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DOI
10.1145/3543434.3543649

Publication date
2022

Document Version
Final published version

Published in
Proceedings of the 23rd Annual International Conference on Digital Government Research

Digital Government and the Circular Economy: Towards an Analytical Framework

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ABSTRACT

Circular economy is high on the political agenda, with governments at all levels setting ambitious goals to move away from traditional linear production models, where goods are used and disposed as waste, towards a future with less use of virgin raw materials, and where valuable materials at a product end-of-life are returned as raw materials or in an environmentally-friendly way to the biosphere. While circular economy is gaining a lot of attention on a policy level, the role that digital government can play to facilitate the circular economy transition is largely unexplored. We carry out a review of existing literature in the fields of digital government and Information Systems (IS) to identify the roles played by digital government in the circular economy. Based on an analysis of 54 empirical research articles, we identify foci and gaps in relation to the different types of roles played by government (*nodality*, *authority*, *treasure*, and *organization*), to stages of the Product Life Cycle (*pre-use*, *in-use*, and *post-use*), and to types of digital technology focused on. Based on these findings, we present an analytical framework to guide future research on digital government in relation to the circular economy, and exemplify the use of the framework drawing on examples from circular economy initiatives in the automotive industry.

CCS CONCEPTS

• **Circular Economy**; • **Digital Government**; • **Sustainability**;

ACM Reference Format:
Rony Medaglia, Boriana Rukanova, and Yao-Hua Tan. 2022. Digital Government and the Circular Economy: Towards an Analytical Framework. In *DG.O 2022: The 23rd Annual International Conference on Digital Government Research (dg.o 2022), June 15–17, 2022, Virtual Event, Republic of Korea.* ACM, New York, NY, USA, 10 pages. https://doi.org/10.1145/3543434.3543649

1 INTRODUCTION

Governments across the world are setting ambitious goals to move towards a more sustainable future, in line with the United Nations' Sustainable Development Goals (SDGs) [1]. Within this context, the concept of circular economy (CE) is gaining increasing attention in national and international political agendas. CE is referred to as "a sustainable development initiative with the objective of reducing the societal production-consumption systems' linear material and energy throughput flows by applying materials cycles, renewable and cascade-type energy flows to the linear system" [2]. The vision behind the concept of CE is of a future where we step away from the traditional linear production mode, where goods are used and disposed as waste, towards a future where there is less use of virgin raw materials; instead of waste, at the end of life of products the valuable materials are returned as raw materials or in an environmentally-friendly way to the biosphere. Benefits of CE include tackling climate change, and reducing pollution and biodiversity loss.

Digital technologies are developing at a high speed and allow for more and more opportunities. In recent years we see advances in blockchain-based applications that allow for immutability of data, Internet of Things (IoT) and Physical Internet (PI), that allow to capture data on item levels, digital infrastructures, and platforms, as well as data analytics and Artificial Intelligence (AI) that can be used to provide further insights from data. Research in the Information Systems (IS) field calls for more attention by scholars to the circular economy and to what these technologies have to offer [3]. However, existing research does not specifically focus on the role of government in investigating the relationship between digital technologies and the circular economy. Similarly, in the digital government research literature, the role that government can play to facilitate the CE transition is largely unexplored.

This leads us to the main research question that we set to explore in this paper, namely: *What is the role of digital government in the circular economy (CE)*?

We carry out a review of existing studies in the digital government field focusing on circular economy initiatives, in order to map what type of role the government takes in the circular economy ecosystem; what actors other than government are involved; and which digital technologies are used in circular economy ecosystems. Based on the findings, we propose a framework and a research agenda for further research on the topic of the role of digital government in the circular economy.

The remaining part of this paper is structured as follows. In Section 2, we present the broad policy context and discuss current policy developments in the area of circular economy, also in relation to digital government. In Section 3, we illustrate the methods used for our literature review. In Section 4, we present the findings of the literature review . In Section 5 we discuss the findings and present a framework for investigating the role of digital government, illustrate the framework with examples from the automotive industry, and identify inputs for a research agenda on digital government and the circular economy. In Section 6, we summarize the study and discuss its limitations.

dg.o 2022, June 15–17, 2022, Virtual Event, Republic of Korea

ACM ISBN 978-1-4503-9749-0/22/06.
https://doi.org/10.1145/3543434.3543649

2 CIRCULAR ECONOMY POLICY DEVELOPMENT

Looking at the policy developments in the recent years, we see that circular economy and sustainability are gaining increased attention. At an international level, the Paris agreement is seen as a landmark in the multilateral climate change process as it is the first binding agreement of nations to make ambitious steps to combat climate change, including limiting global warming to below two degrees Celsius, compared to pre-industrial levels, and to achieve a climate neutral world by mid-century [4]. The formulation of 17 Sustainable Development Goals (SDGs) by the United Nations [1] aimed to redefine the concept of sustainability in the digital age. In particular, SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) focus on the need to rethink production inputs in order to reduce waste outputs.

Within this framework, governments of different regions set up their strategic agendas. For example, China's 14th Five Year Plan (2021-2025), which provides the overall strategic blueprint for the country's economic development, provides for numerous initiatives in the areas of energy transition (e.g., moving away from coal), new urbanization (e.g., reducing energy use and carbon emission in cities), and investment priorities (e.g., investing in digital technologies to promote energy efficiency across sectors), in line with the country's ambition to achieve carbon neutrality by 2060; within the Plan, CE is indicated as a national priority [5]. Key targets linked to CE initiatives to be achieved by the end of the Plan period include: utilizing 60 million tons of waste paper and 320 million tons of scrap steel, producing 20 million tons of recycled non-ferrous metals, and increasing the output value of the resource recycling industry to 5 trillion RMB (US$773 billion) [6].

In the United States, one of the latest policy initiatives has been spearheaded by the US Environmental Protection Agency (EPA), which has published a National Recycling Strategy to be part of a series on building a circular economy for all [7]. Circularity as a principle had been already embraced in the Sustainable Materials Management (SMM) Program that the United States has pursued since 2009, aimed at decreasing the disposal rate, via source reduction, reuse, recycling and prevention, and reducing the environmental impacts of materials across their life cycle [8].

In Europe, the European Green Deal is an important effort that sets the targets and directions for EU countries, which represents "a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use" [9, p. 2]. The Green Deal pays special attention to mobilizing industry for a clean and circular economy, highlighting also that CE allows for new opportunities for jobs. Digital technologies are acknowledged as a critical enabler for attaining the sustainability goals of the Green Deal in different sectors. In March 2020, the European Commission adopted the Circular Economy Action Plan [10], which captures elements such as the sustainable product policy framework, looking at design, empowerment of consumers and public buyers, as well as circularity in the production process. The plan identifies key product value chains such as plastics, batteries and vehicles, electronics and textile, as deserving specific attention. Specific legislative developments to promote circularity or to regulate CE in specific sectors are being developed. For example, a lot of attention is put on batteries, as they can be reused and recycled for new raw materials and the environmental damage from their disposal needs to be limited. The European Parliament is currently preparing a new batteries directive [11]. The Circular Economy Action Plan highlights that research, innovation, and digitization will play an important role in this transition.

On a national level, governments also make specific plans, like the Circular Economy Plan in the Netherlands [12]. The role of government is crucial in such national contexts. The Carbon Border Adjustment Mechanism in Europe, which is aimed to create a level playing field for companies related to products the production of which is very carbon-intensive, including steel and cement, provides for carbon border adjustment tax to be collected at the border when goods are imported into the EU, in order to stimulate circular flows and discourage flows that are less circular and environmentally-friendly. Other instruments that governments use are subsidies to stimulate citizens and businesses to use more circular or environmentally-friendly products. For example, subsidies for electric cars [13] are aimed to stimulate the transition from fossil fuel towards electric vehicles.

While more measures will be introduced in the future to stimulate the transition towards a circular economy, for these measures to work, proper monitoring of the implementation of these measures in practice will be very important. Lack of proper monitoring may jeopardize achieving circular economy targets and goals. This is visible in cases such as plastics that have been exported from the EU for recycling and ended up being disposed as waste [14]; issues with used cars exported to Africa [15], or eWaste [16]. As the flows are global, it is often beyond the jurisdiction of a single country or region to oversee these flows and take the appropriate measures.

Information infrastructures and digital tools, such as digital product passports, are gaining attention as means to allow for visibility and better monitoring of the circular economy flows. However, these developments are still in the early stages, requiring further research on the use of digital innovations for circular economy monitoring [17], [18].

3 METHODS

3.1 Research literature selection

In order to map existing research on the role of digital government in the development of the circular economy, we have analysed research publications in the fields of Information Systems and of digital government. For research in the Information Systems field, the departure point was the review on circular economy carried out in Zeiss et al. [3].

The search was performed in April 2021 using the Scopus search engine, using the following search string: (TITLE-ABS-KEY (government) AND TITLE-ABS-KEY (circular AND economy) AND TITLE-ABS-KEY (information) OR TITLE-ABS-KEY (technology) OR TITLE-ABS-KEY (digital)) AND (LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ECON") OR LIMIT-TO (SUBJAREA , "ARTS")) AND (LIMIT-TO (DOCTYPE , "ar")).

The 68 papers resulting from the search were then manually scanned to ensure both text accessibility and relevance of the content – in alignment with the research question of this study: *What is the role of digital government in the circular economy (CE)*? As a result, one paper was excluded as it was not available in English, three papers were excluded as the full-text document was not accessible, and ten papers were excluded as their focus was considered as not related to the research question of this study. For example, one of the papers that was deemed not relevant for this study was a paper published in 2019 about government and foreign entrepreneurs from the 1920s to the 1940s with no link to circular economy, let alone digital government focus. The scan resulted in a pool of 54 papers.

3.2 Research literature analysis

The 54 papers were then coded in the following four dimensions:

1) Role of government

In order to identify the role that digital government has in each study on circular economy, we have drawn on the well-established framework by Hood and Margetts [19], which categorizes the roles that government can take in digital government initiatives by looking at the type of resources that governments leverage. The framework is frequently referred to through its acronym 'NATO', based on the initials of the four types of resources that government can draw on: Nodality, Authority, Treasure, and Organization. *Nodality* as a resource refers to the property of being in the middle of an information or social network. Government draws on nodality when it leverages its central position in a network to detect or put out information. For example, in the process of tax collection, government draws on nodality when sending out tax reminders, or scrutinizing the internet to detect tax evasion. *Authority* refers to the ability to command, permit, and prohibit through recognized procedures and symbols. Government can use authority to detect and obtain information by requisition, or as an effecting tool; for instance, it can command tax inspections and raids. *Treasure* refers to freely exchangeable resources (usually monies or money-like substances) that can be used by government as incentives or inducements to secure information or change someone's behaviour. An example of drawing on treasure as a resource would be government paying tax informers. *Organization* refers to resources directly owned by government – "a stock of land, building, and equipment, and a collection of individuals with whatever skills and contacts they may have, in government's direct possession or otherwise available to it" [19, p. 102]. An example of organization as a resource would be government officials scrutinizing traffic at ports or airports to collect tax-relevant information [19].

2) Stakeholders involved

When reviewing the papers, we also paid specific attention to which actors of the circular economy ecosystem each empirical study focuses on. Based on a number of iterations that considered the need to balance the granularity of the analysis with its practical use and heuristic, we identified the following categories: businesses (including all private business organizations not taking the role of providing IT); consumers (as individuals); IT providers; NGOs (including consumer groups), and research institutions (including both academic and non-academic organizations, such as private think tanks).

3) Product Life Cycle (PLC) stages

In line with the literature review on circular economy and IS carried out in Zeiss et al. [3], we classified papers based on the stage of the Product Life Cycle [20] they focused on (whenever they focus on any of them). The following stages were used as classification categories: *pre-use*, including studies focusing on activities from product idea to delivery; *in-use*, including studies focusing on activities from product delivery to end-of-life; and *post-use*, including studies focusing on activities from product end-of-life to product next-life.

4) Digital technologies

In our study we were also interested in the type of digital technologies used in each of the empirical cases investigated in each paper. In the analysis we also tried to trace whether the papers that we reviewed addressed digital technologies only on a general level or whether they mention some specific digital technologies. For the cases where specific digital technologies were listed, we made notes about the technologies that were mentioned. As a result, we obtained a list of technologies that were mentioned in the paper that we subsequently further analyzed.

The categories of each of the four dimensions used for the classification were considered non-exclusive so that, whenever applicable, a paper was classified in more than one category in the same dimension.

Two authors independently analyzed all the articles and characterized them using the categories as discussed above. Whenever possible, the analysis was done based on abstracts. When the abstract did not contain sufficient information to perform the characterization, full versions of the papers were reviewed to obtain the information. The characterization was carried out independently and the results were compared. Differences were discussed and resolved to arrive at the final classification.

4 FINDINGS

The 54 papers analyzed all included empirical research on one or more cases of circular economy in which digital government plays a role. While not all the papers were country-specific, the majority of the papers identified one or more country in which the empirical study has been carried out. The total number of countries focused on in the papers is 17.

As illustrated in Figure 1, it is interesting to observe that the country which is by far most focused on is China, followed by India, and then a long tail of countries in Europe, Asia, and the Americas, that are focused on only a handful of times. The focus on China reflects the early initiatives that the country has taken in the area of circular economy for a number of years now. China passed the Circular Economy Promotion Law in 2009, and has acknowledged the circular economy as a national development goal for already more than a decade [21]. This has triggered developments that were promptly followed by research. With the European Green Deal that is now setting ambitious agenda in Europe, we can expect the rise of interest also in the digital government research in Europe on issues such as circular economy.

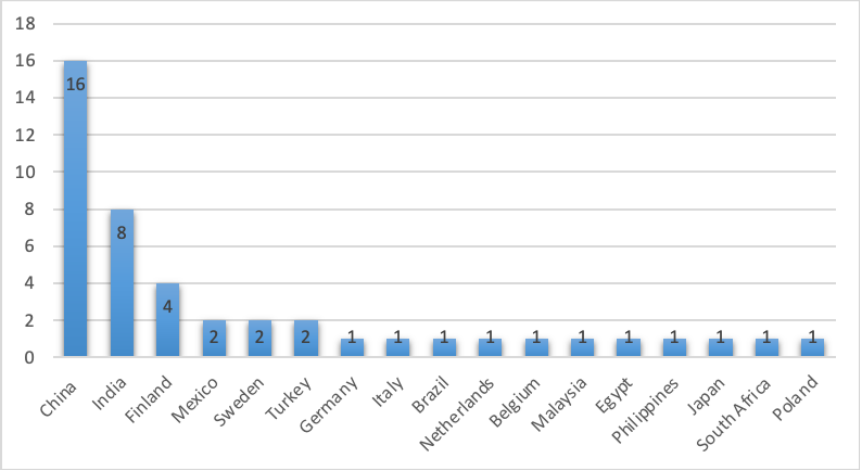


Figure 1: Number of papers by countries focused on in their analysis

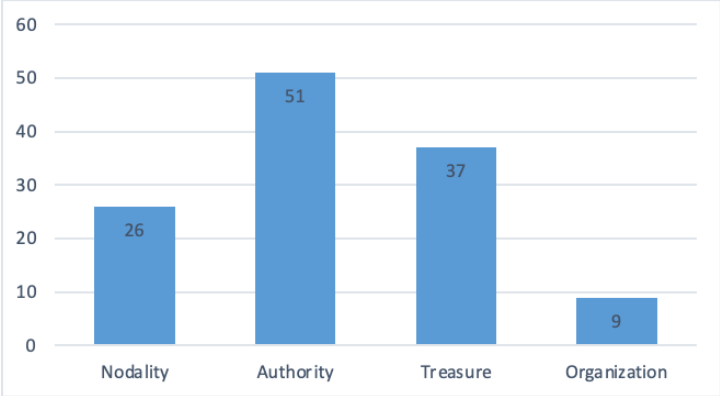


Figure 2: Number of papers by type of role taken by government in their analysis

4.1 Role of government

Figure 2 presents the results from our analysis with respect to the role of government. *Authority* is the role that was mostly encountered, followed by *treasure*. This is not surprising, as shift towards circular economy is often driven from the government side with policies and regulations and stricter requirements for monitoring and control. It is also not surprising that *treasure* appears as a second most encountered role, as it reflects the role of government to use financial incentives and subsidies to enable transitions. These two categories reflect the traditional roles of government of using regulatory pressure and using financial measures for steering a transition.

Our analysis also shows that the roles of nodality and organization are much less focused on. These roles relate to the positioning of the government in the wider ecosystem, building and brokering relationships between actors. These are roles that are very important for the circular economy transition, which requires actions from many actors, including businesses, NGOs, technology providers, and consumers, to identify new business models and models of engagement that will lead towards a future driven by circularity. Yet, in current research these roles have received limited attention and further research can focus on understanding what government can do to better fulfil these roles and to act as an enabler in the circular economy transition.

4.2 Stakeholders involved

Figure 3 provides an overview of the results when we look at the stakeholders involved in the circular economy ecosystems.

The vast majority of the studies focus on business actors in the supply chain, as can be expected in the context of circular economy. Other categories of stakeholders that are less focused on include individual consumers and research institutions. Only three studies include IT providers in their focus – a surprising fact, given the key role that IT plays in the development of circular economy, with its consequences for digital government initiatives.

4.3 Product Life Cycle (PLC) stages

Figure 4 summarizes the findings when looking at the aspect of Product Life Cycle (PLC) stages that are focused on in the reviewed papers. The focus is put largely on post-use stage, as many papers

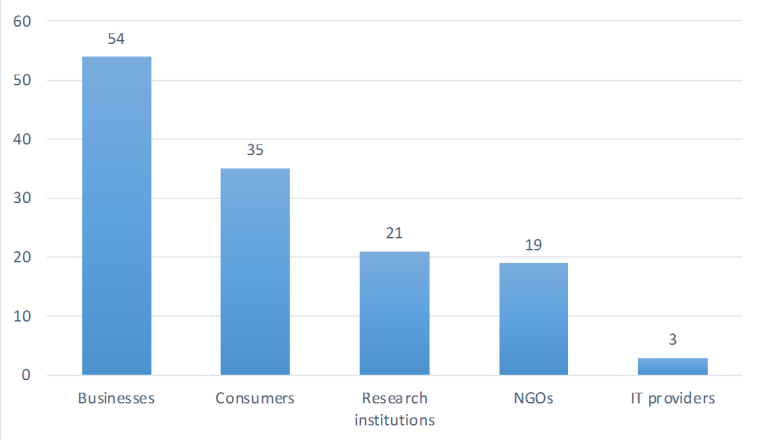


Figure 3: Number of papers by type of stakeholder included in their analysis

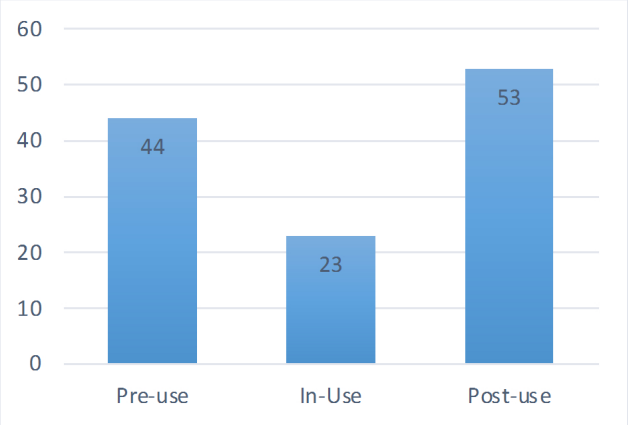


Figure 4: Number of papers by stage of the Product Life Cycle (PLC) focused on in their analysis

were focused on recycling, as well as on the pre-use stage. On the other hand, the in-use stage has received limited attention.

Looking at the pre-use and the post-use stages, businesses usually play a key role as they are involved in the production and logistics processes, as well as the recycling processes at the end of life. For the in-use stage, on the other hand, the role of the consumer can be considered paramount.

4.4 Digital technologies

While all 54 papers analyzed deal with the role digital technologies at least in a general way, 23 have an explicit focus on one or more specific technologies. Figure 5 presents a word cloud to illustrate the technologies that were mentioned in most papers.

The distribution of foci on specific technologies is rather scattered, with no one digital technology attracting most of the attention. The use of sensors in product supply chains, referred to as the Internet of Things (IoT), is the most focused on technology, but it is mentioned in only 5 papers. Other technology keywords include blockchain, Industry 4.0, and information platforms (focused on in 3 papers), followed by a long tail of technologies that have only very few papers dedicated to them – these include Artificial Intelligence, 3D printing, Geographic Information Systems, and robotics.

5 DISCUSSION

Findings from the literature review highlight a number of gaps in existing empirical research, with some of the categories in each of the four dimensions of the phenomenon of digital government and the circular economy (role of government, stakeholders involved, PLC stage, and digital technologies) that are still underinvestigated, despite arguably playing important roles.

In relation to the role of government, the traditional resources of *treasure* and *authority* are mostly focused on, with government stimulating the development of a circular economy either by economic incentives, or by establishing regulation and guidelines. Other potential roles that government can take in the development of an ecosystem for circular economy are relatively overlooked – namely the possibility for government to draw on its central position in important networks (i.e., *nodality*) to educate stakeholders and establish partnerships; and the possibility for government to draw on its own organizational resources, skills, and human resources (i.e., *organization*) to advance circular economy initiatives. In fact, among the key characteristics of the circular economy phenomenon is to draw on complex networks of actors of different nature (public and private organizations, diverse supply chains, etc.), and to require diverse skills (technical, legal, managerial, etc.). Policy interventions in other emerging areas of digitalization, such as Artificial Intelligence (AI), have focused on roles other than *treasure* and *authority*. In fact, a recent analysis of AI in government shows that the other nodality- and organization-related initiatives, such as awareness campaigns, training programmes, and data management actions, are dominant in comparison to regulatory "sticks" punishing certain behaviours, or "carrots" in the form of economic incentives [22]. Future research on digital government and the circular economy should pursue a more holistic view on the phenomenon of circular economy by providing more attention to the *nodality* and *organization* aspects of government role. Examples of key research questions in this dimension would be: what are

Figure 5: Word cloud of technologies mentioned in the papers

the characteristics of effective government information campaigns on circular economy? How can skills possessed by governmental agencies be drawn in the implementation of circular economy initiatives? What criteria should government regulation adopt to monitor circular economy targets achievement?

Existing research also features another imbalance concerning the focus on different stakeholders involved in circular economy ecosystems. The dominant focus on businesses and individual consumers means that other key stakeholders are relatively overlooked, namely research institutions, NGOs, and IT providers. However, understanding the role of IT providers, for example, is crucial when investigating digital government initiatives. Procurement interactions between government and IT providers are, in fact, a complex phenomenon with extensive impacts in terms of power relationships [23], or requirement specifications [24], [25], especially concerning emerging technologies. Future research on digital government and the circular economy will need to zoom out from an exclusive focus on businesses, to encompass a wider ecosystem of stakeholders, including IT providers, NGOs, and research institutions. Examples of key research questions in this dimension would be: what are power relationship between IT providers, government, and other stakeholders involved in circular economy initiatives? To what extent does research conducted by research institutions influence circular economy models? What are partnership models between government, research institutions, and NGOs?

Findings also show that existing research tends to focus mostly on issues related to the pre- and post-use stage of product lifecycles and, to some extent, overlook what happens in the *in-use* stage of a product. This stage comprises the period of the product's use by the consumer, and it is the stage where the goal is to intensify and extend the use of products and their components, in a circular economy approach. Future research should thus not only investigate circular economy initiatives in relation to pre- and post-use (e.g., product design, product recycling), but also in relation to the in-use stage. Examples of research questions in this dimension include: how does government regulation influence product repairing practices? How can digital government platforms improve product sharing and optimize consumption processes?

Last, the review of the literature highlights that specific digital technologies are seldom focused on in research on digital government and the circular economy. Blockchain and the Internet of Things (IoT) are key technologies that have potential to support the achievement of sustainable goals by enabling transparency and traceability in product supply chains and in post-use stages [26]. While this potential is partly acknowledged in existing research, future studies in digital government and the circular economy should give a much closer look at the role of specific digital technologies that carry potential for sustainability such as, for example, Artificial Intelligence [27]. Possible research questions stemming from the need to focus on digital technologies include: what are models of governance of blockchain technology in support of the circular economy? How can government balance regulation with stimulating innovation in the use of AI for circular economy? What skills are required for public servants dealing with Industry 4.0 initiatives for circular economy?

5.1 Towards an analytical framework

Figure 6 below presents a framework for understanding the role of government in the circular economy. The framework builds on the conceptual categories that we used during the exploratory literature review and allows to reason about the role of government in the circular economy from a holistic perspective. At the heart of the framework are the key roles of government i.e., nodality, authority, treasure, and organization. As we have seen in our analysis, the roles of authority and treasure are well recognized in existing literature, while the roles of nodality and organization have received more limited attention, and further research is needed.

The lines in the framework indicate key relationships between different aspects of the circular economy phenomenon. For understanding the role of government we consider that it is important to look at (1) the relationship between government and the Product Life Cycle (PLC) stages; (2) the relationship between government and other actors in the ecosystem, and (3) the relationship between

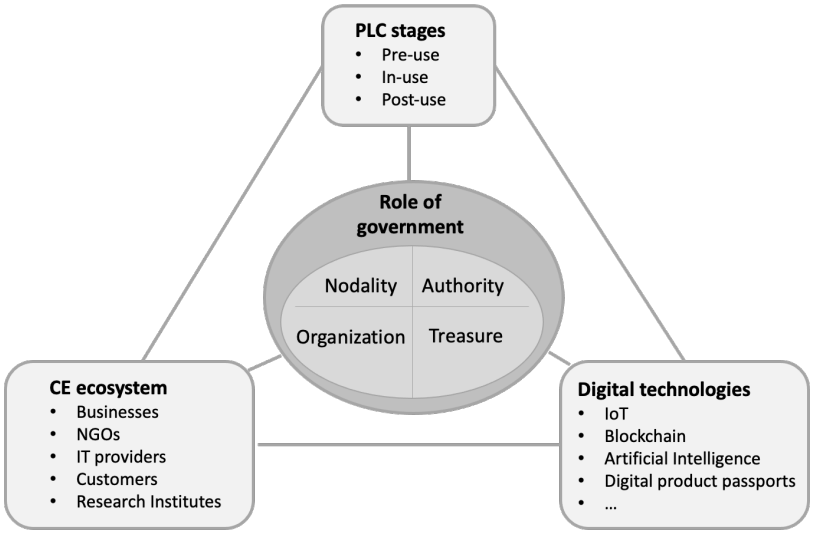


Figure 6: A framework for analysing the role of government in circular economy

government and the different types of information technologies supporting CE.

Our framework also captures that there can be direct relationships between other actors from the CE ecosystem and different PLC stages. The wider CE ecosystem can also use digital technologies to support their CE activities, and these technologies can be deployed at different PLC stages. This allows to capture the broader context of PLC stages, ecosystem actors, and technologies. By putting government with its roles in the center, the framework allows to take a government-centric view, while still taking the broader context of CE into account.

The framework is not meant to be a prescriptive model, but it is rather an analytical lens to structure our understanding of the role that digital government can play in facilitating the circular economy transition. Such understanding may help government organizations to more effectively play their role in the wider CE ecosystem.

In the next section, we provide some empirical examples to illustrate how the framework can be used in analysing the role of government in CE initiatives.

5.2 Applying the framework: examples from the automotive domain

To illustrate the potential usefulness of the framework, we draw on an analysis of an example of circular economy initiatives in the automotive industry. We first discuss some typical roles that government takes in the pre-use, in-use, and post-use stages (see sections A, B, and C in Table 1). We then discuss a scenario where government can take a more holistic view across the stages, taking different roles and engaging with the wider stakeholder community (see section D in Table 1).

5.2.1 Pre-use. Looking at the automotive domain, and looking at the pre-use stage of the CE processes (see also A in Table 1), car manufacturing can be seen as the *pre-use* stage. In this stage, government has a strong role of authority in terms of drafting legislations and the legal framework to put requirements on the manufacturing process. For example, for batteries and vehicles, the European Commission's Circular Economy Action Plan foresees to have rules on mandatory recycled content for certain materials of components [10]. From the point of view of the ecosystem, the primary affected actors are businesses involved in manufacturing of cars, be it the car manufacturing companies, or parts/ materials suppliers.

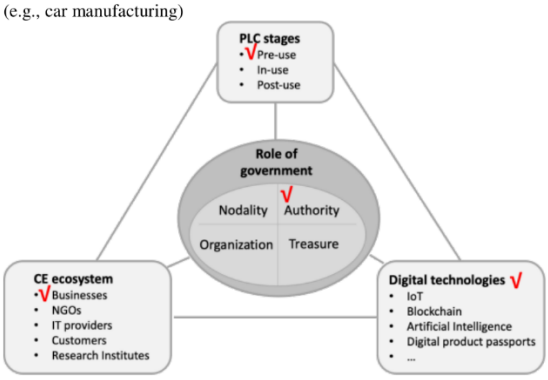
Information Technology plays an increasingly important part in providing visibility on CE and compliance. For example, businesses are required to monitor and report the use of dangerous substances in their products. With targets that the EU is putting on the use of secondary raw materials in new products by 2030 and 2050, it is likely that IT will play an important role in tracing the origin of materials used in new cars, and ensuring that the right percentage of secondary raw materials are indeed used in the production of new vehicles.

5.2.2 In-use. Looking at the in-use stage (see section B in Table 1), a role that government takes actively in some European countries, for example in the Netherlands, is the *treasure* role. Namely, in order to stimulate the transition from fossil fuel cars towards electric cars, governments are providing subsidies to make buying electric cars more attractive [13]. The primary actors from the wider ecosystems are the businesses that would like to make use of these subsidies for buying cars for business use, as well as individual citizens as consumers. One way Information Technology plays a role in this process is to monitor the eligibility for granting the subsidies and to register the ownership of electric cars. In particular, the latter is useful later in the process to monitor the lifecycle of the electric vehicle and, most importantly, to ensure that it is properly disposed.

5.2.3 Post-use. An important role that government has in relation to the post-use stage (see section C in Table 1) is the one of *authority*.

Table 1: Examples of government role in the CE in the automotive industry.

A. Pre-use
(e.g., car manufacturing)

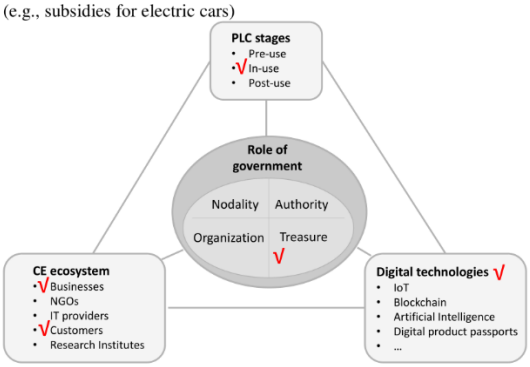


Government role
- Authority (batteries regulation; requirements for use of secondary raw materials)

CE ecosystem
- Primary affected actors: businesses

Digital technology
- IT for proving CE visibility and compliance (e.g., battery passports)

B. In-use
(e.g., subsidies for electric cars)

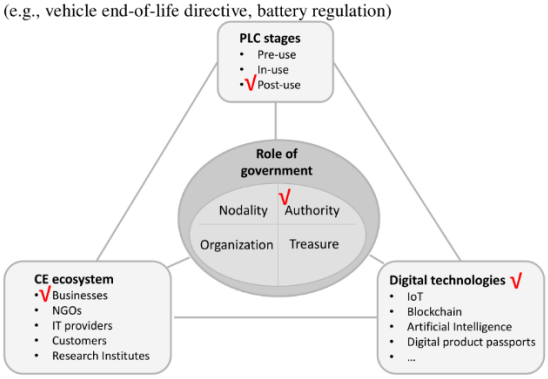


Government role
- Treasure (subsidies)

Ecosystem
- Primary affected actors: consumers, businesses (in case of company cars)

Digital technology
- IT for registration of ownership of cars and monitoring eligibility for subsidies.

C. Post-use
(e.g., vehicle end-of-life directive, battery regulation)



Government role
- Authority (end-of-life vehicle directive, battery regulation, extended producer responsibility)

Ecosystem
- Primary affected actors: businesses

Digital technology
IT for end-of-life registration and for monitoring proper recycling steps

D. A more holistic view on the role of government in all CE stages

Government role
- Government can take more roles while drafting legislation about the *pre-use* stage to use results from the *in-use* and *post-use* stages to prepare the grounds for the CE transition.
- Authority role for drafting legislation can be supplemented by the *organization, treasure* and *nodality* roles for piloting and providing feedback to the legislative process.
  - Organization: working together with NGOs, IT providers and other organizations in piloting and ensuring that the legislation is implementable; aligning internationally on policy and standards;
  - Treasure: providing public funding for piloting and experimentation;
  - Nodality: working with research and education institutions to create training materials and awareness to show best cases and to help governments/ companies/ citizens to make the CE transition.

By establishing regulatory frameworks, such as the end-of life vehicle directive [28], or the battery directive [29], European authorities aim to set requirements on what will happen with vehicles and their parts at the end-of-life stage and how they would be processed in an environmentally-friendly way. Due to the scarcity of certain raw materials, governments are also starting to monitor the flow of Critical Raw Materials (CRM) [30] to be secured for future use. All these can be seen as examples where government bodies are acting in their authority role. The primary actors affected by these regulations are businesses, be it businesses involved in the production who have to take roles also for the post-use stage, or parties like recycling companies involved in the end-of-life stage. Digital technologies play a role in monitoring the processes when the car is unregistered for use, as well as the movement of the vehicle and its components to the appropriate recycling destination and monitoring that the proper recycling processes have taken place. With the upcoming changes to the batteries directive, more information about the battery would need to be shared via battery passports to allow for better extraction of the valuable raw materials so that they can be streamlined as secondary raw materials in the production process of new products (cars or other).

5.2.4 A holistic view on the role of government through all CE stages. While in sections A, B, and C we discussed examples of the typical roles that government plays in terms of authority and treasure, there is also a wide variety of other roles that government plays

and can play more prominently in the future when we look across stages, and taking the broader actor ecosystem into account. For example, authorities at EU level will continue also in the future to revise existing legislations to stimulate the transition towards circular economy and sustainability, for example regarding the batteries used in electric vehicles and the introduction of battery passports. While these changes affect first and foremost the businesses, IT providers will play a key role in enabling the implementation of such passports, NGOs will play a key role in defining standards or echoing requirements from different communities, and research institutes will play a key role in working with these different stakeholders and enabling innovation. Government can play an active role in these piloting and experimentation stages, where valuable lessons learned about what is feasible to achieve in practice can be provided as feedback to the parties drafting legislation.

Taking this iterative perspective, governments can also take a more active role in this piloting and experimentation process, besides the role of authority. For example, governments can take the role of *treasure* and provide public funding for early stages of piloting and experimentation, stages that may be difficult to finance otherwise, as business cases for companies may not yet be clear. What is interesting to notice is that while legislation is drafted at EU level, governments of Member States may be responsible for its implementation. In these cases, national governments can be more active in the *organization* role, collaborating closely with the other actors in pilots as active participants, and helping to make the requirements from the point of view of government more explicit. From this position, government can also take an active role of *nodality*, sharing for example best practices with governments from other Member States, with businesses, as well as with policy makers at EU level.

All these illustrate that it is possible to explore the role of government in a much more holistic and dynamic way, where next to roles of authority, government at different levels can also play an active role in the innovation process by having the roles of *treasure*, *nodality*, and *organization*.

We do see governments acting in such roles as well. In Europe, EU funding programmes[1] have worked as an engine of innovation for decades. In the area of international trade and customs, a series of EU-funded projects[2] with involvement of businesses, IT providers and the active participation of customs and other government agencies, have been developing and piloting innovations in the area of safety and security, revenue collection and trade facilitation [31], [32]. In these projects, governments formed part of the innovation process, acting in their *organization* role and engaging actively with other stakeholders. For example in the CORE[3] EU project, customs authorities worked closely with supply chain partners and technology providers to pilot with data sharing infrastructures for voluntary sharing of business data with government for trade facilitation benefits. Piloting was done also with global blockchain infrastructures, such as TradeLens, to examine the potential offered by such global platforms for customs risk management. Similarly, in the PROFILE[4] EU project, several EU customs administrations collaborated with data analytics providers, external data providers, and academia to examine the possibilities offered by data analytics for customs. This rich knowledge and experience on how government can collaborate with supply chain partners, IT providers, and academia for developing innovative solutions, can serve as a fertile ground for further innovations in the area of circular economy where, next to customs agencies, also other government agencies interested in controlling the circular economy flows can take an active role.

In the area of international trade and customs we also see examples where, taking the innovation perspective, government can also play an active role of *nodality*. One such example is the EU-funded practitioners innovations network of customs professionals (PEN-CP[5], where results from other EU research projects can be further disseminated to other Member States' governments and business communities, allowing government agencies involved in research projects to share results with other administrations. While these examples are from the area of international trade and customs, they show how governments can take a multiplicity of roles, and such experiences may be useful for governments in shaping the circular economy transition. These earlier experiences from other domains can be also instrumental for shaping further research on understanding the role of government in circular economy.

6 CONCLUSION

In this paper we have tried to advance questions on the role of digital government in the circular economy. Based on a review of empirical literature, we highlighted foci and gaps in the existing knowledge base, and suggested directions for future research. The analytical framework we presented, and whose use we exemplified by drawing on the example of circular economy initiatives in the automotive industry, can be a first step towards supporting systematic research on digital government and the circular economy.

Limitations of this study are related to the exploratory nature of the literature review. Future insights into the state of the art of empirical research on digital government and the circular economy should expand the number of research outlets included in the review. Moreover, the proposed framework will need further validation through rigorous case analyses.

The idea of the circular economy is among the most powerful ones available to tackle the epochal challenges of sustainable development, and digital government initiatives have to be geared to enable and shape it. In the close future, the role of digital government needs to be better conceptualized, in order to facilitate the needed growth of a knowledge base for both research and practice.

ACKNOWLEDGMENTS

This research was partially funded by the PEN-CP Project (nr. 786773), which is funded by the European Union's Horizon 2020 research and innovation program. Ideas and opinions expressed by the authors do not necessarily represent those of all partners.

[1] E.g. FP6 (https://cordis.europa.eu/programme/id/FP6), FP7 (https://cordis.europa.eu/programme/id/FP7), Horizon 2020 (https://ec.europa.eu/programmes/horizon2020/en/home) , Horizon Europe (https://ec.europa.eu/info/research-and-innovation/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en)

[2] ITAIDE, CASSANDRA, CORE (http://www.coreproject.eu/), PROFILE (https://www.profile-project.eu/)

[3] http://www.coreproject.eu/

[4] https://www.profile-project.eu/)

[5] PEN-CP- https://www.pen-cp.net/)

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