What to Monitor? In Search for High-level Concepts for Circular Economy and Sustainability Monitoring

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Abstract

To facilitate the transition toward a circular economy (CE), EU policymakers are drafting new policies and legislations at a high speed. This affects a wide set of sectors and leads to legislative complexity. At the same time, the legislative developments requiring Digital Product Passports (DPPs) offer opportunities for governments to tap into a rich set of business supply chain data for CE and sustainability monitoring. Nevertheless, the diversity of these legislative initiatives leads to complexity for governments on what needs to be monitored. There is a need to reduce legislative complexity, to have a more clear view on what governments need to monitor, which in turn would provide more clarity on the types of business data from the Digital Product Passports and digital infrastructures governments may need to access for CE and sustainability monitoring purposes. One approach to reduce the legislative complexity is to have a framework of high-level concepts for CE and sustainability monitoring. The question, however, is how to arrive at such a framework of high-level concepts. In this paper, we explore the potential of the concepts found in the UN Recommendation 46 (initially developed for the traceability of textiles), to serve as a basis for a generic framework of high-level concepts for CE and sustainability monitoring. We examine the suitability by applying the concepts from UN Recommendation 46 to a variety of legislations beyond textiles. Our analysis suggests that the framework has the potential to serve as a high-level framework of CE and sustainability monitoring concepts across sectors, and we identify several areas for further research.

Keywords

circular economy (CE), monitoring, concepts, framework, digital Infrastructures, digital product passport (DPP), legislation.

1. Introduction

Since the introduction of the Green Deal [2], next to already existing directives and regulations, many EU Directives and Regulations have been developed that are gradually

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coming into force to stimulate the transition from a linear toward a circular economy (CE). Examples of new legislations are the Battery Regulation [9], the Carbon Border Adjustment Mechanism [3], and the Proposal for an Ecodesign for Sustainable Products Regulation (ESPR) [5]. This leads to legislative complexity for the authorities because the regulations come on top of existing regulations, come rapidly into force, and affect different sectors. In addition, complexities are emerging because the variety of CE regulations demands different data requirements from different authorities, which affects the monitoring progress and the formulation of policy interventions.

In response to the CE regulations, businesses undertake digitization efforts to demonstrate compliance, such as, amongst others, the introduction of Digital Product Passports (DPPs). Such DPPs are becoming obligatory for some product groups such as batteries. DPPs can be seen as "a structured collection of product-related data with the pre-defined scope and agreed data ownership and access rights conveyed through a unique identifier and that is accessible via electronic means through a data carrier. The intended scope of the DPP is information related to sustainability, circularity, value retention for re-use, remanufacturing, and recycling"[2]. These digitization initiatives offer opportunities for governments to tap into a rich set of business supply chain data (either mandatory or provided by businesses on voluntary basis) for the government monitoring tasks. However, next to the legal complexity related to multiple legislation, this is also coupled with the technical complexity concerning (1) how governments can access this information, and (2) whether this information (if available) is indeed valuable for CE monitoring purposes. To bridge the gap between the legislative and the business data complexities, an approach is needed to align the data needs for CE and sustainability monitoring with how businesses organize their data in information architectures. A first step in that direction is for governments to understand what they need to monitor related to CE and sustainability, given the large number of new regulatory developments. In other words, the first key challenge is how to reduce the legislative complexity for government to better oversee the requirements for data they may need for CE monitoring to fulfill their tasks.

To reduce the legislative complexity, one direction may be to take a more abstract view and to identify a framework with high-level concepts that capture generic information requirements of what governments need to monitor based on the different legislations. This would help to examine what data governments may need from the business infrastructures for CE and sustainability monitoring purposes. However, the question is how such a framework of high-level concepts could look like or can be derived?

In this paper we take the UN Recommendation 46 (hereafter referred to as UN R46) [17] which was developed for the traceability of textiles, and examine its potential to serve as a high-level framework of CE and sustainability monitoring concepts. We examine the suitability of the framework in dealing with a variety of legislations [9, 3,4,6,7,8][3], beyond textiles. While only covering a small sub-set of relevant existing and forthcoming legislations, we aimed to include legislations that are quite diverse. The remaining part of this paper is structured as follows. In section 2 we introduce our theoretical background

[2] See https://cirpassproject.eu/faq/ under the concept What is a Digital Poduct Passport (DPP)?
[3] See the Method section for further details on the legislations that we analyzed

and the UN R46 as a basis for our analysis. In Section 3, we present our research method. In section 4, we present the results of the analysis. We discuss our findings in section 5 and end the paper with conclusions and recommendations.

2. Theoretical background and introduction to UN Recommendation 46

2.1. Theoretical background

This study steps on years of research that has been exploring how governments, such as customs organizations and other government agencies can piggyback on business data available in international supply chains for government control purposes [1, 16, 11, 10, 14]. In particular, this stream of research has examined how governments, next to the data that they receive from the regular business-to-government channels (e.g. import declarations filed by companies to customs before importing goods in the EU) can potentially benefit from the wealth of other business data residing in the systems of the supply chain partners, which is potentially of better quality as the data comes from the original data source. In the wider e-Government context, this also relates to the broader theme of voluntary business-government information sharing and partnership models that can be pursued [15], as well as research on the value of business data for governments [13].

Many of these earlier studies explore business-government data-sharing arrangements in the context of voluntary data sharing, and for supporting current activities of government (e.g., conducting risk analysis for safety and security or fiscal concerns). The emergence of new legislations on circular economy and sustainability as discussed in the introduction add new monitoring requirements for governments. The fast pace of changes in the legislative environment may be overwhelming for government authorities on what to monitor when it comes to CE monitoring, considering that these new legislations can be very sector-specific or affect specific product groups (e.g., the Battery Regulation affecting batteries) or generic in the sense that the same regulation can apply to several or all sectors (e.g., the Waste Shipment Regulation).

Some of these legislations [5,9] make the use of Digital Product Passports (DPPs) mandatory for businesses to disclose business data to other supply chain parties and the authorities. These data can include aspects such as material composition and CO2 emissions related to the products. But also, dynamic data such as the state-of-health data of a battery must be disclosed to the authorities on a need-to-know basis. In the ESPR [5] it is foreseen that only a limited data set will be available in a centralized EU DPP registry. The actual DPP data will be available in the information infrastructure of the businesses or their service providers. In the future, especially in cases in which government authorities want to perform some of their tasks in a data-driven way and want to use these additional business data for risk analysis, it will be key to understand which data governments need for CE and sustainability monitoring. This can be a starting point for evaluating the value of the data available in the business information infrastructures (including DPP data and other data). Previous research in the context of safety and security and fiscal use of external business data sources [13] indicates that the value of business data for the government can be very much dependent on what governments need to monitor. Likewise, what to monitor for CE monitoring is dispersed among different CE and sustainability legislations, which can be

very context-specific. However, they also contain data points that are similar at a more abstract level. For example, both the Battery Regulation which applies to batteries as well as the Carbon Border Adjustment Mechanism which applies to products such as steel and cement, contain the requirement to monitor CO2 emissions. This leads to the question of whether we can identify a set of generic concepts that can be abstracted from the diversity of legislations to reduce the legislative complexity of CE and sustainability monitoring. This generic system of concepts can be seen as a first step towards formulating more formal information requirements towards the information infrastructures using for example ontologies and upper ontologies [18]. In this paper we focus only on how to reduce the legislative complexity. The second step of linking this to formal ontologies for automated access to data is out of this scope of this paper and will be subject to further research.

To address the legislative complexity, we explore the potential of UN R46 to act as a high-level framework of concepts[4].

2.2. Introduction to the UN Recommendation 46 [UN R46]

The UN R46 [17] provides key stakeholders (e.g., governments, businesses, and consumers) with a standardized mechanism based on internationally agreed practices for data collection and monitoring across the value chain in the textile industry. It aims to support key stakeholders in transitioning towards sustainable and responsible business practices that are transparent and accountable. While developed within the textile industry, particularly the garment and footwear industry, this recommendation is intended to be applicable across other sectors, making it relevant to explore its potential within our research setting. This recommendation focuses on two main aspects to monitor, namely traceability-related information and sustainability-related information. Traceability refers to the ability to identify and track the materials and products throughout the supply chain, including (but not limited to) their history, location, conditions, and distribution [12, 17]. Sustainability means that the impact of every activity throughout the supply chain is considered from the environmental, health, human rights, and socio-economic perspectives [17]. The set of concepts from UN R46 is used in Table 1 for analyzing the legislation that we selected for this analysis. We use the UN R46 concepts to map out our in-depth and quick scan analysis of various CE-related regulations, beyond textiles, to examine their applicability in serving as a basis for a high-level framework of concepts for CE and sustainability monitoring.

3. Research Methods

This research is part of the DATAPIPE[5] project. The DATAPIPE project aims to investigate how governments can make use of information available in digital infrastructures of business supply chains (including DPP data) for CE and sustainability monitoring purposes.

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[4] In the method section we explain our choice to start with UN R46
[5] https://www.tudelft.nl/datapipe

3.1. UN Recommendation 46 as a starting point

For this research we considered two options on how to identify high-level concepts for the framework for CE and sustainability monitoring, i.e. (1) looking for existing frameworks that we may adapt for our analysis, or (2) deriving such a framework bottom-up from the regulations. We aimed to identify at least one framework to start the analysis. Our requirements when searching for a framework included considerations such as that (1) it can be used as domain-independent across domains; that (2) the concepts are operationalized to some extent to allow for a finer-tuned analysis, and (3) that would allow for standardization. (4) We also looked at global developments, as business supply chains are global. In the search process, we looked at the UN as an international organization that has been driving the standardization of business information at the international level for decades. We found several UN initiatives at various levels of development. The UN R46 [17] on textile traceability caught our attention. First, the rationale for developing UN R46 was to get assurances about all kinds of sustainability claims based on data from the business systems of the supply chain partners. This type of information and assurances are highly relevant for authorities (specifically customs authorities) who are monitoring international trade flows and are interested in trustworthy information. The concepts of the UN R46 were also already quite operationalized to capture traceability and sustainability-related information. These aspects, in combination with the UN status of the document which may provide the basis for further international standardization, made us consider this document as a potentially suitable starting point for our analysis. The UN R46, however, had one limitation given our study's purpose: it was developed mainly for the traceability of textiles. In our approach, we needed to examine to what extent the concepts defined in UN R46 are suitable to capture concepts from legislations from other sectors beyond textiles. In our study, we first conducted an in-depth application of the UN R46 to one legislation (Battery regulation) beyond the textile domain, followed by a quick scan analysis of a range of other legislations that also have CE and sustainability monitoring requirements. Namely we focused on legislations related to Carbon Border Adjustment (CBAM) [3], REACH on restriction of chemicals [4], the Waste Framework [7], Waste Shipment [8], and Forced Labour regulation proposal [6]. In the selection, we included a mix of more generic and more specific legislations. For our analysis, we considered the selected mix as a good starting point with a diversity of legislations represented. Other legislations can be added to the analysis in the future.

3.2. Data analysis

For the data analysis, we created an Excel file with the concepts from the UN R46. Subsequently, the main documents that we used for the analysis were the legislative documents of the legislations listed in the previous section, supplemented with additional documents to gain a better understanding. The main work on the analysis of the legislation was done by a team including four of the authors that met regularly to discuss the UN R46 concepts and to gain a shared understanding. Subsequently, every team member focused on specific legislations and several alignment meetings took place to discuss the findings and the interpretation of the categories. While the process of interpreting the concepts and

applying these is subjective, by the alignment meetings we aligned our way of working and to reduce the interpretation bias and to achieve inter-coder reliability. Sessions with the wider team were organized where results were presented and discussed. The authors not directly involved in the analysis played an instrumental role in providing critical reflection.

4. Results of the analysis

4.1. Detailed application of Recommendation 46 concepts to the Battery regulation

For the in-depth analysis, the UN R46 concepts were applied to the Battery regulation [9]. In the analysis, we aimed to identify the concepts covered in the regulation, as well as concepts from the regulation not covered in the framework. The results of the first part of the analysis are presented together with the results of the quick scan in Table 1. The establishment of the results can best be illustrated by a set of examples.

Annex XIII of the Battery Regulation states that the "material composition of the battery, including its chemistry, hazardous substances present in the battery, other than mercury, cadmium or lead, and critical raw materials present in the battery" [9, p 108] need to be specified, just as the "materials used in the cathode, anode and electrolyte"[9,p. 109]. Therefore, it can be stated that the UN R46 product-related information concept for the composition is relevant. Also, the category *greenhouse gas emissions* is directly relevant since the regulation describes in that "a carbon footprint declaration shall be drawn up for each battery model per manufacturing plant" [9, Article 7, p. 31) and be reported on. Another illustrative example for the analysis is the water pollution and wastewater management as part of the environment-related information. The category is classified as 'to some extent' relevant for the specific regulation in Table 1 since part of the battery due diligence is listing the "significant adverse impacts in the risk categories listed" [9, Article 52, p. 54], for which water pollution is included.

In general, it can be stated that the concepts defined in the UN R46 align with the concepts of those listed in the legislation concerning battery and battery waste. However, the interpretation of the structure differs. The Battery legislation focuses on the reporting of a specific product. Process, facility, and transport-related information in terms of UN R46 is related to the product level, which is the battery in the case of the Battery regulation. Therefore, the categories are applicable but should sometimes be interpreted differently. For example, facility-related information is about details of the manufacturer of the battery, supplier subcontractors, etc., which each need to be reported in the DPP in relation to the product. Similar interpretation differences in the structure are applicable for the certification or reports category, which needs to be included for a range of aspects. Separate reports need to be filed on tests, carbon footprint declarations, etc., for which each aspect for which sustainability certificates or inspection reports apply.

Also, the concepts mentioned in the R46 are generic. Specification of different concepts is required to align with the level of detail of reporting as enforced by the legislation. For example, the UN R46 describes the concept of carbon footprint, while the Battery Regulation requires to report the carbon footprint "per life cycle stage", such as, production, distribution, and end-of-life. For the second part of our analysis, we focused on the elements named in the Battery Regulation and not in the UN R46. For example, Article 8 of the

regulation describes the information on recycled content that should be documented. However the concept of material type classification (such as primary, secondary, and renewable) does not directly fit directly in one of the existing concepts of the UN R46. Therefore, it is suggested to extend the UN R46 with this category. Also, the Battery Regulation focuses on reporting aspects that are identified before the initial product is placed on the market. Actions that happen over the life cycle, resulting in additions or changes, for example, due to reuse or repair, are considered to a limited extent by the UN R46 but are important from a circularity monitoring perspective.

4.2. Results from the quick scan analysis

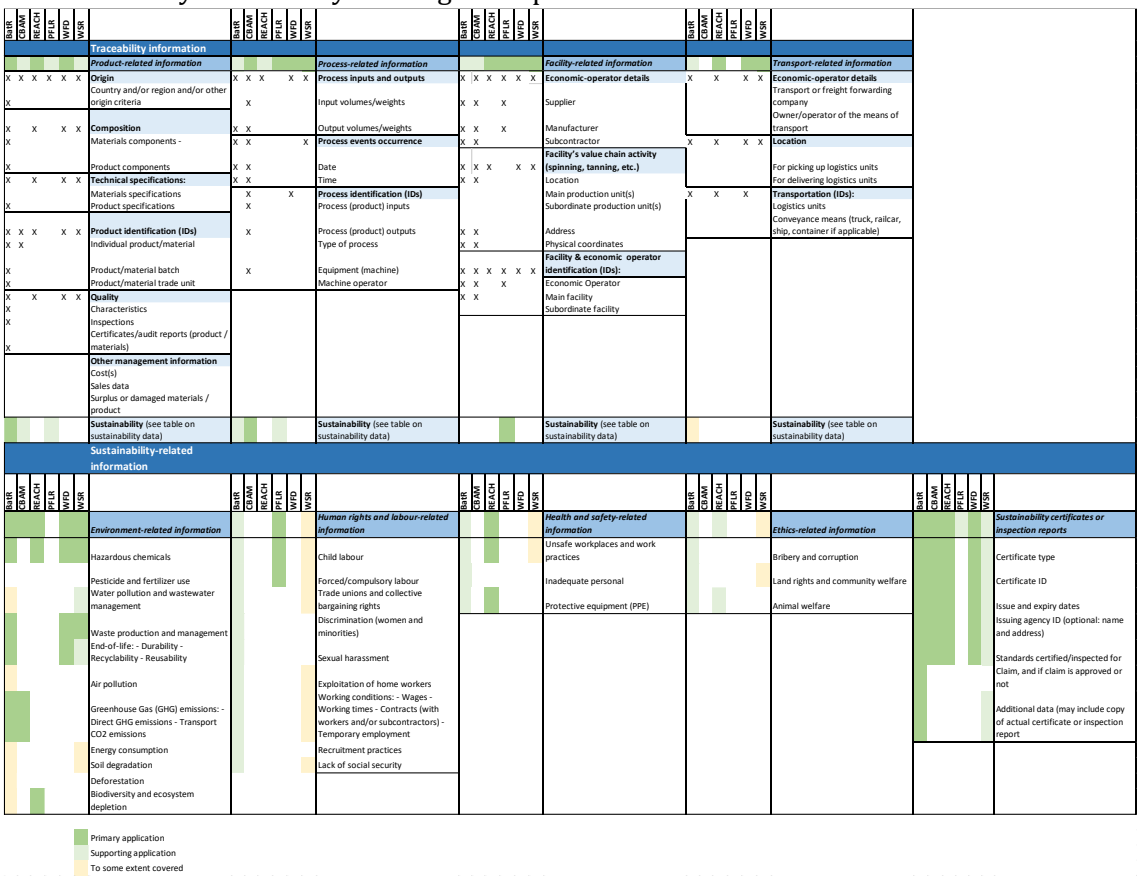
Table 1 includes also the results from the quick scan analysis. It includes the analysis of the in-depth analysis of the Battery and battery waste regulation (discussed in the previous section), as well as the insights from the quick scan from applying the framework to the other legislations we selected. For the quick scan analysis, the selected legislations were analyzed based on the key features that were most prominent rather than going into full detail. Table 1 is structured as follows. The top part of the table covers concepts from UN R46 related to traceability information, including the four main categories from UN R46 related to traceability, namely (1) product-related information; (2) process-related information; (3) facility-related information, and (4) transport-related information. Under each of these four categories, specific sub-categories are defined in UN R46. For the Category product-related information, for example, these sub-categories include Origin, Composition, and Product ID. As each of the four main traceability categories includes the sub-category sustainability, it appears several times in Table 1 under traceability information. The bottom part of Table 1 details the sustainability-related information based on the five main categories as defined in UN R46, namely: (1) Environment-related information, (2) Human rights and labor-related information; (3) Health and safety-related information; Ethics-related information; and (5) Sustainability certificates or inspection reports.

For the traceability-related information, the quick scan was mainly focused on identifying which main category was covered. Also, we introduced a color scheme, where dark green means that a category is the focus of the legislation; light green means that a concept is covered in the legislation but may not be a main focus; yellow means that it is covered only to a limited extent. White, when found in the main categories, indicates that a specific aspect seemed not to be covered in the legislation or this part was not a main part that was immediately visible when analyzing the relevant legislation. Based on the quick scan analysis by applying UN R46 to multiple very diverse legislations that address CE and sustainability monitoring, we derive several observations.

First, despite the diversity of the legislations we analyzed, the concepts of UN R46 seem to work well for capturing key aspects of the legislation on what to monitor. For the traceability concepts, we identified that many of the legislations we identified were interested in information about the products, processes, facilities, and transportation. Sub-categories related to identification were also important, such as identifying the products and facilities. As such, we consider that UN R46 provides a useful set of concepts to serve as

a basis for high-level concepts of what to monitor, allowing us to capture monitoring concepts that can be covered in a diversity of legislations beyond textiles.

Table 1 Summary of the analysis using concepts from UN R46



Second, our analysis shows that the categories can be used (in combination with the color schemes we introduced) to identify the focus of the legislation. For example, while all the key traceability categories may be covered in legislation and these categories are quite related, some legislations, like the Battery Regulation, are more product-focused, going into details of the product and its material composition. Other legislations like CBAM are more focused on the process of how these products are produced and the related sustainability parameters. Yet, other legislations, like the legislation on Prohibiting products made with forced labour, focus on Facilities with specific emphasis on actors and their relationships. Therefore, we observe that in application to legislation, additional aspects could be added (like the color schemes that we introduced) to allow us to capture what the primary focus of specific legislation is, as this will also steer the further understanding of what this legislation aims to monitor (e.g., primarily products, processes, or actors) and what information that resides in the business digital infrastructures may be of value.

Third, we also identify that some concepts occur under different categories. For example, actors like economic operators appear under Facility-related information and Transport-related information. However, some actor categories, especially if they are intermediary actors, may be difficult to categorize under facility or transport. In that respect, it may be

useful to define a separate category of actors or economic operators that can be linked to the other categories, as is done with the Sustainability information category that is added at the end of the four main traceability-related categories (see Table 1).

Reflecting on the bottom part of Table 1 related to the sustainability-related information, we consider that the identified concepts allow for a rich basis for identifying concepts on what to monitor. The category *environmental-related information* and *sustainability certificates and inspection report* cover a variety of concepts that are required by different legislations. The *human rights, health, and safety-related information* are not always the predominant focus, but they provide a rich base to capture these aspects when covered in the legislation, as was the case with the Regulation prohibiting products made with forced labour. Thus the concepts covered under sustainability-related information also provide a good basis to capture information requirements on what to monitor that can be found in legislation. Our analysis also shows that some information may be of interest for monitoring from a legislative perspective that is not included in the UN R46. For example, the Waste Shipment Regulation includes aspects that refer to insurance and finance that are not immediately visible in the UN R46 concepts. Therefore, the UN R46 concepts can be further expanded in the future to also include monitoring related to finance and insurance information.

5. Discussion

5.1. Reflection R46 based on the legislative analysis

From the legislative analysis, our general observation is that the UN R46 can form a basis for a high-level framework of concepts for what to monitor. The UN R46 concepts were developed in the context of textile traceability but by the detailed and quick scan analyses on a variety of legislations, the UN R46 concept seems to be capable of covering key monitoring requirements from these other legislations as well. The concepts are high-level but detailed enough to let us capture key aspects covered in legislation. The traceability aspects could be further used to identify the key focus of legislation from a monitoring perspective (e.g., product, process, facility) and a process perspective that could be a step in the analysis process to identify the focus of specific legislation to better understand what its primary focus for monitoring is. Based on our application of the framework, we also found several ways to extend it, including aspects from the use phases identified in the Battery Regulation, or aspects related to finance and insurance. Based on our analysis, we observe that UN R46 holds the potential to serve as a high-level framework of CE and sustainability monitoring concepts and may need to be further adjusted and tested in further research.

5.2. Implications for policy and potential for standardization

For policy making and drafting future legislations, the high-level framework can serve as a checklist to identify relevant aspects that policy makers want to covered. For authorities that need to enforce the legislation, such a framework can serve for better awareness of what to monitor when it comes to forthcoming CE regulations. While these legislations may

affect a wide set of products, the basic set of concepts for what to monitor can help to deal with the complexity and better understand what aspects are covered in new legislations.

This improved awareness can also support governments to identify information that can be of value for them from the business infrastructures. Based on such awareness, authorities can, for example, attempt to specify standardized information requests (queries) toward the business infrastructure to request access to, for example, specific Digital Product Passport data. These standardized queries may be useful across multiple EU Member States, as far as their legislative requirements are the same. In addition, this framework of high-level concepts can support national authorities to specify information requests (queries) based on national-specific requirements when needed. This research and follow-up research to arrive at a stable set of concepts can also serve as a basis for standardizing concepts for CE and sustainability monitoring at the EU or international level, and toward standardized queries that governments have toward business infrastructures and Digital Product Passports. The step towards such queries however goes beyond the scope of the current study. Here we focused on identifying high-level monitoring requirements only. For making a step toward machine-readable queries towards the business infrastructure, further research is needed to identify what additional aspects (including aspects of semantics, ontologies and upper ontologies, see [18] need to be covered to allow data to be technically accessible and made available to the authorities. As supply chains are global, more standardization on what to monitor may lead to better CE and sustainability monitoring on a global level [19].

6. Conclusions

In this paper we explored the potential of UN R46 to serve as a basis for a high-level framework for CE and sustainability monitoring that can be used to help governments reduce the legislative complexity and to allow them to better understand what to monitor. On its turn it would help governments to better specify what information from the business infrastructures and Digital Product Passports they may need to access to perform monitoring tasks. Our analysis suggests that the concepts provided in UN R46 hold the potential to provide a basis for a high-level framework and we identified areas how this framework can be further adapted. Our research also has limitations, one of which is the choice of UN R46 itself. We do not exclude that there may be other suitable frameworks. One direction for further research is to search for other potentially suitable frameworks and conduct a comparative analysis. Another direction is to including more legislations for the in-depth or the quick scan analysis. Such steps would allow to arrive at a more robust framework which may serve as the basis for standardization. Further research will also be needed to evaluate how these high-level information requirements can be used to specify information requests towards DPPs/digital infrastructures and technical steps required.

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