Digital government and the circular economy transition

An analytical framework and a research agenda

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Digital government and the circular economy transition: An analytical framework and a research agenda

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ABSTRACT

The transition from a linear economy towards a circular economy (CE), based on reusing, repairing, refurbishing, and recycling existing materials and products, is one of the key priorities in pursuing Sustainable Development Goals (SDGs), where governments play a fundamental role, with the support of digital technologies.

Despite the increasing global policy focus on CE, research on the role of digital government in initiating, implementing, and consolidating a transition towards a circular economy is surprisingly scarce and fragmented, and a systematic effort in digital government research is yet to emerge.

To tackle this issue, this article sets out to answer the research question: what is the role of digital government in the transition towards a circular economy? Driven by this research question, we conduct a review on 88 empirical studies in the Information Systems (IS) and digital government fields and discuss existing research foci and gaps in relation to the types of digital technologies used, the types of stakeholders involved, the stages of the product life cycle, and the type of resources that governments draw on to advance the circular economy transition. In addition, we identify two types of transition styles, based on an analysis of the types of roles taken by the government in two cases of transition towards a circular economy.

Based on these findings, we provide two contributions to establishing a new line of research in digital government and the circular economy: an analytical framework, including a static view, a longitudinal view, and a transition style view of the role of digital government in the circular economy transition; and a research agenda that builds on our framework, to guide future research on the role of digital government in the circular economy transition.

1. Introduction

Digital government initiatives are increasingly considered key to the achievement of the United Nations' Sustainable Development Goals (SDGs) (United Nations, 2015). The current trends of digital transformation of government face new societal challenges related to sustainability, such as climate change and natural resource depletion (Medaglia, Misuraca, & Aquaro, 2021), and a corresponding need to transition to more sustainable sociotechnical systems (Corbett & Mellouli, 2017; Markard, Raven, & Truffer, 2012).

Within this context, the concept of circular economy (CE) introduces an approach that goes beyond manufacturing even more 'sustainable' products, but instead focuses on re-using materials that are already there. The circular economy is defined as "an economic model wherein planning, resourcing, procurement, production and reprocessing are designed and managed, as both process and output, to maximize ecosystem functioning and human well-being" (Murray, Skene, & Haynes, 2017, p. 371). The benefits of CE include tackling climate change, reducing pollution, and reducing biodiversity loss.

The circular economy is also gaining increasing attention in national and international political agendas. In Europe, the European Green Deal is an important effort by the European Commission to set targets and directions towards sustainability (European Commission, 2019), where a transition towards a circular economy is a key step and digital technologies play a key role (European Commission, 2020). The 14th Five-Year Plan (2021–2025) of the People's Republic of China indicates CE as a national priority (Hepburn et al., 2021). Key targets linked to CE initiatives to be achieved by the end of the Plan period include: utilizing

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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) (State Council of the People's Republic of China, 2021). In the United States, the US Environmental Protection Agency (EPA), has published a National Recycling Strategy to be part of a series on building a Circular Economy for all (United States Environmental Protection Agency, 2021).

Digital technologies are key to achieving these goals. For instance, we have seen advances in blockchain-based applications that allow for the immutability of data, Internet of Things (IoT) and Physical Internet (PI), that allow capturing data on item levels, digital infrastructures, and platforms, as well as data analytics and Artificial Intelligence (AI) that can be used to provide key insights from data. Following these developments, research in the Information Systems (IS) field has started to devote attention to the circular economy (Zeiss, Ixmeier, Recker, & Kranz, 2021). Nevertheless, research falls short of focusing on the role of government in investigating the relationship between digital technologies and the circular economy. Similarly, while in the digital government research literature there is increasing attention to issues related to the achievement of the Sustainable Development Goals (Medaglia, Misuraca, & Aquaro, 2021), the role that digital government can play to facilitate the CE transition is largely unexplored.

To address this gap, in this article we aim to explore the link between digital government and the circular economy, by tackling the research question: *what is the role of digital government in the transition towards a circular economy (CE)?*

To answer this research question, we adopt a step-based approach, where we first provide a snapshot of existing research at the intersection of digital government and the circular economy; then we adopt a longitudinal perspective to capture the role of digital government in the transition towards a circular economy. As a result, we contribute to establishing a new line of research in digital government and the circular economy by proposing an analytical framework and a comprehensive research agenda.

The article is organized as follows. In Section 2, we discuss the emergence and the current challenges of the circular economy in research and policy, focusing on the role of digital government. In Section 3, we discuss the tool view of government as the theoretical lens that we adopt to investigate the role of digital government in the circular economy transition. In Section 4, we present our research design, detailing the step-based approach of our study. In Section 5, we present the findings of a review of research literature on digital government and the circular economy, focusing on the roles of government, the types of stakeholders involved, the stages of the product life cycle, and the digital technologies used. In Section 6, we turn to conceptualizing the process of transition towards a circular economy from a digital government perspective. We analyse the role of digital government in the circular economy transition using a process view, which we showcase by applying to two empirical cases of circular economy initiatives from our literature review. The application of the process view suggests the presence of two different "transition styles", which we articulate and discuss. In Section 7, we draw on both the findings of our review of the literature and on the analysis of the two empirical cases to propose an analytical framework and outline a comprehensive research agenda on the role of digital government in the circular economy transition, comprising examples of research questions grouped in research areas and research foci. In Section 8, we summarize our contributions and discuss the limitations of our study.

2. Background: digital government and the circular economy

Within the context of the 17 United Nations Sustainable Development Goals (SDG), there is a growing awareness of the role that governments and their use of digital technologies need to play (Estevez & Janowski, 2013; Janowski, 2016; Medaglia, Misuraca, & Aquaro, 2021; Marcovecchio, Thinyane, Estevez and Janowski, 2019). Among the Sustainable Development Goals, an explicit focus on the circular economy is provided in SDG 12 (Ensure sustainable consumption and production patterns). SDG target 12.5 ("By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse") and 12.6 ("Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle"), in fact, draw on the key principle of transforming a linear economy into a circular economy, defined 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" (Korhonen, Nuur, Feldmann, & Birkie, 2018, p. 547).

Government 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 (Rukanova, Tan, Hamerlinck, Heijmann, & Ubacht, 2021a, 2021b). On a national level, governments devise specific plans, like the Circular Economy Plan in the Netherlands, for example (Ministerie van Infrastructuur en Waterstaat, 2021). The role of government is crucial in such national contexts. The Carbon Border Adjustment Mechanism in Europe (European Commission, 2023), which aims to create a level playing field for companies related to products whose production is very carbon-intensive, including steel and cement, provides for a 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 environmentally-friendly. Other instruments that governments use are subsidies to stimulate citizens and businesses to use more circular-friendly products. For example, subsidies for electric cars (Ministerie van Infrastructuur en Waterstaat, 2020) are aimed to stimulate the transition from fossil fuel towards electric vehicles.

This government role plays out within a context that is ripe with challenges. There are numerous examples of how the efforts to move towards more sustainable and circular practices are often troublesome: even if some parties in the ecosystem that includes businesses and governments are doing the right thing, the oversight and control may still be insufficient and lead to pollution of the environment, loss of resources and harm to human health. For example, a recent Greenpeace report on the textile industry revealed that a large percentage of second-hand clothes that have been collected and exported to East Africa still end up as waste at dumpsites (Cobbing, Daaji, Kopp, & Wohlgemuth, 2022). Similarly, products of the fast fashion industry are often found dumped into the environment or burned as fuel (Changing Markets Foundation, 2023). These reports make references to government instruments that can help to get a better grip on what is happening with these flows and make recommendations for improving extended producer responsibility schemes, export transparency, and discuss the role of digital product passports.

While the relevance of the role of digital government in the transition towards a circular economy would seem obvious, research in this area is still both limited and fragmented.

3. Theoretical framework: the tools of digital government

To investigate the role of digital government in the circular economy, we draw on a theoretical lens that conceptualizes the role of government in a digital age based on the nature of the resources that governments can draw on as tools. The well-established framework by Hood and Margetts (2007) distinguishes four types of resources that a government can draw on: *nodality*, *authority*, *treasure*, and *organization*. For this reason, this theoretical framework is often referred to by the acronym "NATO".

Nodality as a resource refers to the property of being in the middle of an information or social network. A 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, governments draw 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. Governments can use authority to detect and obtain information by requisition, or as an effecting tool; for instance, governments can command tax inspections and raids. *Treasure* refers to freely exchangeable resources (usually monies or money-like substances) that can be used by governments as incentives or inducements to secure information or change someone's behavior. An example of drawing on treasure as a resource would be a 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" (Hood & Margetts, 2007, p. 102). An example of organization as a resource would be government officials scrutinizing traffic at ports or airports to collect tax-relevant information (Hood & Margetts, 2007). The assumption behind the NATO framework is that when acting, governments are trying to influence social behavior and shape the world outside, thus drawing on different types of resources in the "toolkit".

The tool approach to the analysis of the role of digital government has its conceptual foundations in the theory of cybernetics and the foundational science of control, and considers the distinctive properties of government rather than of organizations in general. Digital technology acts as both an enabler and a potential threat to the governments' ability to draw on their resources. For example, as nodality denotes the property of being "nodal" to stakeholder networks and of having the ability to disseminate and collect information, the emergence of digital platforms can act as an amplifier of this government resource, but also as a threat to it. For instance, the proliferation of competing information (and misinformation) sources sparked by social media platforms during the COVID-19 pandemic represented a blow to the effectiveness of governments to draw on its nodality resources (Margetts et al., 2021).

While the NATO framework does not claim be comprehensive in terms of covering all possible organizational instruments or forms, it enables comparative analyses in two ways: to compare how the tools are used across different governments, levels of government, or government agencies, and to assess change over time (Margetts & Hood, 2016).

The NATO framework has thus been fruitfully employed to capture the type and significance of government resources employed in tackling a wide variety of challenges related to digital tools, given its parsimony and flexibility. The framework has been used to unpack the role of government in digital phenomena as diverse as Artificial Intelligence strategy-making (Djeffal, Siewert, & Wurster, 2022), big data analytics (Castelnovo & Sorrentino, 2021), e-health (Ossebaard, van Gemert-Pijnen, & Seydel, 2012), digital border control (Broeders & Hampshire, 2013), the ethical implications of Information and Communication Technologies (ICT) (Depaoli, Sorrentino, & De Marco, 2021), crowdsourcing (Taeihagh, 2017), and cybersecurity policies (Li, Guo, & He, 2022). Notably, the framework has been also recently used to investigate the role of digital technologies in the transition towards sustainability goals, such as smart mobility (Wallsten, Sørensen, Paulsson, & Hultén, 2020), and electromobility (Junior et al., 2022). Drawing on this record, we employ the NATO framework to analyse the role of digital government in the circular economy.

4. Research design

To answer the research question *"What is the role of digital government in the transition towards a circular economy (CE)?"*, we adopted a research design articulated in two steps, as illustrated in Fig. 1.

The first step of the design consists in understanding the role of digital government in a circular economy context. This step is to be carried out through a review of relevant empirical studies in the existing research literature, and considers the context of digitalization in the circular economy by identifying what stakeholders, digital technologies, and product life cycle (PLC) stages circular economy initiatives involve, and what resources governments draw on, using the NATO framework. As output of this first step, this mapping exercise aims to provide a snapshot of the role of digital government in existing circular economy initiatives, and of its characteristics (see Section 5).

The second step aims to understand the role of digital government in the *transition* towards a circular economy, by introducing a longitudinal dimension. This step stems from a realization that a snapshot view of the role of digital government in circular economy initiatives falls short of capturing the complex nuances of the changing resources that government draws on over time. This second step consists of the development of a process view of digital government roles in CE initiatives, and on the conceptualization of two different transition *styles*, based on an analysis of empirical cases in which governments shift between resources that they draw on over time, analyzed following the categorization provided

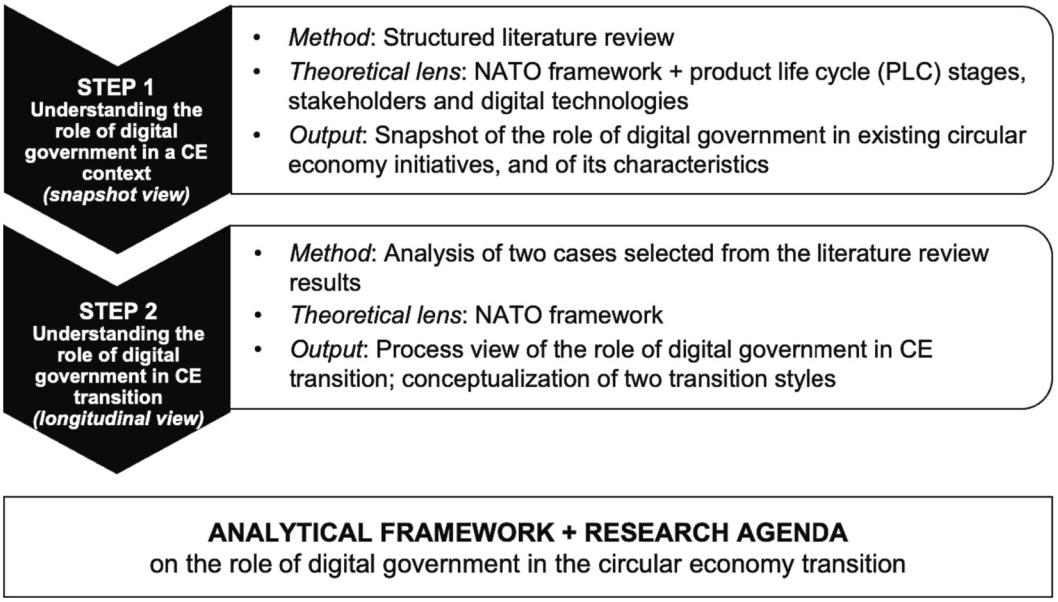

Fig. 1. Research design.

by the NATO framework.

Each of the two steps, including both the snapshot and the longitudinal view of the role of digital government in the circular economy transition, contributes to developing a research agenda that covers all aspects unpacked in our research design. Part of the items of the research agenda are aimed to fill the gaps identified in the snapshot literature review, while part are aimed to stimulate further research that draws on the process view that we propose.

In the next section, we illustrate the methods and findings of the first step of our research design, which is the snapshot mapping of digital government and circular economy research.

5. Mapping digital government and circular economy research

5.1. Article collection and analysis methods

To map existing research on the role of digital government in the development of the circular economy, we have analyzed research publications in the fields of Information Systems and of digital government.

We carried out a keyword search on 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")).

We applied this search query twice, once in April 2021, which resulted in a preliminary analysis (Medaglia, Rukanova, & Tan, 2022). As this field of research has since gained additional momentum, we repeated the same search query in September 2022, and we updated the literature analysis based on this more extensive data set. The final search resulted in a data set of 104 articles. These articles were then manually scanned to ensure both text accessibility and relevance of the content – that is the alignment with the research question of this study: *What is the role of digital government in the transition towards a circular economy (CE)?* The scan resulted in a pool of 88 papers, which were coded in the following four dimensions: role of government, stakeholders involved, product life cycle (PLC) stages, and digital technologies.

Regarding the role of government, we used the four categories of resources indicated in the NATO framework (nodality, authority, treasure, and organization) (Hood & Margetts, 2007) to identify which resources the government would draw on in each empirical case analyzed in each article.

Regarding the stakeholders involved, we paid specific attention to which actors of the circular economy ecosystem each empirical study focuses on. Based on a few iterations that considered the need to balance the granularity of the analysis with its practical use, we created 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).

Regarding the product life cycle stages, we classified papers based on the stage of the product life cycle (PLC) (Herrmann, Hauschild, Gutowski, & Lifset, 2014) they focus on (whenever they focus on any of them), following the approach by Zeiss et al. (2021). 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.

Lastly, we classified articles based on the type of digital technology investigated in each study. 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.

In the first round of article scanning (April 2021), two of the authors independently analyzed all the articles and classified them using the categories discussed above. Whenever possible, the analysis was carried out 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.

In the second round of the scanning (September 2022), three authors were involved in the coding process, using the same categories of analysis as the first round. To ensure alignment in the coding team, 10 articles were coded from all three authors and the differences in coding were discussed to allow for further alignment and consistency between the team involved in the initial coding and the new member of the coding team. After this stage, the remaining articles were coded by two authors (one involved in the coding of the first set and the third author that joined the coding team). The results of the analysis based on this process are presented in the following section.

5.2. Findings

The 88 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, many of them identified one or more countries in which the empirical study has been carried out. In total, 28 countries are focused on in the articles.

As illustrated in Figure 2, it is interesting to observe that the countries that are by far most focused are China and India, followed by a long tail of countries in Europe, Asia, and the Americas, which are focused on only a handful of times. The focus on China reflects the early initiatives that the country has taken around the circular economy for several years now. China passed the Circular Economy Promotion Law in 2009, and has acknowledged the circular economy as a national development goal for more than a decade (Mathews & Tan, 2011).

5.2.1. Role of government

Figure 3 presents the results from our analysis with respect to the role of government. Authority is the government resource that was most encountered, followed by treasure. The analyses included in existing research show that a shift towards a circular economy is often driven from the government side with policies, regulations and requirements for monitoring and control. It is also not surprising that treasure appears as the second most encountered role, as it reflects the traditional role of government in using financial incentives and subsidies to enable transitions.

Our analysis also shows that the resources of nodality and organization are much less focused on. These resources relate to the positioning of the government in the wider ecosystem, building and brokering relationships between actors. These roles 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 and engagement models. Still, in current research, these roles have received limited attention.

5.2.2. Stakeholders involved

Figure 4 provides an overview of the results when we look at the stakeholders involved in the circular economy ecosystems.

Most of the studies focus on business actors in the ecosystem, as can be expected in the context of the circular economy. Other categories of stakeholders that are less focused on include individual consumers and research institutions. The least focused stakeholders are IT providers – a surprising finding, given the key role that IT plays in the development of the circular economy, with its consequences for digital government

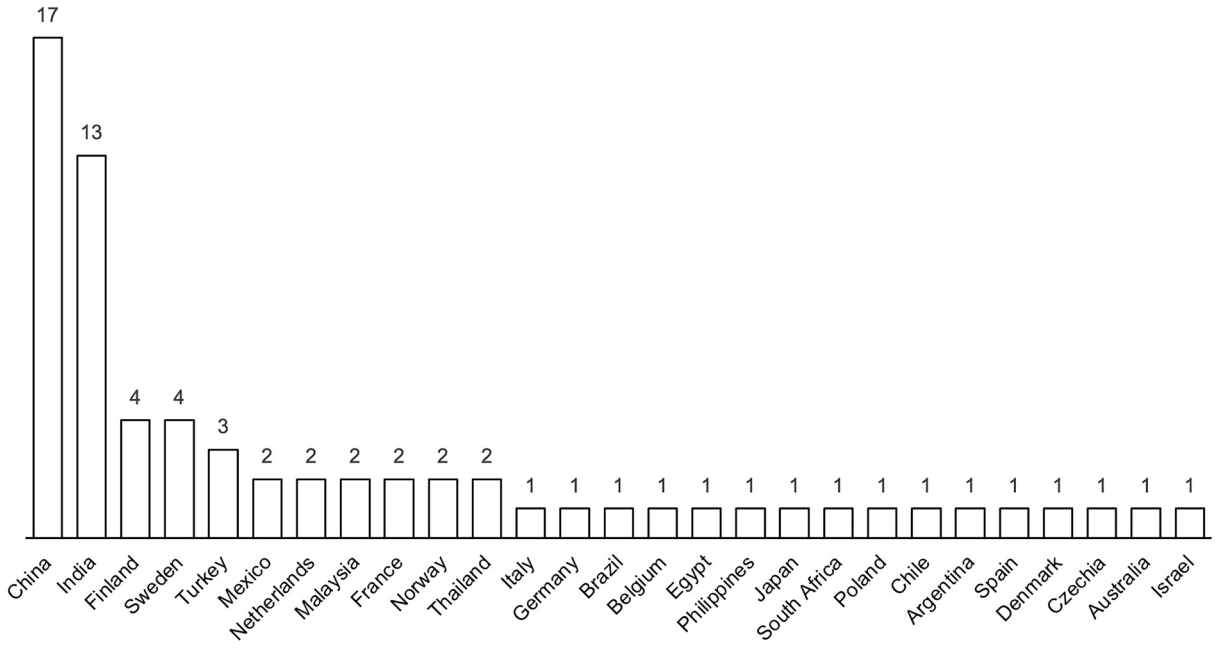

Fig. 2. Number of studies by countries focused on in their analysis.

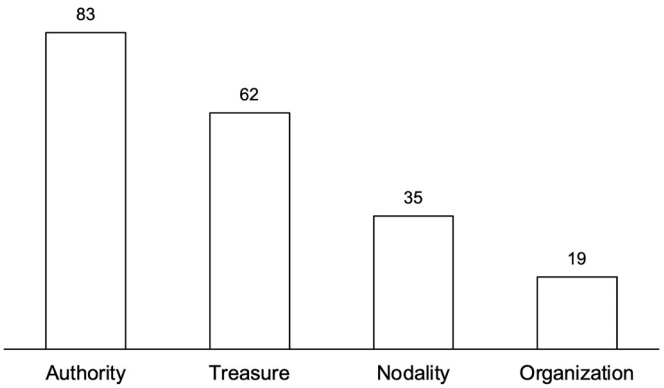

Fig. 3. Number of studies by type of role taken by the government in their analysis.

initiatives.

5.2.3. *Product life cycle stages*

Figure 5 summarizes the findings when looking at the aspect of product life cycle (PLC) stages that are focused on in the reviewed studies. The focus is put largely on the post-use stage, as many studies 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 product end of life. For the in-use stage, on the other hand, the role of the consumer can be considered paramount.

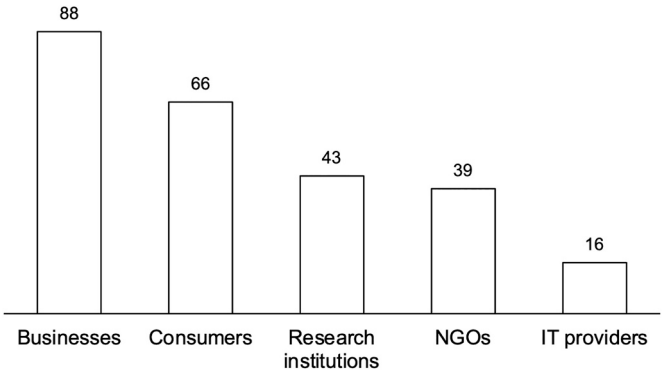

Fig. 4. Number of studies by type of stakeholder included in their analysis.

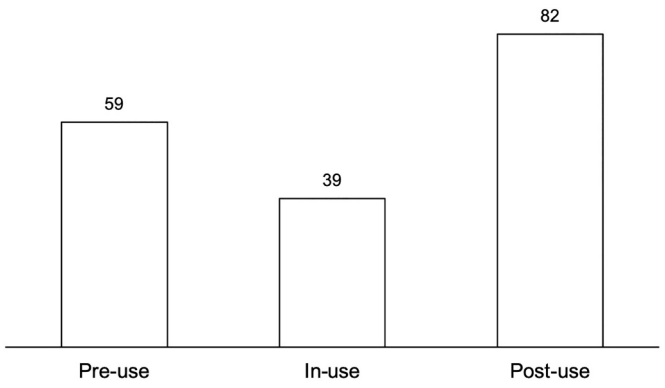

Fig. 5. Number of studies by stage of the product life cycle (PLC) focused on in their analysis.

5.2.4. *Digital technologies*

While all 88 papers analyzed deal with the role of digital technologies at least in a general way, 37 have an explicit focus on one or more specific technologies. Fig. 6 presents a word cloud to illustrate the technologies that were mentioned in the papers.

The distribution of foci on specific technologies is rather scattered, with a prevalence of cutting-edge technologies. The use of sensors in product supply chains, for example, referred to as the Internet of Things (IoT), is the most focused on technology (see Table 1). Other key technology keywords include blockchain, Industry 4.0, and Artificial Intelligence, followed by a long tail of technologies that have only few studies dedicated to them – these include digital twins, robotics, and cloud-based systems supporting circular economy initiatives.

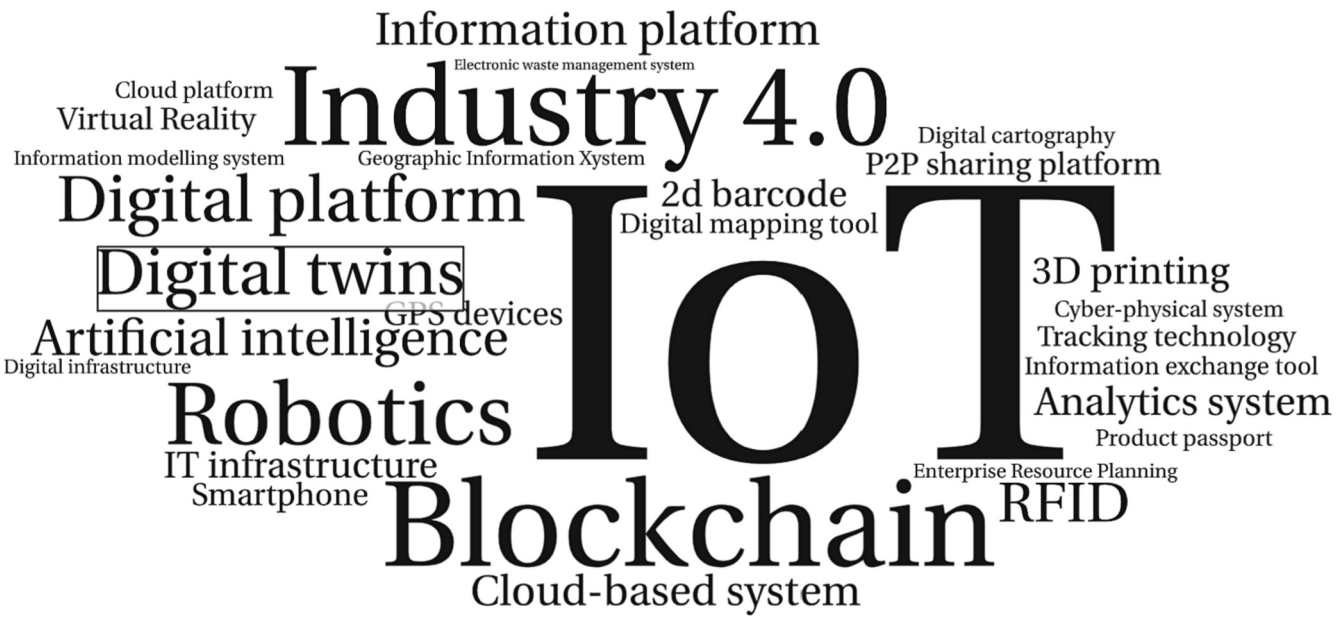

Fig. 6. Word cloud of technologies mentioned in the papers.

Table 1
Technologies focused on in more than one study.

Technology focus	N of papers
Internet of Things (IoT)	10
Industry 4.0	7
Blockchain	6
Artificial Intelligence	5
Digital platform	4
Information platform	3
Digital twins	3
Robotics	2
Cloud-based system	2

6. Circular economy transition: The role of digital government

6.1. Towards a process view

Based on the snapshot resulting from the mapping of existing research on digital government and the circular economy, the second step of our research design (see Section 4) consists of considering the longitudinal dimension of the role of digital government in the circular economy.

Different government policies and regulations are aimed to initiate a transition towards a circular economy. Our review of the empirical research literature showed that, while some resources like authority and treasure have been often deployed, other resources of digital government, like nodality and organization, are often not. While this type of analysis is useful, it provides a static approach to categorize the roles of government with respect to the CE. As governments are introducing policies and instruments to stimulate the transition towards a circular economy, it is crucial to capture this transition, and to explore whether the roles of government change when we take a process perspective and look at the CE transition in terms of stages.

The establishment of circular economy practices as a transition process is also evidenced by the way that CE objectives, and the overall discourse on Sustainable Development Goals, are framed by policymakers: the European Green Deal priority by the European Commission, for instance, focuses on the initiation of a "green transition", seeing it as an evolutionary process over time (European Commission, 2020).

In this perspective, a transition process consists of a first stage of *initiation*, where triggers are put in place to activate government resources, as well as stakeholders and technologies, to set a transition process in motion. This is followed by an *implementation* stage, where stakeholders draw on government resources to carry out initiatives of circular economy. In the third stage, initiatives are the object of a *consolidation* effort, with the establishment of durable practices enabled by technology and involving all stakeholders. Each stage is aimed at the achievement of CE goals, and in each stage government authorities can draw on each of the four types of its resources in using digital technology: *nodality*, *authority*, *treasure*, and *organization*.

Fig. 7 illustrates these stages, and the possible corresponding resources of government, as a process view of the digital government role for the circular economy transition.

It is worth noting that the stages are conceptualized as an iterative process, rather than a linear one. While CE objectives are often set to be achieved at specific points in time in real-life initiatives, these milestones of achieved goals are in fact part of a punctuated cycle, where the consolidation of established CE practices that can be achieved in the third stage of this process can potentially give way to the initiation of a new transition process, characterized by different goals, different stakeholders, and thus draw on different digital government resources.

In the following section, we exemplify the applicability of this process view by referring to two cases of circular economy transition, where the government draws on different types of resources (nodality, authority, treasure, and organization) in each of the three stages of the transition.

6.2. Circular economy transition and digital government: Two empirical cases

To apply the process view and investigate the role of digital government specifically in the context of circular economy transition, we turn to selected cases from the results of our literature review on digital government and the circular economy (see Section 4). Based on a screening of all 88 studies collected in the review, we have identified two cases of digital government in relation to circular economy transition that are especially informative in highlighting patterns of changes in the resources employed by governments.

The selection of two empirical cases followed an iterative approach. First, two of the authors scanned all 88 papers from the literature review to identify empirical studies that employed a longitudinal approach. This resulted in a pool of 10 articles, which were then analyzed by all

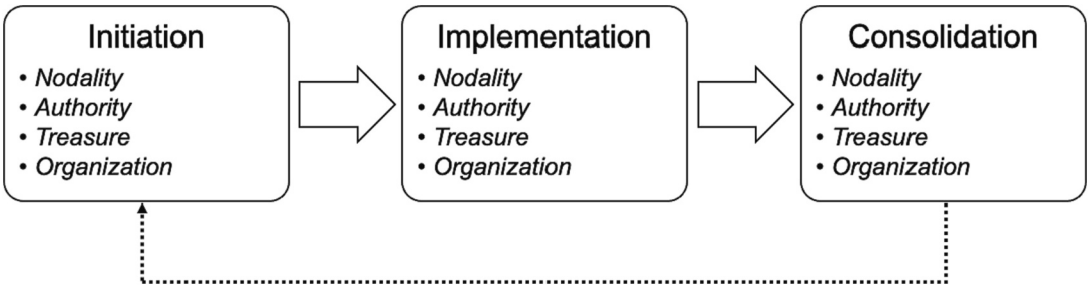

Fig. 7. A process view of circular economy transition: the role of digital government.

three authors to identify empirical longitudinal cases where the role of government changed markedly over time.

These two cases concern, respectively, the use of digital twins in the building industry in the Netherlands (Többen & Opdenakker, 2022), and the use of the Internet of Things for source separation of household waste in China (B. Wang, Farooque, Zhong, Zhang, & Liu, 2021). Details of the two cases have been inferred by all three authors based on the case analysis provided in each of the two articles.

6.2.1. *Case 1 – Digital twins in the building industry in the Netherlands*

One of the industries in which CE initiatives have the most potential to provide benefits is the building industry. The building industry consumes around 40% of all materials globally, and generates 35% of the world's waste, of which most is being landfilled or incinerated (Eberhardt, Birgisdottir, & Birkved, 2019). A case in point is the transition towards a circular economy of the building industry in the Netherlands, enhanced by the use of digital technologies like digital twins and material passports (Többen & Opdenakker, 2022).

In the *initiation* stage, the government triggered the transition process by establishing agreements with other stakeholders, such as private companies in the industry. With the goal of achieving 100% of circularity by 2050, in 2017 a raw material agreement was signed by companies and the government to foster the circular economy, which resulted in the establishment of a transition agenda for the building sector in 2018. The government, in this phase, thus drew on its *nodality* resources, that is on its key position within the network of stakeholders in the industry, to prepare and negotiate the signing of relevant agreements.

In a subsequent *implementation* phase, the government focused on drawing on its *authority* resources. In 2021, a market stimulation of circular buildings started, which coincided with the government establishing the requirement of material passports for construction companies.

To *consolidate* results achieved in this transition phase, the government continued to draw on its *authority* resources to further enforce circularity in the industry. In 2023, the government began requiring circular components to be mandatorily included in all tenders, with a view to rolling these requirements out to all public institutions by 2030.

6.2.2. *Case 2 – Internet of things for source separation of household waste in China*

The second case concerns a circular economy transition in waste management. The process of separation of sources is a key element of sustainable waste management, which is essential for a transition to a circular economy to recover value from household waste. China is the world's largest generator of municipal solid waste (Y. Wang et al., 2018) and has encouraged source separation of household waste through government policy instruments and the use of technology (Zhang & Wen, 2014). In this case, a residential community in Ningbo, a major sub-provincial city in Zhejiang, a province in eastern China, established a project in 2016 to improve source separation of household waste using digital technology (B. Wang et al., 2021).

In the *initiation* phase, the project was kicked off with direct government investments in Internet of Things (IoT) infrastructure, including providing free rubbish bags with scannable 2D codes to all citizens and businesses. Notably, this reliance by the government on its *treasure* resources was a result of previous unsuccessful attempts to push a breakthrough in waste separation by means of promotion and education campaigns.

After this initiation phase of successful diffusion of the subsidized IoT infrastructure, the local government authority focused on an *implementation* phase, by sending out government inspectors to carry out daily random checks on samples of rubbish bags, using 2D code scanners, to identify non-compliant users by cross-checking into a database. In this phase, the authority relied on its own *organization* resources, namely its own employees.

To *consolidate* the outcomes of the initiatives, the government community managers started giving out awards to the best-performing households and publicizing the names of winners, based on credit points assigned in the IoT-enabled system. Award assignment, in this case, represents a reliance on the *authority* resource of the local government agency.

Interestingly, the two cases feature the reliance on different resources at different stages, but also some similarities. Table 2 provides a summary of the characteristics of the transition in the two cases.

6.3. *Digital government and circular economy transition styles*

As the second step of our research design (see Section 4), we draw on the analysis of different resources used by governments involved in digital government initiatives (Step 1) and on the longitudinal dimension of digital government in circular economy transition, to conceptualize different styles of circular economy transition.

The peculiarity of the two empirical cases analyzed in Section 6.2 sheds light on similarities and differences in the type of government role, and thus of government resources relied upon, at each stage of the transition towards a circular economy. To elevate the cases to a higher level of abstraction, we posit the sequence of different resources enacted by governments at different stages of transition as typical of different *transition styles*.

The style of transition exemplified by Case 1 (the use of digital twins in the building industry in the Netherlands) is characterized by the government steering the transition process by mostly resorting to its authority resources, except for the very first stage of initiation of the transition. In the case of the use of digital twins in the building industry in the Netherlands, the transition process is kicked off by voluntary agreements between the construction companies and the government. Following this phase, the government starts drawing solely on its authority resources, such as establishing requirements to facilitate implementation, and then consolidating the transition by mandating CE components in tenders.

We conceptualize this as a transition style of "*progressive enforcement*". We posit that such style captures transitions to a circular economy where governments engaging in the use of digital technology

mostly resort to authority, but in a gradual fashion. In this style of transition towards a circular economy, the government adopts an initial stance that is based on leveraging its network of relationships (nodality). This initial stage, when moving towards consolidating the results obtained, is then enforced in mandatory rules and regulations later in the transition.

A very different style of transition is the one exemplified by Case 2 (Internet of Things for source separation of household waste in China). This style is characterized by a government's initial use of the treasure resource to kickstart the transition towards a circular economy using digital tools, followed by a wider array of resources, including the organizational, in the implementation stage and, only in the consolidation phase, the authority resource. In the beginning, stakeholders are mobilized with the use of seeding fund investments. This mobilization is then consolidated by employing government organizational resources. The result of this seeding is then "harvested" by sanctioning them with the seals of authority.

We conceptualize this transition style as "*seeding and harvesting*", to connotate the distinct features of a process where a government steers the transition towards a circular economy using digital tools by drawing on different government resources, where authority is only one of a wider array employed over time.

Table 3 provides an overview of the features of the two transition styles.

In the following section, we discuss the implications of our findings in both mapping research and conceptualizing transition styles for future research on digital government and the circular economy.

7. An analytical framework and a research agenda

The final output of our research design (see Section 4) is an analytical framework and an agenda for future research on the topic area of digital government and the circular economy transition, drawing on all the findings from our analysis, including both the review of existing research literature, and our case-based definition of different styles of CE transition.

Figure 8 provides a graphical representation of the proposed analytical framework.

The foundation of the analytical framework is the acknowledgment that a circular economy transition occurs within a specific context. This context is characterized by relevant digital technologies (emerging, like Artificial Intelligence or IoT, or well-established, like cloud computing); different stakeholders (like research institutions, businesses, NGOs, and citizens/consumers); and different stages of a product lifecycle (pre-use, in-use, and post-use).

The first step of an analysis of the link between digital government and the circular economy transition involves identifying the type of role that the government adopts. The use of the resource lens, as provided for by the NATO categorization, allows to obtain a static view of such role.

The second step of the analysis provided for by our analytical framework involves adopting a longitudinal process view of the role of government. According to this view, the role of government is focused on at different stages of the circular economy transition, that is the initiation stage, the implementation stage, and the consolidation stage. Moreover, these stages can occur at different levels of government, including the local, the national, and the supra-national.

Lastly, the analytical framework provides for the analysis of different transition styles, determined by the types of resources that the government draws on at each of the three transition phases. The combination of different type of resources corresponds to different paths towards the circular economy.

This analytical framework forms the basis for a research agenda. A research agenda focusing on the role of digital government in the circular economy transition needs to be seen also in the context of the urgent need for action from governments, in collaboration with other stakeholders and enabled by digital technologies, stemming from documented malpractices as, for example, in the textile industry (Changing Markets Foundation, 2023; Cobbing et al., 2022).

Figure 9 provides a graphical overview of how the proposed research agenda draws on each of the components of the analytical framework.

Our review of the literature highlights a number of gaps in existing empirical research, with some of the categories in each of the dimensions of the phenomenon of digital government and the circular economy (role of government, stakeholders involved, product life cycle stage, and digital technologies) that are still under-investigated, despite arguably playing important roles. The two empirical cases we analyzed longitudinally, and the process view proposed, on the other hand, open for research questions related to changes in the role of digital government, and to transition styles towards a circular economy.

We thus put forward six topic areas for a research agenda: 1) digital technologies and the CE transition; 2) digital government and CE stakeholder interaction; 3) digital government and product life cycle (PLC) stages; 4) digital government resources and the CE transition; 5) multilevel governance of the CE transition; 6) digital government and CE transition styles.

Table 4 provides a detailed overview of our proposed agenda for future research on digital government and circular economy transition, detailing the main areas of research, the research foci, and examples of research questions that should drive future empirical research, which we discuss in the next section.

7.1. Digital technologies and CE transition

Our review of the literature highlights that some noteworthy digital technologies are seldom focused on in research on digital government and the circular economy. Blockchain is a key technology that has the potential to support the achievement of sustainable development goals through circularity by enabling transparency and traceability in product supply chains and in post-use stages (Medaglia & Damsgaard, 2020). While this potential is partly acknowledged in existing research, future studies in digital government should give a much closer look at the role of specific digital technologies that carry the potential for sustainability such as, for example, Artificial Intelligence (Vinuesa et al., 2020).

Possible research questions stemming from the need to focus on digital technologies include: What are blockchain technology architectures that can support a circular economy transition? How can the government balance regulation with stimulating innovation in the use of AI for a circular economy transition? What skills are required for public

Table 2
Government resources in the use of digital tools for circular economy transition: two exemplary cases.

CE case	Country	Initiation phase	Implementation phase	Consolidation phase
Digital twins in the construction industry (Többen & Opdenakker, 2022)	The Netherlands	Nodality • Drafting agreements with construction companies	Authority • Establishing material passport requirements	Authority • Mandating CE components in tenders
Internet of Things in urban waste separation (B. Wang et al., 2021)	People's Republic of China	Treasure • Infrastructure direct investments	Organization • Government inspectors carrying out compliance checks	Authority • Award assignment to best performers

Table 3
Digital government and the circular economy: two transition styles.

CE Transition style	Initiation phase	Implementation phase	Consolidation phase	Exemplary case
"Progressive enforcement"	Nodality	Authority	Authority	Többen and Opdenakker (2022)
"Seeding and harvesting"	Treasure	Organization	Authority	Wang et al. (2021)

servants dealing with Industry 4.0 initiatives for a circular economy transition?

7.2. Digital government and CE stakeholder interaction

In relation to the role of different stakeholders involved in circular economy ecosystems, existing research features an imbalance. 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 a complex phenomenon with extensive impacts in terms of power relationships (Medaglia, Eaton, Hedman, & Whitley, 2021), or requirement specifications (Moe, Newman, & Sein, 2017; Riihimäki & Pekkola, 2021), 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. Research will also need to include a focus on interactions between key stakeholders, such as between governments and citizens/consumers. This focus was exemplified by Case 2 in our study (Internet of Things for source separation of household waste in China) where it highlights the dynamic of government authorities interacting with citizens and consumers using the treasure resource in the initiation phase towards CE transition: direct government investments in this phase, in fact, included providing free rubbish bags with scannable 2D codes to all citizens (Section 6.2.2).

Examples of key research questions related to digital government and CE stakeholder interaction would be: what are the power relationships between IT providers, government, and other stakeholders involved in circular economy transition initiatives? To what extent does research conducted by research institutions influence circular economy transition? What are partnership models between government, research institutions, and NGOs to stimulate a circular economy transition? What role does the government take in interacting with citizens and consumers?

7.3. Digital government and product life cycle stages

Regarding research on different stages of the product life cycle (PLC), our findings show that existing research tends to focus mostly on issues related to the pre- and post-use stages of product life cycles and overlook what happens in the in-use stage. This stage comprises the period of

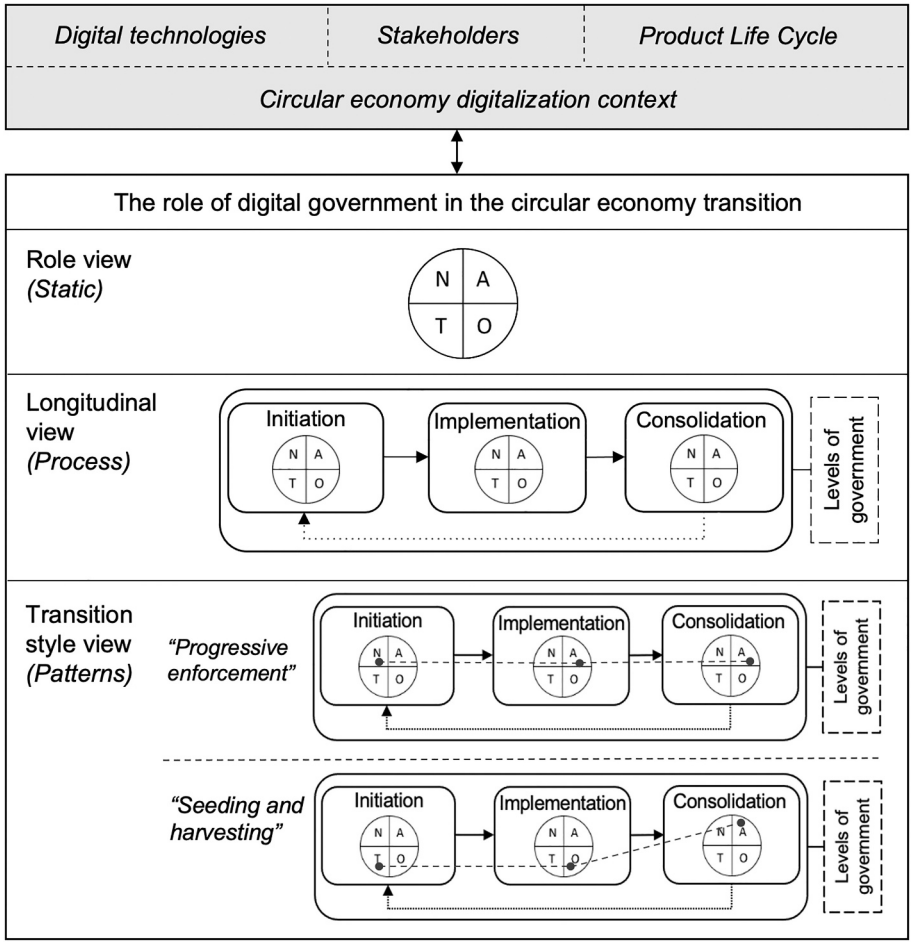

Fig. 8. Digital government and the circular economy transition: an analytical framework.

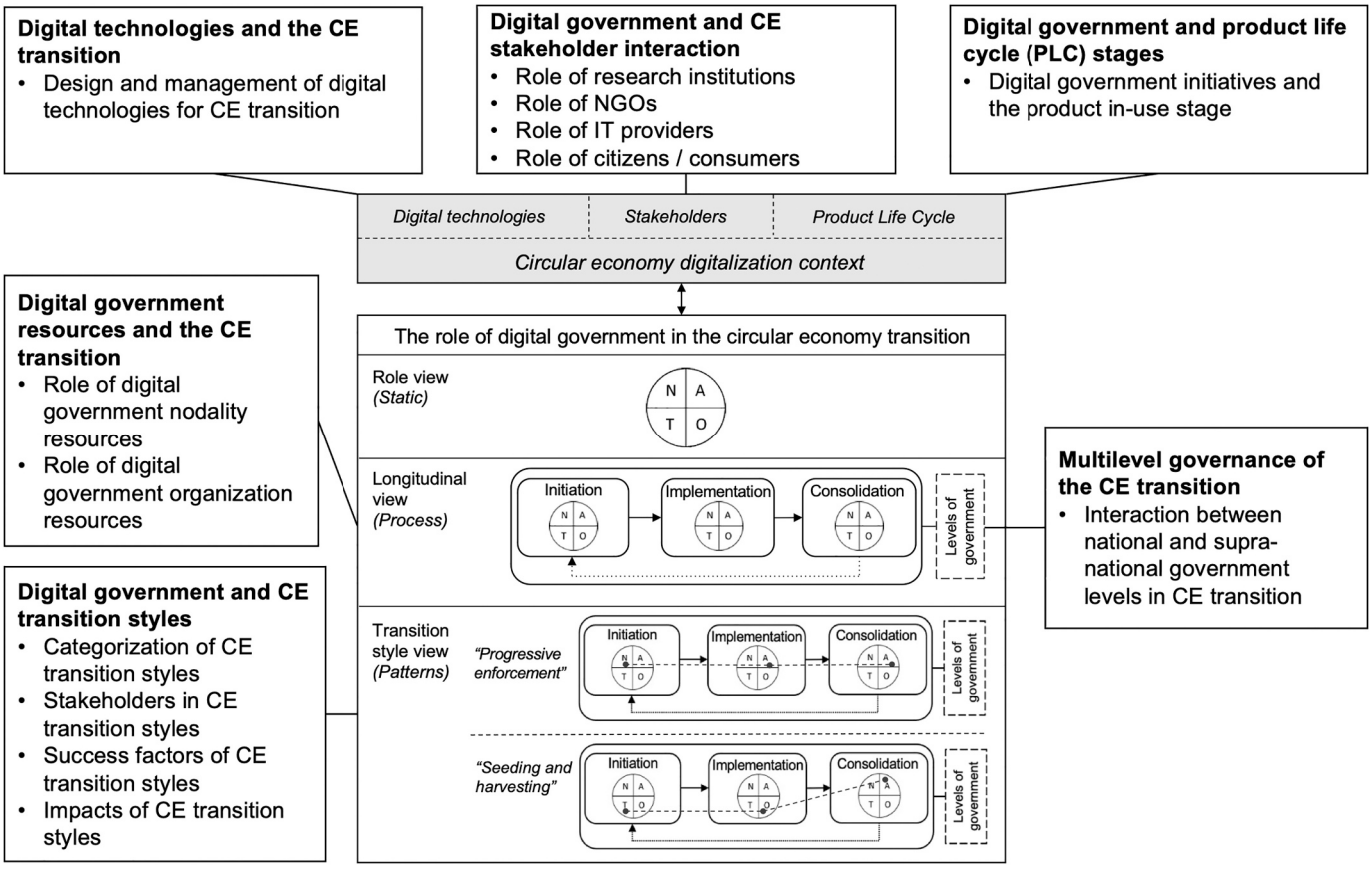

Fig. 9. Digital government and the circular economy transition: A research agenda.

product use by the consumer, and it is the stage where the goal is to intensify and extend the use of products and their components. 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 area include: how can digital government services influence product repairing practices? How can digital government platforms improve product sharing and optimize consumption processes?

7.4. Digital government resources and the CE transition

In relation to the role of government, as shown by our review of the literature, the traditional resources of treasure and authority are mostly focused on, with the government stimulating the development of a circular economy either by economic incentives, or by establishing regulation and guidelines. Other potential roles that governments can take in the development of an ecosystem for a circular economy are relatively overlooked – namely, the possibility for a government to draw on its central position in important networks (i.e., nodality) to educate stakeholders and establish partnerships; and the possibility for a 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 natures (public and private organizations, diverse supply chains, etc.), and requiring diverse skills (technical, legal, managerial, etc.).

Future research on digital government and the circular economy should pursue a more holistic view of the phenomenon of the circular economy by providing more attention to the nodality and organization aspects of the government's role.

Examples of key research questions in this dimension would be: what are the characteristics of effective online government information campaigns on a circular economy transition? How can skills possessed by governmental agencies be drawn towards initiatives for a circular economy transition?

7.5. Multilevel governance of CE transition

We see governments drawing on the resource of nodality and of organization as well. In Europe, EU funding programmes have worked as an engine of innovation for decades. In the area of international trade and customs, a series of EU-funded projects with the 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 (Rukanova et al., 2020; Rukanova, Zinner Henriksen, Heijmann, Arifah Arman, & Tan, 2018). In these projects, the government formed part of the innovation process, acting in their organization role, and engaging actively with other stakeholders. For example, in the CORE[1] EU project, customs authorities worked closely with supply chain partners and technology providers to pilot data-sharing infrastructures for the voluntary sharing of business data with the 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[2] EU project, several EU customs administrations collaborated with data analytics providers and external data providers to examine the possibilities offered by data analytics for customs. This rich knowledge and experience on how government can collaborate with supply chain

[1] http://www.coreproject.eu/
[2] https://www.profile-project.eu/

Table 4
Digital government and the circular economy transition: A research agenda.

Area	Research focus	Research question examples
1) Digital technologies and the CE transition	Design and management of digital technologies for CE transition	• What are blockchain technology architectures that can support a circular economy transition? • How can the government balance regulation with stimulating innovation in the use of AI for a circular economy transition? • What skills are required for public servants dealing with Industry 4.0 initiatives for a circular economy transition?
2) Digital government and CE stakeholder interaction	Role of research institutions	• To what extent does research conducted by research institutions influence circular economy transition?
	Role of NGOs	• What are partnership models between government, research institutions, and NGOs to stimulate a circular economy transition?
	Role of IT providers	• What are power relationships between IT providers, government, and other stakeholders involved in circular economy transition initiatives?
	Role of citizens/consumers	• What role does the government take in interacting with citizens and consumers?
3) Digital government and product life cycle (PLC) stages	Digital government initiatives and the product in-use stage	• How can digital government services influence product repair practices? • How can digital government platforms improve product sharing and optimize consumption processes?
4) Digital government resources and the CE transition	Role of digital government nodality resources	• What are the characteristics of effective online government information campaigns on a circular economy transition?
	Role of digital government organization resources	• How can skills possessed by governmental agencies be drawn towards initiatives for a circular economy transition?
5) Multilevel governance of the CE transition	Interaction between national and supra-national government levels in CE transition	• What are government resources used at different national and supra-national levels (e.g., EU) in digital government CE transition initiatives?
6) Digital government and CE transition styles	Categorization of CE transition styles	• What are other possible styles of transition in the use of digital government resources towards a circular economy?
	Stakeholders in CE transition styles	• What are the stakeholders involved in different styles of CE transition?
	Success factors of CE transition styles	• What are success factors of different styles of CE transition?
	Impacts of CE transition styles	• What type of impacts do different styles of transition in the use of digital government resources towards a circular economy have?

partners, IT providers, and academia for developing innovative solutions, can serve as a fertile ground for further innovations around the 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, governments can also play an active role of nodality. One such example is the EU-funded practitioner innovation network of customs professionals (PEN-CP[3]), 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 when 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 the circular economy.

The supra-national level of government action, such as the EU level, can thus be considered as a given and as something external that defines changes at a national level. While to some extent this is the case, national governments also bring their inputs to the supra-national level and help shape the decision-making process. Taking a multi-level perspective on the interactions between national and supra-national levels would allow us to advance even further our understanding of the role of government with respect to a circular economy transition.

Research questions related to the interaction between national and supra-national government levels in CE transition can include: what are government resources used at different national and supra-national levels (e.g., EU) in digital government CE transition initiatives?

7.6. Digital government and CE transition styles

Different cases of engagement of digital government in CE transition initiatives feature different types of "styles" of transition. Our analysis of two empirical cases focused on how governments can employ different resources during different phases of a transition towards a circular economy using digital tools. Our identification of two styles of transition, the "progressive enforcement", and the "seeding and harvesting" styles, can be the first step towards an articulated agenda of research into the features, the stakeholders involved, the success factors, and the impacts of not only these two styles, but of possibly a wider typology of styles.

Research questions related to this area can therefore be: what are other possible styles of transition in the use of digital government resources towards a circular economy? What are the stakeholders involved in different styles of CE transition? What are success factors of different styles of CE transition? What type of impacts do different styles of transition in the use of digital government resources towards a circular economy have?

8. Conclusion

Sustainability and the circular economy are high on the political agenda. The global discourse on the need to shift from a linear to a circular economy is gaining increasing momentum, both in policy and in research. While governments will certainly play a role in the circular economy transition, what roles governments can play to facilitate the transition using digital technologies is still unclear. Moreover, a dedicated stream of studies in digital government scholarship is missing. The main question that we set out to explore in this paper was thus: *what is the role of digital government in the transition towards a circular economy (CE)?* As a result of this study, we developed a conceptual framework that can be used as an analytical lens to investigate the role of digital government in the CE transition. Based on this framework, we defined an agenda for future studies.

Our study is, of course, not devoid of limitations, mostly linked to the exploratory nature of our approach. First, we acknowledge that the

[3] https://www.pen-cp.net/

literature review we carried out is not comprehensive, and we call for future efforts to map the field at the intersection of digital government research and of circular economy research, to both expand the scope and refine the categories of the analysis. Second, further empirical work is needed to test, refine, and enrich our process view of digital government and the circular economy transition. In the research agenda, we suggest in fact investigating not only the changing role of government resources over CE transition phases, but also the role of other stakeholders such as businesses, NGOs, research institutions, and IT providers. Third, given one of our main goals of contributing to the understanding of the role of digital government in the circular economy transition through the proposition of an analytical framework, we have limited our analysis of circular economy transition styles to two published studies as examples. The two cases are not to be considered as comprehensive in terms of all possible characteristics of circular economy transitions impacted by digital government initiatives: they are meant to represent only two of the potentially many other transition styles that future research might uncover. Moreover, the limited number of illustrative cases that we found through the literature review was due to the requirements of featuring cases that focus on the role of government through all stages of a circular economy initiative (initiation, implementation, and consolidation), and of featuring cases in which the government role changes over each stage. This has unfortunately proven impossible within the pool of 88 cases. We call for the collection of primary data with the analysis of new cases using our proposed analytical framework.

The concept of the circular economy is part of a necessary and urgent global conversation over the transition towards a sustainable society for everyone, and digital government research needs to be geared to both enable and shape such a transition.

CRediT authorship contribution statement

Rony Medaglia: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Visualization, Supervision. **Boriana Rukanova:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Visualization. **Ziyan Zhang:** Formal analysis, Data curation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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