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Border Crossing and Circular Economy Monitoring in a Global Context: Challenges and Opportunities

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ABSTRACT

Circular economy (CE) and sustainability are high on the political agenda of governments nationally and internationally. We see different regulatory developments where governments aim to put stricter rules and requirements towards businesses to ensure the transition toward a more circular and sustainable future. The use of digital infrastructures, including transparency systems and digital product passports is starting to play a vital role in supporting governments in their CE monitoring efforts. Yet there are challenges to be overcome. Many government procedures are set up in laying out very detailed requirements about what one government agency can do in a singular phase of the circular process (e.g., customs performing specific checks at the border) or a single Member State (e.g., organizing Extended Producer Responsibility in a specific country). While these efforts are valuable building stones towards CE monitoring, they are fragmented, and blank spots in CE monitoring occur when borders are crossed, and another country needs to take over the CE monitoring tasks. As for circularity, even if many efforts are spent by a single government agency or a single country, all these efforts may be in vain if the proper CE monitoring of the next step is not secured. While earlier research identified this problem, there is still limited understanding of the problem itself and directions to address it systematically. In this paper, following up on earlier research and with insights gained from an EU project on CE monitoring, we shed further light on the problem. More specifically we conceptualize CE monitoring by putting the CE flows at the center and exploring deficiencies for governments and businesses to safeguard the monitoring of CE flows. We examine two routes that can be followed to ensure continued CE monitoring when borders are crossed, namely the government route, as well as the business route (enabled by traceability systems and in-control mechanisms of businesses). We discuss the need for a global governance layer that can facilitate both routes and propose further directions to advance CE monitoring by taking a global perspective.

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CCS CONCEPTS

• **Information systems** → Information systems applications; Enterprise information systems; • **Social and professional topics** → Computing / technology policy; Government technology policy.

KEYWORDS

Circular Economy, Monitoring, Border crossing, Global, Business, Government, Digital Product Passport, Supra-national, Supply Chains

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1 INTRODUCTION

Since the publication of the EU Green Deal in December 2019 [1], a series of Directives and Regulations have been issued to establish stricter rules and requirements for businesses to ensure the transition towards a more circular economy (CE). Geisdoerfer et al define the "Circular Economy as a regenerative system in which resource input and waste, emission, and energy leakage are minimized by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling" [2, p. 766]. A CE intends to replace the linear production cycles of make, use, dispose, and waste with production cycles in which waste is limited by the reuse of resources at the end of a product life cycle or by returning the resources to the environment in an environmentally friendly way. In addition, circularity can be improved by a change in product design and manufacturing to reduce the use of natural resources and (critical) raw materials. As well as by stimulating the reuse of products e.g., via a second-hand market or improving the repairability and maintenance of products to extend their life cycle. These strategies are captured in the 9R framework of circularity [3]. The EU regulations address these strategies, examples amongst many others are the Corporate Sustainability Reporting Directive (CSRD) [4], the Regulation on Batteries and Waste Batteries [5], the Proposal for regulating the End-of-Life Vehicles [6] and the Ecodesign for Sustainable Products Regulation (ESPR) [7]. The ensuing obligations on businesses need to be monitored by governments. To this end, digital infrastructures, including traceability systems and digital product passports will be instrumental in supporting governments in their CE monitoring activities [8]. Yet there are

challenges to monitoring full circular product cycles because many government procedures contain detailed requirements about what one government agency can do in a singular phase of the circular cycle (e.g. customs authorities performing specific checks on the import of products at the border) or what a single Member State can do on a national level (e.g. the monitoring for corporate sustainability reports or extended producer responsibility). While these efforts are valuable building stones towards CE monitoring, they are fragmented, which causes blank spots in CE monitoring when borders are crossed, and another country needs to take over the CE monitoring tasks. Even if a single government agency or a single country monitors the full circular cycle, their efforts may be in vain if the proper CE monitoring of the next phase such as in the case of cross-border movement of goods, is not secured.

Whereas earlier research acknowledges this deficiency [9] a systematic analysis to map the problems and develop directions to address them systematically is lacking. Hence, in this paper, we conceptualize CE monitoring by putting the CE flows at the center and by exploring deficiencies for governments and businesses to safeguard the monitoring of full circularity cycles. Next, we examine two routes that can be followed to ensure CE monitoring when borders are crossed. The first one is the so-called *government route* which examines how governments collaborate to transfer CE monitoring responsibilities when borders are crossed. The second one is the so-called *business route*, which is enabled by traceability systems and in-control mechanisms of businesses. Our analyses demonstrate the need for a global governance layer to facilitate both routes to ensure safeguarding the CE flows. To this end, we propose future research directions to advance full circularity monitoring by adopting a global perspective.

The structure of this article is as follows. In section 2 we present the conceptual foundations to describe the context of our research as well as our research approach, where we focus on the management and policy insights on the topic of CE monitoring and border crossing, taking the global perspective into account. In section 3 we present two examples to illustrate the current barriers to full circularity monitoring. Subsequently, we explore two routes for addressing border crossing issues and their effect on full circularity monitoring in a global context: the government route in section 4 and the business route in section 5. We finalize the paper with a discussion and conclusions (section 6).

2 RESEARCH CONTEXT AND APPROACH

A 2021 call to information systems (IS) researchers to address the grand societal challenge of moving from a linear to a CE by Zeiss et al [10], led to publications on a wide variety of topics in which the research domains on CE and information systems are bridged. Spurred by either the implementation of EU regulations for circularity and/or by the promises of new digital applications such as Machine Learning, Artificial Intelligence, Blockchain technologies, Cloud Computing, and IoT [11], this interdisciplinary field shows a fast take-up. The CE-IS cross-over publications represent a wide range of perspectives. Some focus on how ICT can support visibility in circular supply chains [12–15], other researchers address the availability of data to enhance circularity, e.g., by using digital product passports [16, 17]. The domain of study can be specific such as logistics [15] or food [18], or agnostic to explore digital applications or platforms that can be used in several domains [19]. However, research into digitization for the role of governments in the CE transition is still scarce [20–25]. Within this research domain of e-government for CE monitoring, the monitoring of cross-border aspects of circular flows is even less studied. Previous research presented a framework of border crossing and levels of control for CE monitoring to highlight that governments may lose control in CE monitoring when borders are crossed [9]. In this policy paper, we provide an analysis of the issues to identify possible perspectives and ways forward.

Our framework of Border Crossing and Levels of Control [9] visualizes four viewpoints to conceptualize the issue of border crossing and levels of control when it comes to CE monitoring. The first view is the *focal point view*, which brings attention to specific products subject to CE monitoring and specific government agencies that are involved in their monitoring as a starting point for the analysis. The second view, called *the global CE view*, zooms in on the processes related to the circularity of a product, from the sourcing of (scarce) raw materials, production, use, extended use, end-of-life treatment to secondary raw materials that re-enter the economic and production system [3]. The third view is the *government level of control view,* which addresses border crossing aspects, e.g., when goods enter a specific EU country, they remain there under domestic control of national government agencies or whether border crossing is taking place e.g., to other EU Member States or non-EU countries.

Border crossing leads to partial control of national authorities for monitoring CE flows. This can be addressed by collaborations with other countries, but if such agreements are weak or not in place at all, then full CE monitoring control is lost. This can hurt reaching policy objectives toward a CE. The fourth view in our framework represents the *government procedures* which can be very specifically related to a particular lifecycle aspect of a product. For example, the import of a new car into the EU is subject to specific import procedures whereas the export of a second-hand car out of the EU is subject to specific export procedures. The framework can be used to examine the interactions between these four views: on the one hand to deep dive into the details of specific government procedures and on the other hand to take the global CE view into account. In this paper, we use this high-level framework as a starting point for an inventory of the challenges for full CE monitoring when products cross borders. We specifically focus on the parts of the framework that refer to the cross-border aspects when it comes to the outer EU borders and challenges and opportunities offered by the government and the business route, but we do not go into the detailed government procedures' view.

2.1 Research approach

This policy paper is based on research conducted in the EU-funded project DATAPIPE[1]. The goal of the project is to examine how digital infrastructures and digital product passports can be used as external business data sources by the government for CE monitoring objectives. Within the project, we applied a case study research

[1] https://www.tudelft.nl/datapipe

approach to analyze the challenges and solutions for CE monitoring. Two of these cases are presented as illustrative examples in section 3.1 on cars and section 3.2 on textiles. As the research is primarily aimed at conceptualization and developing frameworks, we adopted an exploratory, inductive approach to reviewing relevant EU and national legislations and documents regarding circularity [5, 26–28], and academic articles related to policy developments and the digitization of e-government, such as data-sharing infrastructures [21] and digital product passports [17, 29–32]. In addition, we conducted a review of conference proceedings on the topic of green customs [21, 33–36] and analyzed relevant publications by international organizations such as the World Customs Organization (WCO) [37, 38], the World Trade Organization (WTO) [39], and the United Nations (UN) [40–43]. All analyses were performed and discussed by at least 2-3 researchers in the project team and presented and discussed in regular interactions with relevant stakeholders in the domain of CE monitoring took place during the entire project. They represent the business as well as government perspectives on CE monitoring when products cross borders. This policy paper offers a perspective on directions that governments and businesses can explore to improve circularity monitoring when borders are crossed and to identify future research topics to this end.

3 CHALLENGES FOR CE MONITORING WHEN CROSSING BORDERS: TWO ILLUSTRATIVE EXAMPLES

To illustrate the challenges for CE monitoring when products cross borders, we present two running examples. The first is related to cars and the second to textiles. They are meant as a point of reference for the presentation of the routes to address the challenges in sections 4 and 5.

3.1 The example of cars crossing borders

There is a variety of issues that relate to the circularity of vehicles (see e.g., the UNEP report [44] and [6] in which some of these problems are elaborated on). For example, one problem is missing vehicles, caused by a lack of data on the vehicle's whereabouts. In this case, CE monitoring is hampered as a government authority cannot ensure that the car has been properly disposed of at the end-of-life stage [6].

A second problem is related to the export vehicles that approach their end-of-life to e.g., Africa, which poses challenges for CE monitoring. The EU has clear legal rules and guidelines with environmental requirements during use and the disposal of end-of-life vehicles [6, 45]. For example, in the Netherlands, a specialized organization organizes the extended producer responsibility for the end-of-life treatment of cars. Such organizations need to report to the government how the targets set for end-of-life vehicles are met [46]. However, when the cars are exported outside of the EU, it is not clear how these vehicles are used or disposed of and whether monitoring mechanisms are in place to ensure proper environmental concerns about the end-of-life treatment [47]. If such mechanisms are not in place, then no matter how well the EU monitoring procedures are implemented in one country, the CE monitoring process may be broken, and the car could have a large negative environmental effect during the use phase or when disposed of improperly beyond the EU. This can lead to pollution or the loss of resources such as critical raw materials. This example shows the necessity to take a global view of CE monitoring.

3.2 The example of textile crossing borders

Textiles and fast fashion pose challenges to circularity monitoring because textile supply chains can be long, and many borders are crossed during their lifecycle. An example of a textile lifecycle is for clothes that are imported into an EU Member State, to be sold in shops, worn, and at the end of life their owners bring these to collection points or charities for reuse or recycling. After sorting, a selection of these clothes can be exported to businesses outside the EU for reuse, repair, repurpose, recycling, or recovering the materials [3]. Many steps in this process may reflect good business and government practices where clothes are properly sorted and exported to businesses abroad. But after borders are crossed it becomes more difficult for EU governments to monitor what happens with these textile flows [48]. Some of these flows enter the secondary market, where valuable clothes with economic value can proceed toward a follow-up destination for use or recycling. However, the control mechanisms that are in place may not be sufficient to ensure how the remaining flows are being dealt with. This can result in clothes that are exported for recycling being dumped as waste or burned, with the associated negative environmental consequences. While parts of the textile flows may be well under control and stringently monitored, more is needed to close the monitoring gaps when the goods leave countries with more stringent CE legislation. From a global CE monitoring perspective, when clothes are disposed of in landfills or burned in the open air, there is only one planet, and the CE measures have not been able to prevent this pollution.

Whereas these two examples may overly simplify the issues, they are instructive to imagine more specific and actual steps in monitoring circularity flows. The rise in EU regulations and strict rules for CE monitoring practices can be at odds with policies and developments in non-EU countries that can hamper full CE monitoring when borders are crossed. Therefore, efforts need to be made to cover areas that are currently less well secured from a CE monitoring perspective.

3.3 Mapping the problem of cross-border aspects of CE monitoring

In Figure 1 we visualize the problems of the cross-border aspect of CE monitoring. It builds on [9], however, it takes a more focused perspective by zooming in on the cross-border aspects and specifically when non-EU borders are involved. In addition, as we aim to see how CE monitoring is safeguarded at a global level, we place CE monitoring at the center of our conceptualization. Hence, at the center of Figure 1 are the CE flows as the core aspect to be safeguarded by CE monitoring. Around these CE flows, a circle for the *monitoring efforts of businesses* that implement the CE flows of a specific product is mapped. We also add a circle to represent the CE *monitoring efforts of governments*. For both businesses and governments, the monitoring may be enabled by digitization as represented by the *digitization circle* around the CE flows.

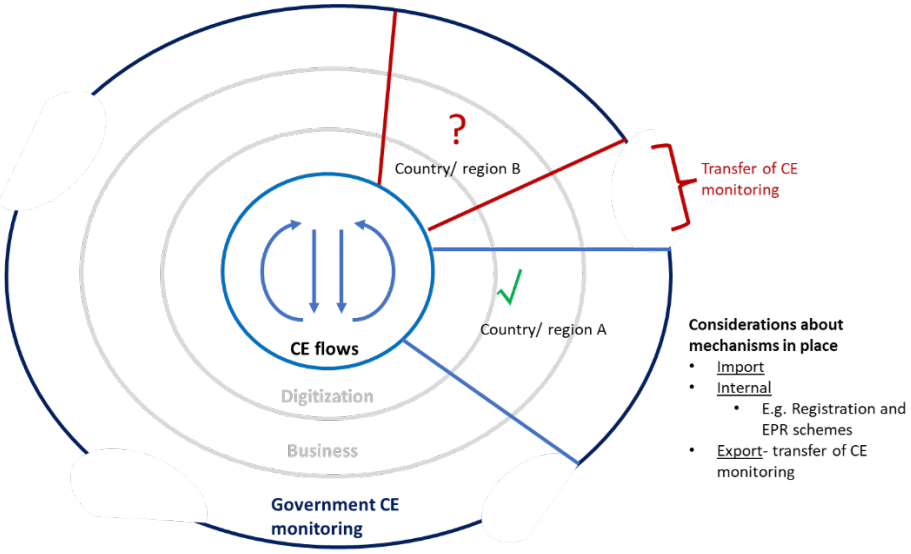

Figure 1: Conceptualization of the issues with transferring CE monitoring when borders are crossed

For mapping the problem domain of border crossing and CE monitoring, we first take the government circle as a starting point for conceptualizing the problem. The broken lines represent the current problem that CE monitoring efforts can break when borders are crossed. As shown by our two illustrative examples, even if mechanisms (such as extended producer responsibility schemes) are in place in some countries for specific product groups (like cars), when borders are crossed safeguarding the CE monitoring may be hampered. Whereas progress is made in specific countries or regions to have better CE monitoring, the CE monitoring efforts may still break when the goods are exported to a country with less stringent CE monitoring. This is captured in Figure 1 by the broken outer circle labeled with *government CE monitoring*: a part of the CE monitoring in Country A is assumed to be covered well and thus marked with the check sign in green. With this check indicator, we assume that in country A the processes related to crossing borders like import and export, but also procedures inside the country, like for example Extended Producer Responsibility systems that allow for proper monitoring of end-of-life treatment of cars, are in place. However, while all export procedures in the country of export may have been performed according to the requirements, this does not mean that CE monitoring is assured when the goods leave the country. In Figure 1 this is indicated with the question mark for country/region B. Due to these uncertainties, we marked the transfer of CE monitoring when borders are crossed as red in the figure.

For full circularity monitoring, the gaps need to be bridged to gain more control of the product flows even when borders are crossed. In the next sections, we explore two routes to do so, namely (1) the government route, and (2) the business route to achieve a better grip on CE monitoring.

4 THE GOVERNMENT ROUTE FOR CE MONITORING

In this section, we explore the *government route* on what may be possible to improve CE monitoring when borders are crossed. In the EU context, we have CE monitoring at a Member State level. If products cross the border to another EU Member State, the products will remain within the EU. Regulations that set rules for all EU Member States provide mechanisms to get a better grip on the CE flows. The implementation of the different regulations in the Member States and the monitoring by multiple government agencies across them may still pose challenges. However, there will be a common legal framework and, in some cases, common government systems that allow government authorities to access information for improving the CE monitoring and the information exchange across Member States.

In addition, the EU legislation also puts requirements on EU businesses and businesses importing products on the EU market. These businesses need to disclose information to the authorities to allow for better CE monitoring, even when these products are produced outside the EU. Although these mechanisms may still display shortcomings and may need to be further improved, they are a step toward improved CE monitoring by government-to-government collaboration between EU Member States. For now, therefore, we will not investigate the border crossing aspect within the EU in detail, but we will focus on the border crossing outside the EU. While we do not aim to be exhaustive, we discuss some aspects that we observe that take place at the EU level, but also broader in the international context to secure better CE monitoring.

The first aspect is that some countries introduce legal measures such as restrictions or bans for the import or export of specific flows to gain more control over CE flows. An example is the ban introduced by China on the import of plastic waste as a reaction to the large volumes of waste entering the country. This ban led to displacement effects where imports increased in other countries

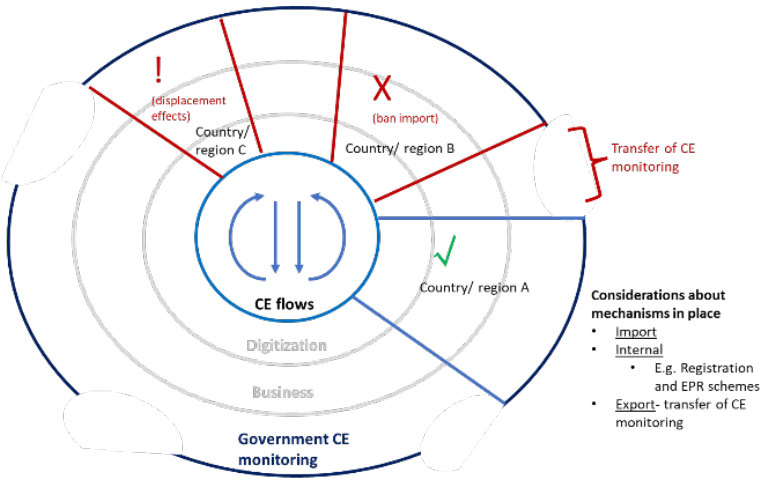

Figure 2: Ban for import and displacement effects

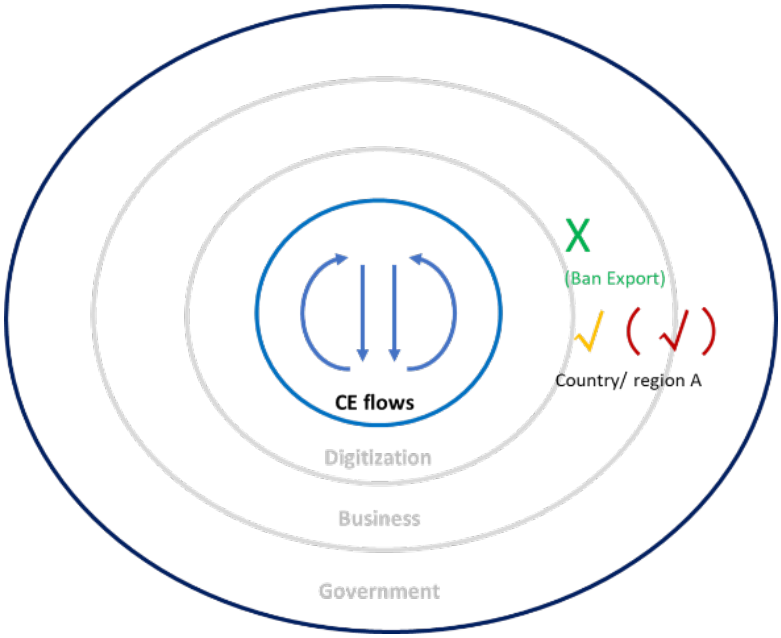

Figure 3: Ban on export, and keeping the CE monitoring in own control—may cause issues with the capacity to cope

[49]. Some countries in Africa introduced import restrictions on second-hand cars [50]. These restrictions aim to prevent that the importing countries end up with environmental issues of end-of-life import flows. The downside to these import restrictions is potential displacement effects when these flows are redirected to countries with less strict policies, as presented with the plastic waste import ban above. This situation is depicted in Figure 2, where Country A may have fulfilled the CE monitoring requirements and performed the allowed export procedures. However, other countries may not want to take the burden of CE monitoring and dealing with these flows and introduce an import restriction. This may bring benefits for country B by preventing dealing with the CE monitoring of these flows, but displacement effects may appear by transferring the CE monitoring issues to other countries. Thus, while bans may work to some extent for the countries introducing them, there are still CE monitoring issues from a global perspective.

The second aspect is that at the same time, the governments of exporting countries/regions take measures to ban or restrict the export flows of waste (e.g., as in the EU proposal for a new regulation on waste shipment [51]). In these cases, governments take responsibility for dealing with the CE monitoring obligations and to cover parts of the CE flows internally, rather than exporting these. As such, the CE monitoring will be contained within the specific country/region's boundaries. However, with no or limited

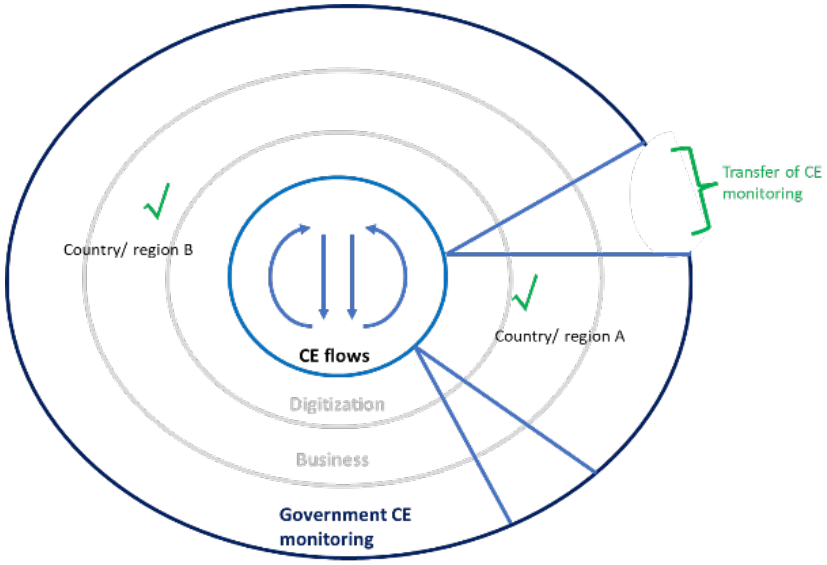

Figure 4: Transfer of CE monitoring to a country which has strong CE monitoring practices in place

export, more CE flows need to be handled internally, which may lead to capacity issues to cope with the amounts of waste.

A third aspect is the role international organizations have played and will continue to play in international trade flows, CE, and sustainability monitoring. These organizations are in a strong position to play a key role in improving the international aspects of CE monitoring. Customs organizations around the world monitor import and export flows. Traditionally focusing on fiscal, safety, and security aspects, but nowadays more attention is paid to circularity and sustainability aspects as well. The WCO is setting the stage to shape its future role in the circularity and sustainability transition. Several steps have been taken to start the discussions on this topic and to engage in follow-up actions, including the WCO 1st Green Customs Conference in 2022 [35, 36], a study on CE and customs [37], and a CE Customs Action Plan [38], to mention a few. Specific countries also take these aspects into account and reflect on their national situation and way forward (e.g., in Indonesia, see [52]). Similarly, particularly important work is done at the level of the WTO [53] and the UN whose *2030 Agenda for Sustainable Development* and its 17 Sustainable Development Goals (SDGs) [40] serve as a global framework for a sustainable society. More specifically, the UN plays a key role with its UN Environmental program [54], and specific instruments like multi-lateral environmental agreements which allow making agreements between countries, as well as in setting recommendations for traceability systems [43] and transparency [55].

These international organizations play a key role in exchanging best practices, but also through support instruments that enable countries to make agreements at the international level to gain more control when it comes to CE. Additionally, they play a crucial role in discussions on setting international standards and recommendations. Countries can come to bilateral agreements (as depicted in Figure 4) for which these international organizations can develop frameworks and agreements between governments on how to handle the transfer of CE responsibilities when the CE flows are imported into a country and how are they monitored. This is represented in Figure 5, where the international organizations and their frameworks may collectively provide grounds for governing CE monitoring on a global level, as it is beyond the responsibilities of single countries to define CE monitoring requirements at a global level.

The above discussion provides insights into measures that governments can take themselves to keep more control of the CE flows (by limiting the import and export flows) or by making collaborative agreements with other governments or introducing governance frameworks at a global level to ensure and safeguard better CE monitoring when borders are crossed. The EU with its new legal frameworks for CE also plays a key role in setting requirements for CE monitoring (including requirements for digital product passports) which will affect international trade flows. With its strong regulatory frameworks, the EU may inspire other regions to adopt similar measures in the future.

An important enabler for CE monitoring is digitization and access to data. In this respect, international organizations like the EU and the international organizations mentioned above play an active role in setting requirements for businesses to establish digital product passports, reporting systems on sustainability and circularity aspects, and recommendations for traceability systems to provide evidence to substantiate CE and sustainability claims, not in the least to prevent "greenwashing": "false claims regarding the circularity of products for business benefits" [12, p. 9], [37, p. 43]. Government-to-government collaboration and data sharing between EU Member States already initiated systems where multiple governments can share information. In the future, data sharing across governments of different regions with the purpose of CE monitoring may enable access to more accurate source information originating from other government agencies. While having such data sharing between governments on a global level may be hard

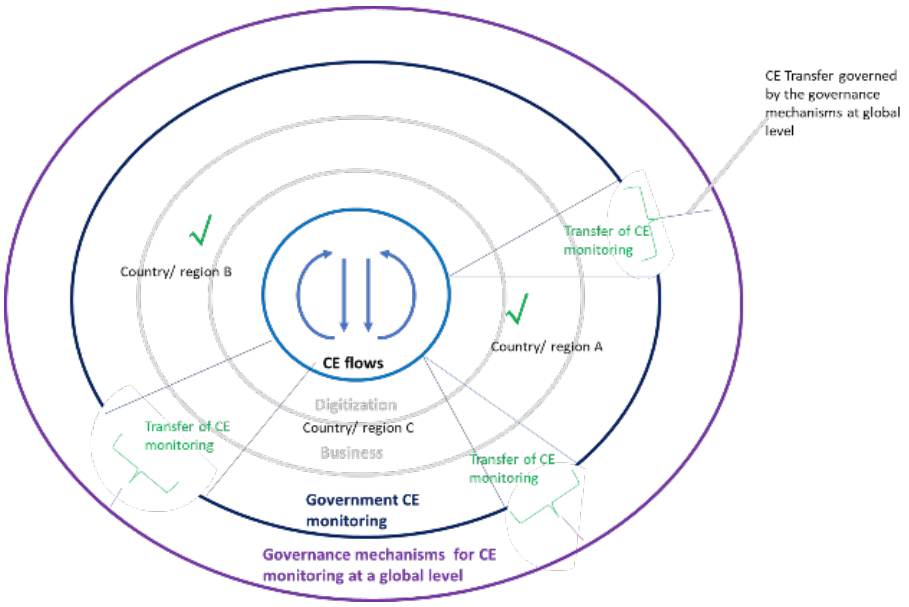

Figure 5: Transfer of CE monitoring to a country which has strong CE monitoring practices in place

to achieve, it may still be possible to explore that as part of the collaborative agreements between countries.

5 THE BUSINESS ROUTE FOR CE MONITORING

In this section, we examine the *business route* that may contribute to secure full CE monitoring. CE flows go through international supply chains which are often global in nature. For businesses, it is also a challenge to be in control of these CE flows. Two key challenges are depicted in Figure 6. The first challenge is that different supply chains are involved through the distinct phases of circularity (e.g., supply chains for bringing a product on the market may be different from those involved in the use and reuse phases and end-of-life) [12]. Responsibilities are transferred between stakeholders along the supply chain, e.g., the producer brings the product to the market but after use, other parties can take care of the repair, reuse, and end-of-life treatment. As such, parties that bring the product to the market can potentially lose the required full overview for CE monitoring, especially in the use and post-use phases. This leads to gaps in the company's control over the CE flows. While digitization plays a key role in enabling companies to achieve better transparency and traceability, during the distinct lifecycle stages, information may exist in different systems or infrastructures [12]. In Figure 6 we refer to this as the gap in visibility infrastructures.

Taking the *business route*, the question is what businesses do to be in control of the CE flows. Despite visibility systems that companies are putting in place, the issue remains that after the products are sold, the producers or parties placing the products on the market have difficulties to keep/get control of the products after use when they get lost in other supply chains.

There may be opportunities to regain control of the CE flows by some big companies that place large volumes on the markets. Some of these companies already have parts of the puzzle in place to play a key role in the CE monitoring process. Visibility systems and control over the supply chain are part of the story. But the other part is related to the customer, where digitization and channels to connect to the customers through loyalty systems and digital apps put these companies in a strong position to take the next steps in gaining control of the product after it has been sold. Some companies are already promoting take-back systems, but these can go further into incentives systems coupled with customer interactions where companies may try to get the goods back and offer incentives for new products in return [56].

One of the challenges for reuse and recycling is that parties in the downstream supply chain do not know much about the product, materials composition, etc. to be able to decide on the proper reuse and recycling strategies. While digital product passports can allow the sharing of information downstream, this information is expected to be at a minimal level to comply with the, by regulation required, mandatory information compared to the potential rich pull of data available in business systems. Parties bringing the product on the market have a strong information position as they have a lot more information about the product (e.g., for batteries they will know the exact recipes) compared to what may they need to share with external parties (e.g., recyclers) by law. This coupled with CE design strategies that companies may adopt, and smart strategies for repair, reuse, and other circular strategies [3] may put some of these companies in a strong position to regain control of their product and organize the CE flows responsibly, even if many borders are crossed. Thus, CE monitoring can be secured by the companies themselves or through smart partnerships with partner organizations. Together they can ensure that they are in control of the CE flows. Connecting their digital infrastructures that contain data to enable this CE monitoring in a way that they can share data and overcome the gap at the digital layer can further enhance

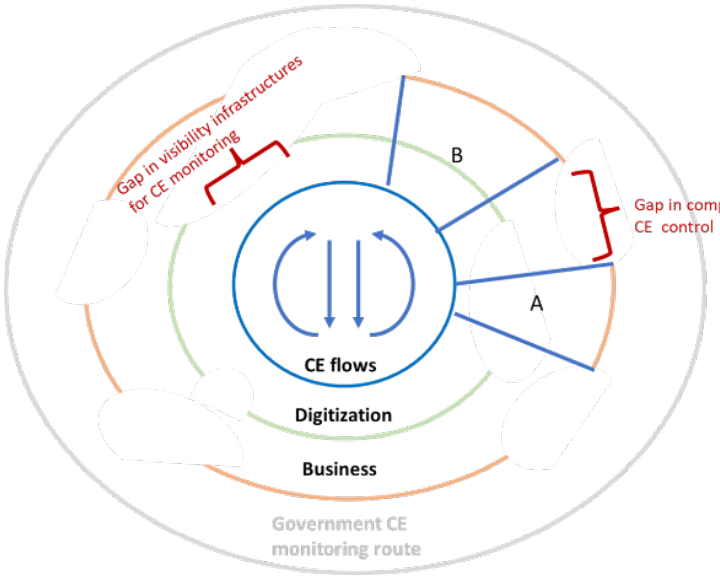

Figure 6: Gaps in company control and gaps in visibility infrastructures.

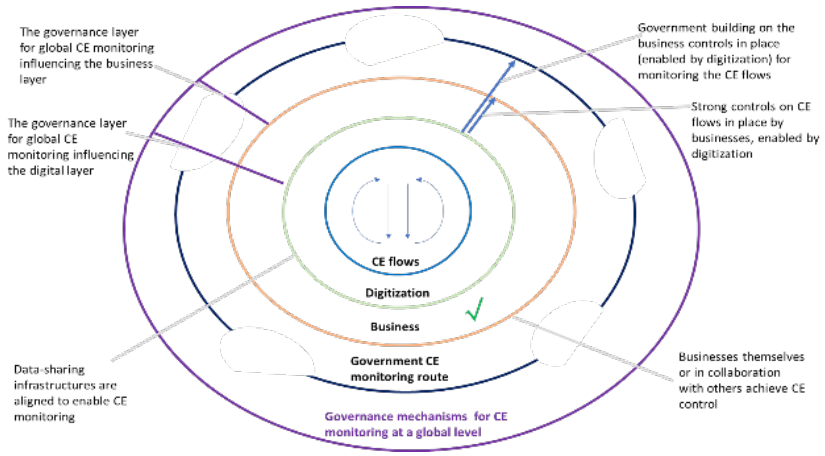

Figure 7: Addressing gaps in visibility infrastructures and business control: governments building on these business controls for CE monitoring

these processes. This is another route to secure CE monitoring on a global level, which is in the hands of businesses that are closer to the actual CE processes and may in some cases prove to be a shorter route compared to the complex government route where governments need to have agreements with other governments to close some of the CE monitoring gaps.

To illustrate: an example of a gap in the digital layer of end-of-life vehicles can be that parties in the chain (e.g., car dismantlers) need data on a battery's state of health to decide whether to repair or reuse the battery for a second life or to send it for recycling but currently have no digital access to this data. Using digital product passports may close this information gap, as they allow for sharing this information along the supply chain. An example of a gap in the business layer is when businesses lose control of what happens with a battery in the car they place on the market. Part of this gap can be bridged by collaborating with other parties that take the responsibility for circular end-of-life treatment of the battery. There are even cases in which the Original Equipment Manufacturers (OEMs) or car companies themselves want to keep control of these end-of-life flows. Such models can also contribute to closing the gap on the business level of how to enable better CE control.

While this scenario may be realizable for only a limited number of businesses, if they deal with big volumes, it may already bring gains for CE monitoring. Governments can then rely on their embedded business controls for CE monitoring purposes, and they can check the IT systems and procedures in place to ensure that the business CE monitoring mechanisms function as required.

This concept is in line with concepts of trusted traders and trusted trade lanes [22], [57] where governments rely on business controls, however now applied with a broader scope to CE monitoring. This scenario is indicated in Figure 7 the CE monitoring is secured by bridging the CE monitoring gaps at the business and digital layer and not necessarily at the government level. One specific government can check the embedded controls, but the safeguarding of the CE flows is ensured by business mechanisms. To this end, governance mechanisms for CE monitoring at a global level need to be in place. These are to include but are not limited to: governance mechanisms and frameworks at a global level about businesses in control of CE flows to close the gap on the business layer; governance mechanisms and frameworks to allow data sharing and visibility to close the gap on the digital layer to support CE monitoring; and governance frameworks and mechanisms for governments to use these embedded CE controls at the business and digital layers.

6 CONCLUSIONS

Monitoring for CE is increasingly important to ensure that businesses follow government policies and adhere to CE regulations and that society moves towards a CE transition. However, supply chains are global and products cross borders during their lifecycle which makes it extremely hard for governments to gain control of CE flows. No matter how many times things go well, and governments are in good control of CE flows, cross-border flows can lead to gaps in CE monitoring and/or the transfer of CE monitoring responsibilities. These gaps will make preceding circularity efforts in vain. Therefore, we need to go beyond what a single country does to ensure CE monitoring within its national borders, it is key to consider cross-border aspects. This paper contributes to earlier efforts to better understand the cross-border aspects of CE monitoring. We present two routes that can be followed to secure CE monitoring when borders are crossed: the government route and the business route, as well as challenges and opportunities to take the next steps to close gaps in the CE monitoring process. Especially digitization and visibility infrastructures, and developments related to digital product passports can play a crucial role for businesses to show they are in control of the CE flows of their products and governments can piggyback on that for CE monitoring. In this policy paper, we propose some directions to be explored to make the next steps in securing CE monitoring when borders are crossed. We discussed the need for global governance layers that can facilitate both routes and enable closing CE monitoring gaps at the business, digital, and government layers. This paper raises questions and proposes directions to explore potential solutions but is not aimed at providing specific answers. Rather it is aimed to inspire further discussions on cross-border CE monitoring aspects among businesses, policymakers, international organizations, and the broader stakeholder group interested in CE in joint exploration for solutions. It can also serve as inspiration for research on the topic raised, particularly to better understand the context and conditions for the business and government routes for CE monitoring.

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