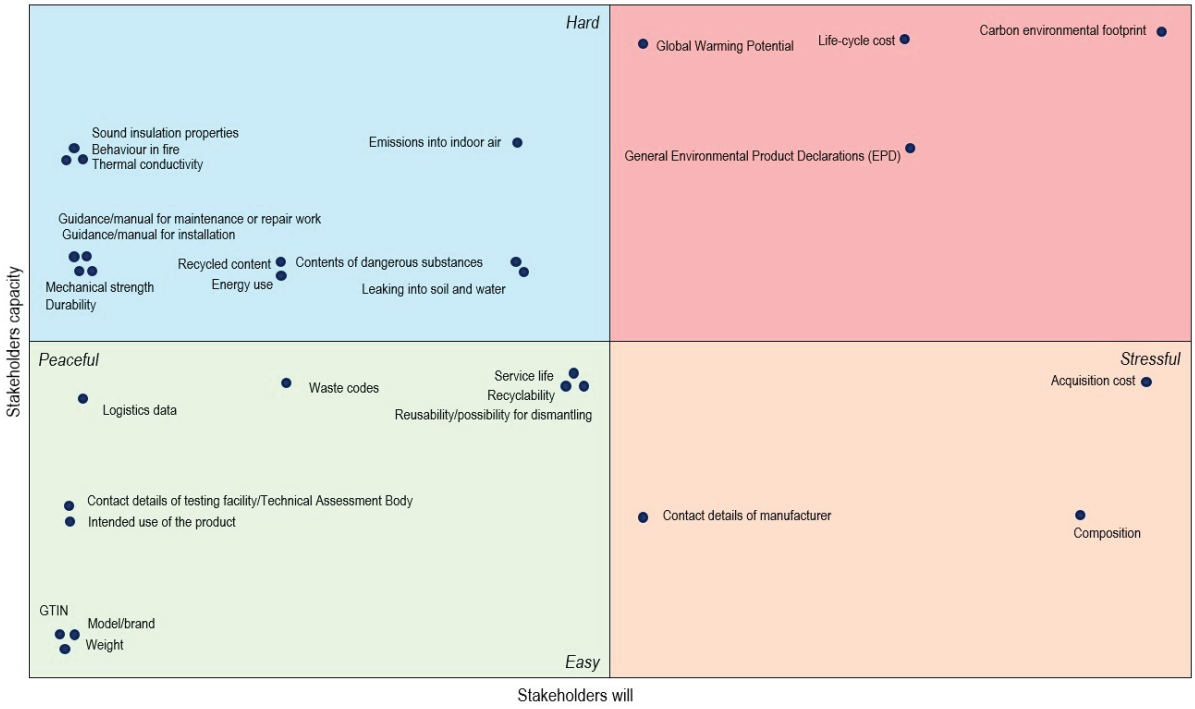


Figure 3: Reasonability matrix regarding DPP data framework

Finally, it is interesting to see that environmental aspects such as “carbon footprint”, “global warming potential”, and even “EPD data” lie within the “most uncomfortable” square of the matrix. The effort associated with delivering these datasets and the lack of knowledge and understanding of the purpose and benefits were found to be aspects contributing to the evidenced situation.

One aspect raised relating to EPDs is their future potential to support sustainability outcomes in the CI. It is by the focus group participants that EPDs are documents aggregating substantial amounts of data relevant to Ecodesign and Level(s) methodologies. At the same time, its implementation has led to much confusion, meaning that the data is not always provided in a way that can be easily used. The 2011 version of the CPR was anticipating EPDs to become mandatory, but in the new version, they are not clearly mentioned. As a result, questions can arise regarding whether they are required to be maintained and updated. This also raises concerns regarding how dataset requirements will be modified to accommodate the number of characteristics to disclose so that the process is not too cumbersome. Based on Figure 3, the following can be deduced: The manufacturers' vision and the present business value of product information are not entirely aligned with the short-term requirements.

Conclusions

This paper discusses the data framework and the business value of manufacturers facing construction products information. This is a crucial and challenging topic because the ecodesign and CPR regulations are still under development. Stakeholders are employing several initiatives for DPPs to become strategic elements, but their added value and feasibility must be adequately anticipated. Considering the maturity of the existing documentation, DPP's understanding and associated dataset “data framework” requires more development.

Also, given the digitalisation requirements set by the ecodesign proposal, ideally, DPPs should aggregate all meaningful characteristics. This would support improved information flows and decrease complexity throughout the life cycle. At this point, LOIN can support improved data management. However, overcomplicating data requests or setting as mandatory unrealistic characteristics can endanger the accomplishment of the objectives.

The AECOO value chain has been developing and implementing several processes based on ISO standards relevant to Data Templates and BIM. These should be considered as existing practices when discussing DPP implementation in the CI and from a multi-sector perspective, as this is essential to mitigate potential future problems.Similarly, the EPDs' situation must be clarified in the regulations proposals. Despite all problems, a lot of resources have been invested by manufacturers to disclose this type of data. From the manufacturer's perspective, there is an apparent misalignment between the data requests and the willingness and/or business value perception to deliver the data. This means that a streamlined implementation might struggle or be deemed to fail due to inconsistent visions and misaligned strategies.

In line with these limitations, this study presents some findings that can be relevant to the future development of

DPPs in the construction industry. First, specific strategies must be drawn to recognise the manufacturer's role in the value chain and as a central data supplier for DPPs. Second, incentives should be set, explaining the importance of the data requests and supporting their disclosure. This would bring other enthusiasm for proportionality among the stakeholders involved. Third, manufacturers' competitive advantage cannot be endangered, and all requests that impact this dimension must be worked on in detail.

These aspects are vital in defining new lines for what is reasonable regarding product data disclosure, mainly the one facilitation circular economy. Furthermore, future work will continue exploring the manufacturers' perception of the data requirements and studying the characteristics that should be part of the data framework. Further clarification between different concepts must become clearer, mainly at lifecycle and dataset levels. This applies to DPPs, material passports, circularity passports, and product circularity datasheets, among others. Finally, lessons from the past must be considered to avoid repeating errors. However, some were systematised at the introduction of CPR regulations, but more work is still required. Failure or errors in accomplishing defined goals would be critical for the CI value chain and for delivering high-performing and sustainable built assets, which could also have ripple effects on other sectors of the global economy.

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