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Polycentric Governance of Privately Owned Resources in Circular Economy Systems

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ABSTRACT Natural resource scarcity is giving rise to new forms of resource governance and so enhancing the transition to more sustainable resource use. One key development is the growth of circular economy systems, where residual resources are reused in closed-loop systems. This requires an understanding of how diverse actors collectively govern the sustainable use and sharing of privately owned residual and waste resources. Our empirical analysis of three circular economy systems in Finland, the United States and Spain shows how a polycentric form of governance develops through collective action between businesses, the public sector, and societal actors based on multiple units of cooperation. Adopting insights from the polycentric governance of commons, we develop a theory of polycentric governance for privately owned residual resources. Our findings show that polycentric governance involves three main interacting elements: mutual adjustment between actors, practices for collective agency, and structures for sharing resources. As well as contributing to the understanding of collective action for sustainability, these findings also advance the interorganizational governance literature.

Keywords: polycentric governance, collective action, sustainability, interorganizational governance, system-level governance

INTRODUCTION

The sustainable use of material resources is a human imperative: current levels of natural resource overuse are already threatening not only global ecosystems but also economic and societal systems (George et al., 2014). Environmental research has made it clear that natural resource scarcity, climate change, water scarcity, and other grand challenges are caused by the overexploitation of shared natural resources and the lack of cooperation to

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find collective solutions (George et al., 2016). In view of these challenges, practices such as recycling, reuse, and remanufacturing of material resources are currently being adopted in many resource-dependent industries (George et al., 2014). The scarcity of critical natural resources and the development of new enabling technologies have catalysed new innovations to reintroduce waste as a raw material at different stages of the value chain (Murray et al., 2017). Although natural resource scarcity is a major challenge for global production and socio-economic systems, the changes that are now being made to the circular use of residual materials have not received enough attention in management science. Existing theories in management tend to focus on immaterial resources such as financial and human capital and to isolate the firm from the natural resource system in which it is embedded (George et al., 2014).

There are increasing calls that businesses now need to adopt a systemic collective action approach to sustainability (Ansari et al., 2013) and to explore the new forms of collaboration required by resource sustainability (Bowen et al., 2018; Gagnon and Capron, 2020). Most of these processes require cross-cutting collaborative efforts by various organizations (Ferraro et al., 2015) and new principles of natural resource reuse (George et al., 2014). One prominent example is the circular economy (CE) paradigm, which calls for cooperation between businesses for the reuse, recycling, and remanufacturing of residual resources (Esposito et al., 2018; Porter et al., 2019), often with help from non-governmental organizations (NGOs) and environmental public agencies (Bansal and McKnight, 2009). By residual resources, we refer to privately owned resources such as waste and by-products from industries that can cause environmental harm if mismanaged. These residual material resources are private because they either belong to the industries that created the waste or by-product or are in the hands of waste management companies. These resources could often be valuable, but their recovery and reuse is hindered by quality and quantity issues. Furthermore, firms may be hesitant to share information about their residual resources as this could reveal sensitive details about the composition of their products, for example. Due to these challenges, existing organizational theories do not provide adequate solutions for the collective governance of these privately owned residual resources.

While many theories focus on interorganizational relations such as cross-sector partnerships (Selsky and Parker, 2005), meta-organizations (Valente and Oliver, 2018), and industry self-regulation (Bowen et al., 2018), they do not say enough about the ways in which organizations address the collective action dilemma of privately owned residual resource governance. Thus, our research question here is this: How do multiple actors collectively govern the sustainable use of privately owned residual resources, and how does this governance model develop?

To explore the collective forms of governance of privately owned residual resources, we look beyond the current theories in management research and draw inspiration from the polycentric governance of commons (Ostrom, 2014). Typical commons include natural resource systems such as waterways, forests, and fisheries in common ownership (Ostrom, 1990), but others have also studied immaterial commons such as knowledge (Fjeldstad et al., 2012) or novel ways of organizing food, energy, or urban commons (Albareda and Sison, 2020). Polycentric governance refers to an *interconnected system of governance* where actors from multiple sectors coordinate collective action and develop structures for sharing common

resources, which eventually leads to an emergent order for common goals (Doh et al., 2018; McGinnis, 2016; Ostrom, 2014). We believe that, due to sustainability pressures, there are important lessons to be learned from polycentric commons governance that aims to avoid the overuse and waste of resources through new institutions for collective action (Ostrom, 2010). Industrial production and consumption generate residual material resources, which are conventionally considered non-valuable. These resources are now becoming increasingly valuable as they can be reintroduced in circular processes to generate value (Paquin and Howard-Greenville, 2013). But the sharing and exchange of these residual resources also brings important challenges, such as lack of resource information, lack of scale, and disconnected governance mechanisms. Understanding the growth of CE systems can therefore potentially help us to understand the development of new polycentric forms of governance, where privately owned resources (material or immaterial) are shared to generate collective benefits, as opposed to traditional commons research in which the starting point is common ownership (e.g., forests).

In order to answer the research question, we undertake a comparative case study (Yin, 2013) of three CE systems in Finland, Spain, and the United States. We find that heterogeneous organizations are able to develop polycentric governance models through the dynamic interplay of three key elements: *mutual adjustments* enabling collaboration and actor adaptation; *practices for collective agency* that enable information sharing about privately owned residual resources; and new *structures for sharing* resources that support diverse, interconnected units of governance.

We also show how actor and structure-induced dynamics between the three elements enable sharing and increasing resource value. Our main contribution is to propose polycentric governance as a novel perspective on developing collective action for sustainable resource use. Furthermore, our framework of polycentric governance development contributes to our understanding of the dynamics of interorganizational collaboration (e.g., Gulati et al., 2012) and to research on commons in management studies (e.g., Albareda and Sison, 2020; O'Mahony and Ferraro, 2007).

THEORETICAL BACKGROUND

Interorganizational Governance, Resources, and Collective Action

In the management field, governance research is expanding its traditional focus on corporate governance and taking a growing interest in the governance of complex interorganizational questions (Tihanyi et al., 2014). This is opening up new governance challenges, such as the growth of new interorganizational governance mechanisms and new conceptualizations of governance (Tihanyi et al., 2014) based on how organizations use and affect natural resources or raw materials (e.g., coffee industry standards) (Levy et al., 2015) or climate change (Ansari et al., 2013). Here, the theory of polycentric governance could offer helpful conceptualizations of practices and structures of collective action compared with prevailing management theories. In this section we first discuss current streams of research on interorganizational governance and collective action, scrutinize their shortcomings, and then discuss polycentric governance and how it could help address those shortcomings.

An important stream of research has been built on interorganizational governance and network theory. This line of inquiry has often focused on elements of the network structure that enable collective behaviour (e.g., Gulati et al., 2012; Provan and Kenis, 2007). Somewhat surprisingly, research on interorganizational networks has mostly focused not on collective-level outcomes (Albareda and Waddock, 2016; Provan et al., 2007) but rather on actors within the network (Dahan et al., 2010; Quelin et al., 2017). This is a critical issue given the growing interest in collective agency as a source of change in interorganizational relations (Bridwell-Mitchell, 2016; Koschmann et al., 2012). Research on interorganizational network governance generally emphasizes structural enablers of collective agency (Provan and Kenis, 2007), or economics-based explanations related to contracts, as is usually the case in alliance research. In addition, while this stream of research often addresses resource governance, the resources in question are typically immaterial resources such as technology, money, or personnel rather than the material resources that lie at the heart of sustainability challenges. Currently, sustainability pressures are making residual resources a core issue of interorganizational governance, pushing both private actors (that generate material waste) and public agencies (that manage this waste) to explore new forms of collective agency and to search for governance practices that will help them share residual resources sustainably with other organizations.

Another stream of research has focused on interorganizational governance from a collective action perspective (Ansari et al., 2013) in contexts such as innovation (Hargrave and Van de Ven, 2006), environmental protection (Bowen et al., 2018), and market formation (Lee et al., 2017). Collective action forms of governance blend the traditional roles of public and private sector organizations (Mahoney et al., 2009; Quelin et al., 2017), leading to hybrid forms of governance (Seibel, 2015). For instance, the private sector can collectively act through industry self-regulation (Bowen et al., 2018; Lenox, 2006) or with stakeholders (Bridoux and Stoelhorst, 2020).

Research in this stream often emphasizes the role of coordinated mechanisms (e.g., certification and labels) in enabling collective agency (Wijen and Ansari, 2007). While such mechanisms are typically found in self-regulation initiatives, they enable not necessarily collective agency but individual agency, as they tend to set rules for the governance of participants' own actions rather than collaborative actions (Bowen et al., 2018). Moreover, there is a lack of knowledge about the governance of collective action of broader systems of actors, which reaches beyond intra-industry self-regulation or temporally and spatially bounded cross-sector partnerships. On the other hand, some studies in this stream are rooted in social movement theories (King, 2008), which emphasize contentious politics and collective identity as sources of collective agency (Wijen and Ansari, 2007). In regard to resources, studies of collective action in the management literature generally do not address the social dilemmas related to resource overuse, with some notable exceptions (Bowen et al., 2018; Gatignon and Capron, 2020).

On the other hand, the collective governance of material resources has been a core topic in studies on collective action and polycentrism by E. and V. Ostrom. From the 1960s onwards they focused on collective efforts to manage common-pool resources such as municipal water systems, local forests, and fisheries to avoid the tragedy of the commons (Ostrom, 1990). Polycentric governance expands the idea of commons governance to a larger, even global scale, addressing complex global issues such as climate change

(Ostrom, 2010). Compared with many theories of interorganizational action, one key feature of polycentric governance is its explicit focus on the *relationships between actors and their resource systems*. Ostrom's studies highlight monitoring activities for common-pool resource systems.

Polycentric governance refers to an idealized form of governance based on multiple centres of decision-making at various levels, interacting through formal collaboration and informal commitments (McGinnis, 2016; Ostrom, 2014). These interactions generate an emerging system in which multiple independent actors can mutually adjust their activities and create new institutions to address common problems (McGinnis, 2016). It can include a mix of governance mechanisms from different sectors, rather than being based on markets or hierarchical state coordination (Ostrom, 2014). There are three main dimensions that explain how polycentric governance functions (McGinnis, 2016). First, polycentric governance includes a *structure of actors from multiple sectors with diverse institutions*. Second, these actors interact through *mutual adjustments* that facilitate changing patterns of behaviour and novel collective practices. Third, this leads to an *emergent system*, capturing *economies of scale* at multiple levels of governance. The theoretical perspective of polycentric governance is based on these ideals, and much of the research on polycentric governance is focused on how far real-world governance initiatives correspond to these ideals and under what conditions (McGinnis, 2016).

In the field of management studies there is scant interest in commons and polycentric governance, and that interest is mainly focused on knowledge commons (Albareda and Sison, 2020; Fjeldstad et al., 2012; O'Mahony and Ferraro, 2007). Ansari et al. (2013) combined the idea of commons with an institutional theory approach in the context of global climate change logics. Some scholars have also applied it to studies of cross-sector partnerships and industry collective action (e.g., Bowen et al., 2018; Ferraro et al., 2015). However, polycentric governance is clearly distinguishable from cross-sector partnerships. While research on cross-sector partnerships explores interaction between organizations from different sectors that address societal problems (Selsky and Parker, 2005), polycentric governance focuses on institutions for collective action across larger systems of actors that do not necessarily all interact with one another (Ostrom, 2010). Recent research has studied how polycentric governance contributes to solving scale conflicts in relation to grand environmental challenges (Doh et al., 2018) and the role of firms in developing open institutional infrastructures in emerging markets to fill institutional voids (Gatignon and Capron, 2020). This reflects the novel interest of management scholars in collective action and polycentricity.

On the whole, Ostrom's theories have paid rather limited attention to residual resources. In commons studies, resource users are often small business owners, and thus they are often concerned with coordination between individuals. Although firmly focused on the sustainable use of commons resources, Ostrom's theories mostly rely on a linear conception of the economy, where resources are extracted, used or consumed, and ultimately discarded. The recent shift to CE thinking turns the focus to maintaining value in resources as they are reused and recycled across multiple organizational owners. The focus is more on organizations' interactions aimed at retaining value in resources, not on their coordinated actions with a natural resource system. In this study, our analysis is concentrated on the meso level, i.e., interorganizational collective action. For this

purpose, we need a new conceptualization of polycentric governance that builds more strongly on interorganizational analysis and addresses the challenges of sharing of privately owned residual resources that need to be shared as commons resources. We next discuss the unique challenges of resource governance in CE development and the promises held by polycentric governance in addressing those challenges.

Polycentric Governance for Circular Economy

CE proposes to transform the current linear economy into a closed-loop economic system (Murray et al., 2017). Various strategies have been suggested for CE, including the forming of circular supply chains, product reuse, sharing platforms, and material recycling (Esposito et al., 2018). CE typically involves complex collaboration, as is evidenced by the wealth of research into industrial symbiosis and eco-industrial parks, or novel projects in which firms collectively develop CE practices (Chertow and Ehrenfeld, 2012). In many cases, this does not require cross-sector partnerships, but private and public initiatives to share information about and exchange scalable resources (Porter et al., 2019). CE aims to address the same underlying social dilemma of resource overuse and sharing that relates to common-pool resource systems. For this reason, we think that theorizing on the governance of resources in CE systems can benefit from insights from polycentric governance.

The nature of residual resources in CE presents distinct challenges for resource governance (see Table I) that hinder progress towards a more circular and sustainable economic model. CE systems are often contrasted with standard supply chains (Ashton, 2008) that operate under different logics and governance mechanisms (Bansal and McKnight, 2009; Patala et al., 2014). Previous research has shown how CE projects face three key sources of complexity that hamper their development. First, due to their material nature, many residual resources are rivalrous, in contrast to other resources (such as knowledge and data) that firms may utilize collectively. This can lead to *mutual*

Table I. Links between circular economy management challenges and polycentric governance features

<i>CE governance challenges</i>	<i>Feature of polycentric governance (PG) that can address the challenge</i>
Mutual lack of resource information – e.g., firm A could utilize a residual material from firm B but is unfamiliar with the resource as it originates from a different industry	PG involves mutual adjustments (McGinnis, 2016) between parties, allowing for information transfer or a ‘short mental distance’ (Ashton, 2008)
Lack of scale – e.g., firm A and firm B produce residual materials that firm C could use, but the volumes are too small to meet the business needs of firm C	PG recognizes ‘scale economies’ as one outcome, where coordination processes at different levels support an economically optimal result (McGinnis, 2016)
Disconnected governance of residual resources – e.g., organizations A, B, and C have disconnected governance mechanisms in regard to residual resources, with lack of coordination	PG is cross-sectoral, involving interconnections among private organizations, collective groups, and public authorities. It is able to generate adaptive capacity to common challenges (McGinnis, 2016)

lack of resource information as companies engaging in CE are often hesitant to share information that may have competitive implications (Walls and Paquin, 2015). Second, firms often lack a continuous supply of residual resources that meet specified quantity and quality requirements (Bansal and McKnight, 2009), leading to *lack of scale*. Third, unlike common-pool resources, residual resources are privately owned, but they can incur collective costs through ecosystem degradation. Thus, the public sector is often involved in CE systems through waste management organizations, for example. This leads to *disconnected governance of residual resources* in both public and private realms (Patala et al., 2014; Walls and Paquin, 2015).

To expand polycentricity, we link these challenges to core features of polycentric governance that have been developed in the area of common-pool resource systems. Mutual adjustments in polycentric systems could allow actors to form *new ways to share information on their residual resources*. Scale economies, another core feature of polycentric systems, have the potential to allow actors to *overcome issues of scale* with their residual resources. Third, the core structural characteristic of polycentricity can help overcome *challenges related to disconnected governance units* (McGinnis, 2016). However, as outlined earlier, residual resources also have distinct characteristics which set them apart from common-pool resources, complicating the direct application of polycentric governance theory. For instance, it is unlikely that the monitoring activities that are typical of common-pool resource systems are applicable to privately owned residual resources. We thus undertake empirical research into three CE systems to abductively develop a theory of polycentric governance for privately owned residual resources in CE systems.

METHODOLOGY

Research Design

Our study is exploratory in that it is concerned with a fast-growing field with little existing theorizing. Our focus is on gaining a deeper understanding of collective governance for sustainable resource use. We selected three cases in which actors had developed collective governance initiatives for CE practices, giving us a diverse view of governance practices. To build a theory for a new phenomenon, we made use of the theory of polycentric governance (Ostrom, 2010). We adopted an abductive approach (Mantere and Ketokivi, 2013), which depends on a continuous dialogue between theory and the empirical data. This allowed us to develop constructs that are both informed by a theory novel to management studies and grounded in the empirical data (Dubois and Gadde, 2002; Mantere and Ketokivi, 2013). Using a theoretical sampling approach (Patton, 2002), we compare three CE systems in Finland, the United States, and Spain.

Our approach relied on synergies between the abductive approach and the multiple case study design. We conducted an in-depth study of three cases, which not only allows for deeper theorizing than single case studies but also makes it possible to identify critical elements for purposes of theorization. This approach has been successfully

used in the management field before (Granqvist and Ritvala, 2016; Halme et al., 2012).

We started out with a more traditional inductive single case study of the *Finnish Industrial Symbiosis System*. As we analysed the data, it became clear that governance of the network had similarities to the characteristics of polycentric governance. We then designed a multiple case study that would answer the central research question and be suited for developing a theory of polycentric governance within the context of privately owned residual resources. Consequently, we selected the *Basque Circular Economy* and *Devens eco-industrial park* cases based on existing data, which showed that their key characteristics were well-suited for studying polycentric governance. Furthermore, their scale and length of operation allowed for a comparative study (see case selection). We also collected more data on the *Finnish Industrial Symbiosis System* case through a second round of interviews.

Theoretical sampling refers to identifying manifestations of theoretical constructs that can help elaborate the construct and its variations (Patton, 2002). Our cases here share a key similarity which makes them fruitful for studying polycentric governance: they span multiple industries and comprise diverse organizations engaging in collective action around CE. On the other hand, a source of variation is provided by key differences between the cases with respect to number of members, temporality (age), and geographical dispersion. Furthermore, we chose cases from three different institutional environments to better understand if polycentric governance can emerge in different types of institutional environments. Prior research suggests that hybrid institutional arrangements between markets and hierarchies have appeared in various countries around the world (Powell, 1987). However, the aim of our study was not to identify different conceptions of polycentric governance from different institutional environments, and therefore we did not choose cases from drastically different institutional environments (e.g., countries where state-owned firms play a large role).

FISS, Finnish Industrial Symbiosis System, Finland. The FISS program is aimed at facilitating industrial symbiosis, a specific type of CE model, in Finland across multiple regions. It was launched in 2013 with public sector support. The coordinators of the system organize workshops and offer consulting for symbiosis projects with firms. Participation in these workshops is mostly voluntary and informal.

Devens eco-industrial park, Massachusetts, USA. The Devens eco-industrial park was originally created as a redevelopment project for a former US army base in 1994, with a commitment to sustainable development through the long-term Devens Reuse Plan. In early 2017, there were 102 businesses in the region, 70 per cent of which were Small and medium-sized enterprises (SMEs). The majority of these are in light industries, including pharmaceuticals, light manufacturing, and biotech (Veleva et al., 2015).

BCE, Basque Circular Economy, Basque Country, Spain. BCE is an emergent, self-organized network of CE projects and collective activities developed by interconnected actors including large companies, SMEs and start-ups, technological centres, public agencies, and public-private organizations. Originally, BCE emerged with a call for market-

oriented CE projects. During 2013–16, 36 CE projects have been funded, involving more than 150 companies and NGOs and 17 technological centres. The ongoing projects have generated cooperative practices, knowledge, and training without any central coordination.

The key characteristics of the cases are summarized in [Table II](#).

Data Collection

We collected data from multiple sources, allowing us to compile rich descriptions and to triangulate the data (Gioia et al., 2013). The data was collected between 2013 and 2017. It consists of semi-structured and structured interviews^[1] and direct observation at the companies, public agencies, NGOs, and other members of the CE systems. This is complemented with archival data, such as reports, websites, and media articles (see [Table III](#)). We took several measures to reduce retrospective bias, which is often a concern in qualitative research. First, in the BCE and FISS cases that have developed more recently, we conducted two rounds of interviews (one and two years apart) in order to capture changes in the systems. Second, we used detailed archival data from all three cases. The archival data for the oldest case (Devens) was especially detailed (including comprehensive governance plans, detailed annual reports of activities, and multiple surveys of firms in the region) and gave us additional insights into the development of the case.

Interviews. Our primary data consist of 98 semi-structured and structured interviews with leading managers of the organizations involved in the CE projects and other CE system activities. The 98 informants came from 78 organizations, 14 of which represented the public sector, two public-private organizations, 47 from the private sector, ten non-profit organizations, two universities, and three research centres. The interviewees were typically middle managers, top managers, or professionals and were chosen based on identification by other interviewees and knowledge of the cases. To retain consistency, each case was fully studied by the same researcher, who recorded the interviews and took notes. We designed the first interview protocols based on our research questions and included open-ended questions concerning the system's activities as well as questions about its structure, processes, and outcomes. We learned from the first set of interviews and updated our questions for the subsequent interviews. We wrote summaries of the interviews, sharing notes between the two researchers in charge.

Observations. We also participated in collective workshops and meetings and made site visits, taking field notes about collective insights. These notes were also incorporated in the ongoing process of analysis. During our visits we talked with a number of employees in charge of different activities. The observations allowed us to gather data on collective behaviour and were key to further grounding our findings in the data.

Archival data. Finally, the primary research data were complemented by archival data: reports from individual organizations and coordinators of collective activities as well as industry, company, and media articles. These documents provided both retrospective

Table II. Main characteristics of the three research sites

<i>Case</i>	<i>FISS (Finland)</i>	<i>Devens (USA)</i>	<i>BCE (Spain)</i>
Geographical scale	National	Local	Regional
Coordinating organizations and responsibilities	Motiva (public); main coordinator Sitra (public); initial funder and promoter Regional intermediaries (public-private); regional coordinators	Devens Enterprise Commission (public); firm recruitment and permits Devens Eco-efficiency Center (non-profit); environmental consulting/education Mass Development (public); land-owner, redevelopment coordinator Devens Recycling (private)	Ihobe (public); initial funder and promoter Basque eco-design centre (public-private) main standardization, knowledge, and education Innobasque (public-private); sharing information Clusters and networks (private); coordinators and promoters
Year of initiation	2013	1993	2013
No. of organizations	~400	~100	~150

Table III. Data collection

<i>BCE case</i>	<i>FISS case</i>	<i>Devens case</i>	<i>Total data</i>
Primary data <i>Interviews:</i> 45 interviews	Primary data <i>Interviews:</i> 22 interviews	Primary data <i>Interviews:</i> 31 interviews in 31 organizations; 23 firms, 3 public sector organizations, and 5 non-profits (2013 and 2017)	Interviews: 98 transcripts; 1136 pages
29 interviews	15 interviews		+ 180 pages
29 organizations with 30 informants: 4 public, 2 public-private, 3 NGOs, 6 MNCs, 8 SMEs, 3 start-ups, 1 university, 2 technological (2017)	11 organizations and 22 informants: 5 firms, 3 public agencies, 1 non-profit, 1 university, 1 research centre (2014)		
16 interviews	7 interviews in 7 organizations, 2 firms, 5 public agencies (2016)		
15 organizations with 16 informants: 2 public, 2 public-private, 2 NGOs, 5 MNCs, SME, 4 start-ups (2018)			
Observational data: 29 observational notes: company facilities with circular economy projects. Feb 2017–July 2017	Observational data: 5 field visits, 2 seminars, 1 resource workshop, 1 Jan 2014–April 2014 and Oct 2016–Dec 2016	Observational data: 1 field visit Feb 2017	Field research notes: 217 pages 10 PowerPoint presentations from events 721 pages of reports
Secondary data <i>Archival documents</i> Public reports on circular economy projects (2 reports) Ihobe reports (2014–17) Ihobe circular economy project summary files	Secondary data <i>Archival documents:</i> 3 eco-industrial park reports FISS industrial symbiosis case studies (20 cases)	Secondary data <i>Archival documents:</i> Devens Reuse Plan DEC public reports (N = 12) DEEC annual reports (2008, 2011–15)	17 project summary files 41 pages of case reports

(Continues)

Table III. (Continued)

<i>BCE case</i>	<i>FISS case</i>	<i>Devens case</i>	<i>Total data</i>
<i>Archival websites</i> 28 organizational websites Circular Basque database, Circularhub, Basque Eco-design Center, Basque Eco-design Hub	<i>Archival websites; FISS websites</i>	<i>Archival websites; DEC websites, DEEC websites</i>	26 organizational websites 2 project websites
<i>Newspaper articles</i> Articles concerning circular economy. Jan 2016–Oct 2017			28 articles

data and details that the informants had not mentioned and were particularly important for understanding the conditions for the emergence and the drivers of the three cases. This information was validated in the interviews, where we asked participants about the early stages of their respective projects. This helped us to create timelines for each case.

Data Analysis

To gain an initial understanding of the governance systems in each case, we started with an analysis of different levels of CE activities, projects, and organizations, including relational maps and timelines of each case. We then analysed the data from the interviews and observations by using a three-stage coding process (Gioia et al., 2013) with the help of NVivo 11. In addition, we used our secondary (archival) data for triangulation purposes in each coding stage.

Two authors carried out the coding process separately for each case. The third author remained disconnected from the field research, helping to review the data analysis as an external researcher. Our descriptive first-order codes emerged from the interview transcripts and observation data (Strauss and Corbin, 1998). Data collection and analysis proceeded simultaneously. Our aim was to discover themes emerging from the grounded data and explore their interrelationships to understand how polycentricism works in the collective governance of privately owned resources. This meant we were not blind to new concepts emerging from the data and complementing the original concept of polycentric governance. Therefore, we made sure that we consistently followed the basic principles of qualitative theory building and grounded data analysis. To provide an example, this first step resulted in three unique first-order codes related to actors' changing roles in CE.

In the second step, we grouped descriptive codes into more interpretative second-order themes. Applying abductive reasoning (Mantere and Ketokivi, 2013), we contrasted these themes with the original constructs of the theory of polycentric governance in order to see whether the emerging themes corresponded with, complemented, or contradicted the theoretical constructs. At this stage, we also conducted cross-case analyses to compare the themes and the emergence of polycentric governance between the three cases. This helped us to move towards theoretical constructs that answer the research question. This procedure allowed us to describe and explain the observed phenomenon. To illustrate this stage, the three codes for changing roles were linked to a second-order category, termed role adjustments.

In the third stage, we proceeded to the aggregate conceptual categories. Moving back and forth between our empirical data and the theory of polycentric governance (McGinnis, 2016; Ostrom, 2010), we were able to infer three new explanatory constructs: mutual adjustments, practices for collective agency, and structures for sharing (see data structure in Figure 1). These concepts and their interactions make up the theoretical model explaining polycentric governance of privately owned resources (see Figure 3). We used the aggregate category of *mutual adjustments* originating from Ostrom's theory to describe the role adjustments along with two other second-order codes, as illustrated in Figure 1. However, the other two aggregate categories were new concepts. Our coding showed that the development of collective agency is a central part of polycentric governance in this context, where actions are largely voluntary. Thus, *practices for collective agency*

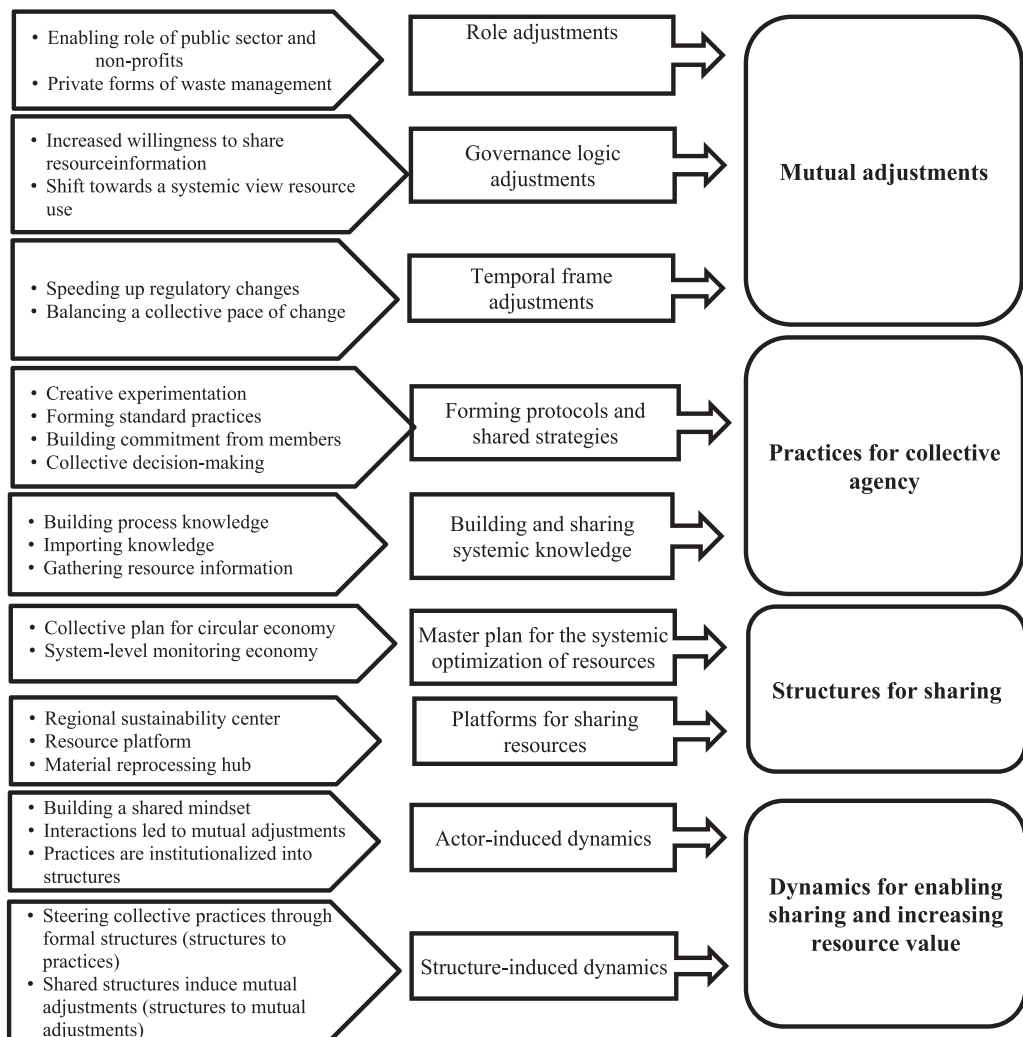


Figure 1. Coding framework: Data structure

was a more fitting concept than for instance the more rule-focused concept of institutional diversity (McGinnis, 2016) in polycentric governance theory. The third category, *structures for sharing*, is similar to the idea of emergent order (McGinnis, 2016) but offers more clarity on what kind of emergent order can support the sustainable use of resources in CE systems. Lastly, we identified *dynamics for enabling sharing and increasing resource value*, which are the interactions between the three elements of governance.

FINDINGS

Our data analysis identified three key interconnected elements of polycentric governance of privately owned residual resources: *mutual adjustments*, *practices for collective*

agency, and *structures for sharing*. The following sections first discuss all these elements in detail. We then compare the development of these elements to identify the recursive dynamics between the three elements. These are discussed in the theory development section, where we also present a theoretical framework for polycentric governance (see Figure 3).

Mutual Adjustments

We found that different sector participants were able to make various mutual adjustments between actors and their interorganizational activities. Participants jointly adapted towards common goals within the system (McGinnis, 2016), enabling the formation of systemic governance mechanisms (Ostrom, 2014). As illustrated in Table IV, we distinguished three forms of mutual adjustment: *role adjustments*, *governance logic adjustments*, and *temporal frame adjustments*.

Role adjustments. Role adjustments, in essence, are shifts from the organization's role within its immediate network (e.g., supply chain) when moving to the system level (Provan and Kenis, 2007). These adjustments/shifts come about as a result of interorganizational interactions. Many organizations found that they required adjustments to their earlier ways of operating.

First, in all three cases we found evidence of public sector or non-profit actors shifting from their traditional roles to that of a coordinator or facilitator of CE to promote advanced projects. Public actors were active participants in the system, providing resource information, technical know-how, and infrastructure services and influencing the system through public procurement. In FISS, for example, these activities were handled by Motiva, a government-owned firm specializing in environmental and energy-related services. In BCE, this role was assumed by the Environmental Agency, which allocates part of its resources to disseminating knowledge about CE implementation and projects. The agency adopted the role of facilitator: 'We have changed completely with regard to how we connect with companies. We used to disseminate voluntary environmental management tools. But during the past decade we have enhanced companies' ability to adopt an advanced approach to sustainability, fostering collective projects to rethink resource scarcity as a business opportunity' (Top manager, public environmental agency, BCE). We also identified examples of NGOs adopting market and innovation logics. For example, one non-profit engaged in textile and appliance waste recovery was committed to changing its role and moving towards entrepreneurial projects and to developing new remanufacturing products with private companies. 'We aim for an inclusive economy. We recovered waste to help long-term unemployed people. When we learned about CE, we recognized both a social and a business opportunity, and since then we have explored circular business models' (Director of Innovation, non-profit organization, BCE).

A second role adjustment involved private sector firms assuming part of the responsibility for the stewardship of materials recycling, a domain that traditionally belonged to municipal waste management organizations: 'In the first company I founded, we developed recovery systems for rare metals. But lower value metals were usually discarded. For me that was

a huge waste of resources so I decided to build a new business model around by-product reuse' (CEO, metals waste reprocessing, FISS). Some firms specialized in the collection and/or reprocessing of waste material. A case in point is Devens Recycling Center, a private company specializing in construction and demolition materials. Others were engaged in take-back management within their own supply chain to collect specific waste streams for further use. In the case of BCE, large waste management companies with high research and development capacity adopted a leading role in take-back management services.

Governance logic adjustments. We identified distinct changes in governance logics that were key adjustments among actors associated with a development towards polycentrism. Governance logic adjustments refer to shifts in an organization's governance logic that depart from conventional individual practices of corporate or state governance and lead towards more system-level governance logics.

The first form of logic adjustment involved a shift towards sharing resource information in private sector firms. We found such logic adjustments in all three cases, although there were some differences. Coordinators within these systems promoted open information sharing and developed trust with other members by acting as information intermediaries. Typically, they would not allow full public access to resource information and owners, but rather maintained a semi-open database to restrict access to information to a specified group of participants, such as workshop attendees. This was critical for building trust among participants that competitors would not gain access to their resource information. Devens and FISS adopted this semi-open model of information sharing. We also found how some of these firms gave up some of their resource autonomy for collective benefits by sharing physical resources such as waste, infrastructure, equipment, or even personnel: 'When I founded this venture, I knew it wouldn't have worked as a greenfield investment. The only viable method was this kind of symbiosis, where I can use some materials and share infrastructure with an existing firm' (CEO, metals waste reprocessing, FISS).

A second example of a governance logic adjustment involved a shift from a narrow supply chain view towards a systemic view of resource use. This contrasted with the conventional narrow view of the firm's own industry and supply chain that prevents firms from recognizing cross-industrial CE opportunities. In FISS, system coordinators actively encouraged firms to search for cross-industrial CE opportunities: 'It's particularly important today to understand the broader picture. That's why we often like to focus on the little details that we can't see and manage the bigger picture' (Expert, sustainability service provider, FISS). This was enabled by environmental management techniques such as life-cycle assessment and industrial ecology, as well as by specific individuals coming from a multidisciplinary background. In FISS, for example, an SME manufacturer of a closed-loop system in food production mentioned that their key personnel's experience from different industries was a major contributor to their ability to integrate CE into their business. In BCE this view was evident in collaborative project design. In one project, a waste management company was able to move from a narrow approach to waste management towards a systemic CE innovation approach: 'Following the goal to set up a new CE project, we had to understand the whole ecosystem of possible partners, broad market goals, and a whole

approach to industry remanufacturing and reusing solutions' (Innovation manager, private waste management company, BCE).

Temporal frame adjustments. A third type of mutual adjustment focused on synchronizing the *temporal frame* of activities between different sectors. As views differed on the pace of regulatory changes, the time frame of system-level activities, and the pace of operational changes, mutual adjustments were needed for collective action for CE.

First, in all three cases the public sector had to adjust to different private and collective processes. Decision-making in the public sector often had a longer time horizon than in the private sector, which hindered CE activities. We found examples of temporal adjustments in the public sector that were aimed at speeding up regulatory processes to facilitate CE. For instance, permit procedures for waste reuse were considered too slow in FISS, and therefore some coordinators lobbied for regulatory changes. At Devens, the authorities granted expedited permits for green building certified projects. In the case of BCE, the cycle of funding calls was adapted to business needs: 'The reason why public funding schedules for CE projects are shorter than other innovation calls is because we want to be very flexible and adapt to the rhythm and needs of businesses' (Project manager, public environmental agency, BCE).

Second, some respondents stressed the importance of maintaining a steady collective pace of change that suited all parties. While some actors who championed CE were ready to adopt new practices at a faster pace, not all agreed. There were several instances in which organizations said they had had to curb some of their more ambitious CE plans as they had failed to find collaborators: 'You have to progress at a pace that is acceptable to the whole collective. If it's clear that not all are on board, you can't press ahead but have to slow down and find ways to gain their understanding' (Director, regional development organization, FISS). In the case of BCE, the pace of market acceptance for CE ultimately restricted the pace of change: 'We are at a moment where some companies are clearly interested in CE, but the market is still emerging. Public agencies and industry associations support companies, but many companies still can't sell remanufactured products in the market' (Project manager, economic development public agency, BCE).

Finally, although many of these mutual adjustments were aimed at tackling the CE management challenges explained previously, we saw how these challenges persisted even with the emergence of multiple units of governance. In the BCE case, for example, some industrial clusters were able to share information between members, yet they failed to set up continuous information flows. Furthermore, new problems emerged due to insufficient mutual adjustments. In the FISS case, some of the local networks that did not have a prior history with CE practices were unable to develop enduring CE practices due to insufficient information sharing, for example.

Practices for Collective Agency

As we analysed the data further, we also identified a second set of practices contributing to the development of collective agency that enables polycentric governance. Compared with mutual adjustments, *practices for collective agency* go beyond organizational-based

agency towards collective empowerment. We considered collective agency to reflect a capability to generate multi-level coordination processes for systemic outcomes. Past research has found that collective agency is supported by peer learning, community interaction, and shared understanding among actors (Bridwell-Mitchell, 2016; Koschmann et al., 2012; Wijen and Ansari, 2007). Our data indicated that collective agency on polycentric governance develops mainly based on two types of governance practices: *protocols and shared strategies* and *systemic knowledge management*.

Forming protocols and shared strategies. A key aspect of developing collective agency is the formation of *protocols and shared strategies*. These processes involve interaction among actors, shared spaces for collaboration, and joint coordination. They are shared methods of operation which enable collaborative CE practices and processes as system-level outcomes.

First, the respondents mentioned creative experimentation as a key antecedent for developing new ways of reusing residual resources. The use of waste materials was often based on an effectuation logic, i.e., finding opportunities in the resources at hand, which is closely akin to entrepreneurial thinking (Halme et al., 2012). Examples included experimenting with various models, technologies, and tools for reuse, and taking cues from natural processes. Many firms also viewed themselves as pioneers in CE, building new types of CE business models or products: ‘They felt like they were pioneers, part of a new park and so they were more willing to experiment to do that, and then their corporate masters sort of got the bug a little bit later and now they’re all on board’ (Director, public agency, Devens). Experimentation also took place in BCE.

Second, our study also showed that the protocols included standardization practices such as shared sustainability standards and ecolabels. These practices had the dual role of allowing for shared sustainability goals and allowing for the recognition of specific milestones. For example, Devens had used the Ecostar program to help firms reach sustainability performance standards in 25 different categories. Firms that reached these standards in 15 categories received the Ecostar label. However, this program was put on hold after the more widespread adoption of external standards in the region. Keeping the Ecostar standards up-to-date required great effort, and the coordinators felt that they had fulfilled their initial purpose. ‘Five years after the launch of the program, lots of new certification programs started to come on the scene, and they were more robust’ (Director, non-profit, Devens). In 2018, Devens gained LEED sustainability certification for sustainable communities, demonstrating a shift towards external standardization. In the other two cases, by contrast, EU and other international standards were being adopted instead of internal ones: ‘We have adopted different EU labels, such as the EU ecodesign label. It shows our environmental and health and safety improvements and standards. We are now moving toward long-term durability of the products’ (Director of innovation, chemical company, BCE). The EU has been promoting multiple CE tools and practices (European Commission, 2015), some of which were used at BCE and FISS.

Third, we also identified practices for fostering a commitment to act among members. In the case of Devens, these practices included a membership system, which helped to improve community relations and provided additional benefits: ‘Members are able to attend the forums for free. The other benefit is we offer them services to

help them make progress with sustainability initiatives' (Director, non-profit, Devens). FISS and BCE had no such formal membership in place at the system level, but some coordinators did work to build up commitment through community development events, regular seminars, annual conferences, etc.: 'The way to keep track of this movement and encourage more public commitment among companies has been through the organization of training workshops, and funding new CE projects' (Entrepreneurs and CEO, CE start-up, BCE).

One final type of protocol was related to involving a wide range of stakeholders in governance activities (e.g., through boards of directors, regional coordinator meetings, or project coordination) and in collective decision-making. The Devens Enterprise Commission included representatives from the surrounding municipalities and local firms, and the Devens Eco-Efficiency Center formulated its strategy together with business members: 'The companies will work with the Eco-Efficiency Center and help set the strategy for the long term' (Director, public agency, Devens). FISS system governance was primarily a joint effort among the national network coordinator and local coordinators (usually business development organizations in a specific region).

The protocols outlined earlier bear a similarity to Ostrom's concept of shared strategies (Ostrom, 2005). These are institutional arrangements that specify types of action taken by actors in specific circumstances but do not include clear mandates or sanctions associated with stricter institutions.

Building and sharing systemic knowledge. The second type of processes aimed at developing collective agency were related to *building and sharing systemic knowledge*. Participants in the systems analysed here engaged in various knowledge development and sharing activities in order to improve their collective understanding of CE.

The first form of systemic knowledge management that we identified was related to building up technical process knowledge. A key issue for CE is the technological expertise needed to reprocess specific material streams. All systems relied on some form of collaboration with experts (e.g., academics or consultants) to build and disseminate CE knowledge. The FISS system, for instance, relied on a network of sustainability experts called Solved and used their expertise through either consultancy or the wider dissemination of technical knowledge. In BCE, two consultancies brought technological knowledge into multiple CE innovation projects in order to develop new remanufacturing solutions: 'We decided to create a consultancy firm to support companies in their efforts to develop advanced projects, because we saw this need, and we could receive external training in life-cycle assessment, CE and ecodesign knowledge ...' (Co-director, specialized environmental consultancy, BCE).

Second, participants in all three cases also searched for advanced knowledge outside the main system. In each case members adopted initiatives for importing knowledge. Coordinators occasionally visited other CE sites around the world to bring new knowledge into their own systems: 'We have been testing this facilitation model that was used in the (British) NISP industrial symbiosis program' (Senior expert, National development organization, FISS). In the case of BCE, public agency and leading companies invited experts to conferences and at the same time themselves visited different leading facilities and sites across the European Union to learn and exchange

information: ‘In the nineties we invited various experts to discuss CE issues. Later on, we also visited eco-parks in Germany and Denmark to learn about their experiences. Currently we organize annual conferences where we invite leading companies in Europe to share their tools and experiences’ (Top manager, public environmental agency, BCE).

Third, all systems collected CE-focused resource information in some form of a database, such as a spreadsheet (Devens) or CE-focused software (FISS). Typically, this involved collecting resource information from firms, for instance on quantities and qualities of resources available and on resource needs: ‘We ask the companies to come to a meeting and bring samples of their orphan by-products. Then they go around the room and start doing trades. We’ll also take them downstairs to the storage room and set up displays so other people can come in and see what’s available’ (Director, public agency, Devens). This information made it easier to find new CE matches. In BCE, information about the CE projects was disseminated through the Circular Basque website. System coordinators also gathered data on best practices for CE, for instance through case studies, which could be used to replicate successful ideas on other sites.

Structures for Sharing Privately Owned Resources

The third element of polycentric governance for CE systems is related to the development of *structures for sharing* privately owned residual resources. Our analysis of the three cases revealed that the systems also adopted more established governance structures for collectively facilitating CE. We found that these arrangements were related to the emergent *master plan for systemic optimization of resources* and *platforms for sharing resources*.

Master plan for the systemic optimization of resources. The first type of structure that we identified was the development of system-level arrangements for optimizing resource use. In all three systems we found leading actors setting up long-term collective plans for resource use. For instance, key stakeholders in the Devens system had developed a long-term redevelopment plan for the next 20 to 40 years that outlined future resource use, infrastructure development, environmental factors, zoning needs, etc. This plan served as a blueprint for development activities in the area, while more specific goals were addressed on a regular basis. The FISS system, for its part, started to link its goals to the national CE roadmap, which emerged as a holistic nationwide blueprint for developing CE. Some local coordinators also developed more specific CE roadmaps for their own region. In BCE, public agencies took the lead in developing a collective plan for CE transformation. The public environmental agency published a CE report to promote a long-term agenda for CE transformation for the next years (Ihobe, 2018): ‘Now we see CE as an opportunity that can bring new direction for us (...). This opens the possibility to set up a future plan for regional competitiveness, including a set of policies for remanufacturing, reprocessing or green procurement’ (Top manager, public environmental agency, BCE).

A second key structure involved system-level monitoring of the outcomes and impacts of transforming to CE. Coordinators typically monitored the achievement of

goals and quantified the benefits gained through the system's actions. Devens had a comprehensive process in place for assessing outcomes and impacts: 'In 2015, 47 businesses, non-profits, municipal entities, and schools from 15 towns repurposed over 14,000 pounds of materials' (DEEC annual report, 2015). FISS and BCE had also developed monitoring activities, but these were more focused on outcomes, for instance the number of firms reached, projects funded, and partnerships formed, rather than impacts. This was likely due to the shorter time that these systems had been in operation.

Platforms for sharing resources. Lastly, we identified three types of platforms for sharing resources at the system level. These arrangements combined governance mechanisms in novel organizational units. In what follows, we outline the key characteristics of these platforms and discuss how each of them addressed the identified challenges of CE.

The first form we term a regional sustainability centre. These organizations specialized in gathering sustainability knowledge and coordinating CE activities within a specific region. Their main activities included gathering and disseminating resource knowledge and acting as a cross-industrial broker. In the Devens case, such a centre incorporated civil sector governance through its formal status as a non-profit but also worked closely with the public sector. In the FISS case, this role was assumed by different types of organizations in different regions, including public economic development organizations, private sector organizations, and non-profits. At BCE, a regional eco-design centre played a key role in disseminating resource knowledge and promoting collective CE projects: 'This center aims to bring together large companies, SMEs, public agencies, industry associations, universities and the whole value chain to set up collective CE projects' (Manager, public environmental agency, BCE).

The second form of platform, a resource exchange platform, focused on intermediating CE relations by providing resource information and/or a marketplace. The FISS system had adopted a software-based solution for information collection. Devens had implemented a similar concept through a spreadsheet list and a warehouse with resource samples. In BCE, the environmental agency managed a waste inventory with all relevant information, and it set up a new project to search for resource synergies. Such a platform can help to improve resource information sharing in a similar way as a regional sustainability centre: 'Our aim is to have all workshop coordinators using the Synergy database, in order to have a large information pool on available resources and resource needs, even on the national level' (Sustainability service provider, FISS).

The third type of platform, a resource and material reprocessing hub, addressed the reprocessing of specific material streams. This form of system governance was like a municipal waste management site but included firms reprocessing specific material streams, thus combining public and private governance. For example, one of the waste management sites we observed in Finland had six companies operating on the premises, in fields such as biogas production and bitumen reprocessing. The organizations together formed a hub for the procurement, handling, and reprocessing of various resource streams. This form of platform addresses the issue of lack of scale,

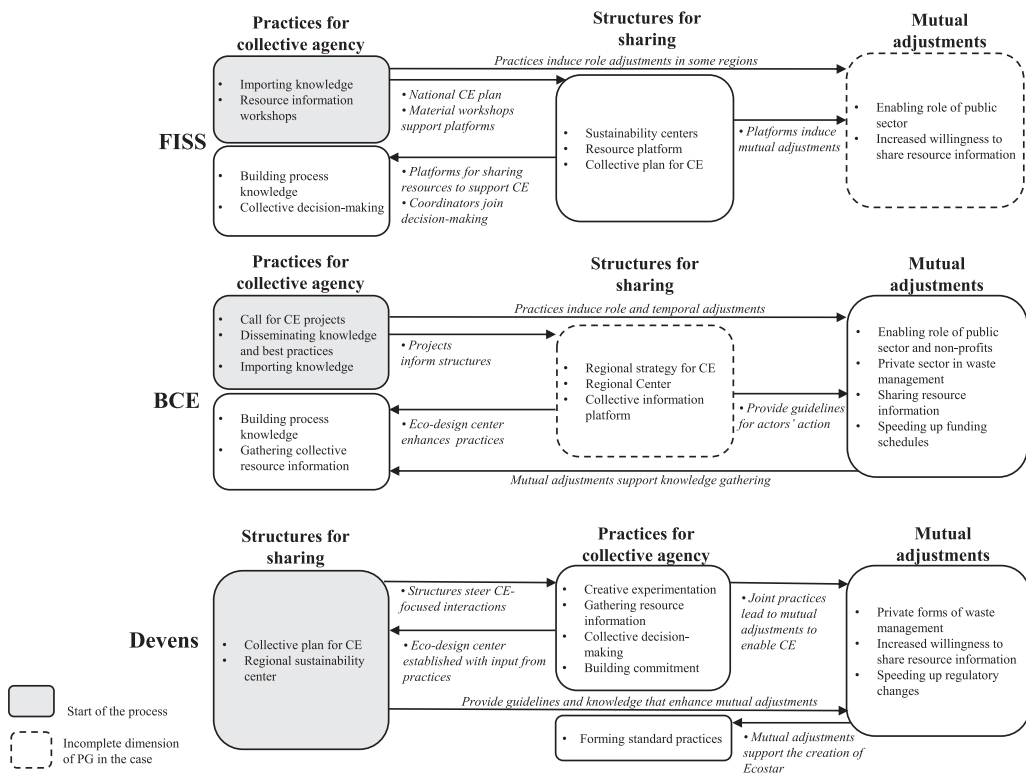


Figure 2. Comparison of the development of the cases

as private sector firms can achieve scale economies by organizing and specializing in reprocessing specific resource streams.

Theory Development

Based on our cross-case analysis, we now discuss in more detail the interactions and temporal development between the three elements of polycentric governance identified earlier. We illustrate the development of the cases in Figure 2, which provides empirical evidence of the interactions between the three elements of polycentric governance.

Our comparative analysis allows us to theorize the mechanisms of interaction between the elements of polycentric governance outlined previously. We use these insights to construct an *integrative framework of polycentric governance for privately owned residual resources* (Figure 3). The framework incorporates the key elements of *mutual adjustments*, *building practices for collective agency*, and *structures for sharing* and suggests two key types of dynamics between these elements, i.e., *actor-induced dynamics* and *structure-induced dynamics*.

Actor-induced dynamics originate either from the participants mutually adjusting their behaviour for collaboration or from the interactional practices for collective agency. First, practices for collective agency can lead to mutual adjustments as the interactions allow actors to learn from each other and become more amenable to adjusting

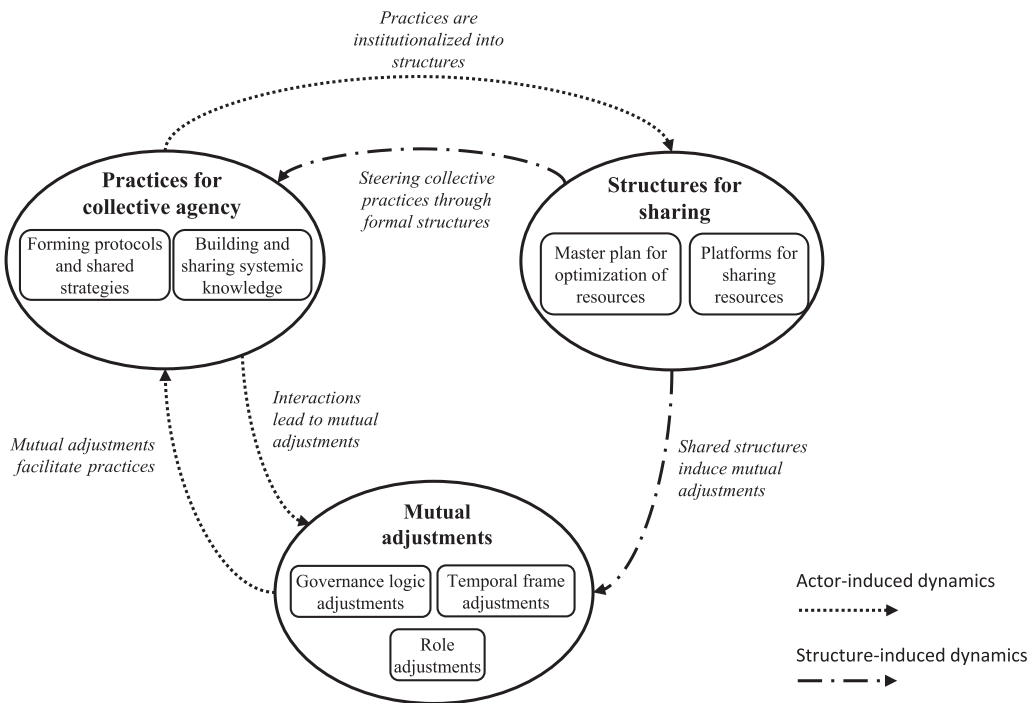


Figure 3. Framework of polycentric governance for privately owned resources

their own operations. The BCE case demonstrated the dynamics between practices and mutual adjustments in the case of CE innovation projects. These novel practices facilitated mutual adjustments when actors working in cooperative projects adjusted their roles and temporal frames. For example, firms and NGOs worked cooperatively, with firms adopting traditional public roles such as waste management and NGOs becoming entrepreneurs in the markets. Second, mutual adjustments can also facilitate practices for collective agency between actors as they take on new roles or enact new governance logics or temporal frames. This was evidenced, for example, by the development of the Ecostar Program in Devens, which was only possible after actors in the area had started to develop sustainability goals of their own. In the case of BCE, we saw that the adoption of novel temporal frames or governance logics (e.g., increasing their willingness to share resource information) supported continuous improvements in actors' practices.

A third type of actor-induced dynamics led from practices of collective agency to structures for sharing resources. As practices of collective agency become more established, they can develop into structures for sharing through a process of institutionalization. For instance, resource workshops aimed at collecting material information in FISS eventually led to a more expansive resource marketplace. The formation of shared strategies in the FISS program also became an input to the wider efforts to set up a national CE program in Finland. Similarly, in Devens, the initial collective activities around information sharing eventually led to the emergence of the Devens Eco-Efficiency Center as a new governance unit that could better support collective activities.

Table IV. Empirical evidence of polycentric governance in the three cases

<i>Cases</i>	<i>Case evidence</i>	<i>Illustrative quote</i>
Mutual adjustment processes		
Role adjustments		
Enabling role of public sector and non-profits	Governmental agency (Devens and BCE) or public-owned firm (FISS) provides services or funding or facilitates knowledge for CE	'My activity during the last years aimed on supporting companies to improve the eco-design and innovative products. We introduced new methodologies – eco-efficiency, eco-design, circular economy, remanufacturing. This is the knowledge that businesses need.' (Responsibility manager, public environmental agency, BCE)
Private forms of waste management	Private sector involved in take-back initiatives and waste collection (all)	'DRC currently recovers over 80% of the raw material from Construction and Demolition materials. This recycled material is used as feedstock for such end markets as new concrete, new metal, wood veneer, gypsum, and recycled cardboard products.' (Webpages, recycling company, Devens)
Governance logic adjustment		
Increased willingness to share resource information	Semi-open information sharing through a neutral organization (Devens and FISS)	'The resource data should pass through a neutral service organization because much of it is confidential. If it's completely open, that would decrease the amount of data firms are willing to share.' (Senior expert, national development organization, FISS)
Shift towards a systemic view of resource use	Cross-industrial meeting groups, hiring people with diverse industrial backgrounds (all)	'Our knowledge is very integrative. We started recovering waste batteries. We then set up our team, but needed to think about the market. We built our own technology by integrating diverse knowledge. In parallel we collaborate with multiple partners, technological centres, our clients who are also suppliers, end-users.' (Entrepreneur, CE start-up, BCE)
Temporal frame adjustments		
Speeding up regulatory changes	Accelerated permit procedures (Devens and FISS) or project schedules (BCE) to enable circular economy activities	'These new (EU) end-of-waste criteria have helped, but in many cases slow permission procedures for material reuse are a hindrance. This leads to using virgin materials.' (Senior expert, national development organization, FISS)
Balancing a collective pace of change	A gradual pace in developing CE relationships, aligning leading companies with second or third movers (all)	'I must say that most of them see the need to change (to CE), but only few advanced companies go for it. We need to adapt to different approaches and move faster than those who do not want to change.' (Standards and quality manager, industry association, BCE)

(Continues)

Table IV. (Continued)

<i>Cases</i>	<i>Case evidence</i>	<i>Illustrative quote</i>
Practices for collective agency		
Forming protocols and shared strategies		
Creative experimentation	Resource workshops, experimentation of new CE activities (all)	'Since we developed a new technology for recovering waste in metallurgy we have been testing new products and services to solve real needs with our partners and clients. Experimentation is our way of exploring new CE tools and knowledge.' (Director, technological centre spin-off, BCE)
Forming standard practices	Adopting ecolabels (FISS and BCE) or developing ecoprogrammes (Devens) as means of standardizing practices	'We are going through a national rating process for sustainable communities. We think we'll be a five star community at the end of the day which is the most you can get. What we're trying to do is use that sort of third-party certification to sort of build the Devens sustainability brand and create value for the companies.' (Director, public agency, Devens)
Building commitment from system members	Regular community development events (all), membership system (Devens)	'What we do is we say if you want to come to Devens, you have to make a commitment to sustainable development, and as part of their application process, the firms that are here talk about how they are going to comply with the sustainable development vision of Devens and how they fit in.' (Director, public agency, Devens)
Collective decision-making	Regular coordination meetings with representatives from the public and private sector for decision-making (all)	'It was not like the traditional concept of public service (...). We wanted to engage companies to set up a public-private partnership. We discussed together about how to set up it, and seven large companies engaged with public administrations. (...) Now we also involve industry associations, SMEs, universities.' (Responsibility manager, Eco-design centre, BCE)
Building and sharing systemic knowledge		
Building process knowledge	Formal network of technical experts (Devens and FISS), knowledge dissemination forums, informal meetings (all)	'Our goal has been to develop an expert network for CE. The idea is that if coordinators or companies have a need for a specific area of expertise (in their CE projects) they can find it here.' (Senior expert, national development organization, FISS)
Importing knowledge	Information exchange with other CE programs and visits to other sites (all)	'We visit leading sites in Europe to learn from them, and then adapt and apply advanced knowledge.' (Top manager, public environmental agency, BCE)
Gathering resource information	Resource database and dissemination (all), and resource warehouse (Devens)	'This kind of resource databased model is an excellent business development tool. Especially if we can also map the resources spatially, this allows organizations to use the tool when planning for the location of new facilities.' (Senior expert, Innovation Fund, FISS)

(Continues)

Table IV. (Continued)

<i>Cases</i>	<i>Case evidence</i>	<i>Illustrative quote</i>
Structures for sharing		
Master plan for the systemic optimization of resources		
Collective plan for circular economy (system-level principles)	Long-term development plan and coordination plan for CE (all)	‘When we started the transition from the military base to the industrial park, the reuse plan specifically states that the priority will be on sustainable redevelopment with equal priority given to the economic, environmental, and social needs of the community.’ (Director, non-profit, Devens)
System-level monitoring	Monitoring CE activities and systematic assessment for impacts (all)	‘Every year we publish a report about all CE projects that receive public funding. It includes information about economic, social, and environmental impacts, technology and future market development.’ (Project manager, public environmental agency, BCE)
Platforms for sharing resources		
Regional sustainability centre	A centre to disseminate knowledge amongst CE system members (all)	‘When you engage in this kind of business (CE), you have to network with many parties. The local centre for economic development has been extremely helpful. Many entrepreneurs don’t even realize how much information and help they have available.’ (R&D manager, bioenergy and food production solution provider, FISS)
Resource platform	Database for resource information and exchange (Devens and FISS)	‘We have used the Synergy software to collect resource information, follow projects and identify new material synergies. In the UK, the resource database included a total of 15,000 firms.’ (Senior expert, regional development organization, FISS)
Material reprocessing hub	Site or centre for reusing and recycling materials (all)	‘The Envi Grow Park is an eco-industrial park where materials, energy and knowledge is recycled in a closed-loop system based on principles of sustainable development ... the businesses in the park process municipal waste, organic waste, and various streams of glass, metals, cardboard, electronics, and construction material.’ (Case study, Envi-Grow Park, FISS)

Analysis of the three cases suggests that actor-led dynamics were the key catalyst for the emergence of the FISS and Basque cases. The FISS case was initiated through new practices for collective agency, including the coordinator decision-making group and resource workshop model. These eventually led to the establishment of new coordinating units for CE in local networks, the adoption of the Synergy database, and the formation of longer-term plans for CE development (structures for sharing). Similarly, the Basque case was initiated through actors adopting cooperative CE projects. The bottom-up practices and experimentation eventually led to more formalized practices

for collective agency (e.g., collective workshops), which catalysed with mutual adjustments between actors. Eventually, cooperative discussions were started in the region to establish more permanent policy frameworks for CE and platforms for sharing resources, such as the circular hub and the regional strategy for CE promoted by the Basque government.

Second, we identify *structure-induced dynamics*, which originate from structures for sharing. The first process of this type was a steering effect from structures of sharing to practices of collective agency. For example, the Devens Reuse Plan provided steering for much of the CE activities in the region, including the Ecostar Program and resource workshops. The platforms for sharing resources also became important determinants of knowledge sharing practices, such as the Synergy database in FISS, providing criteria for resource data collection, or the EHS roundtables organized by DEEC, giving a format to sharing CE knowledge. In the case of BCE, the creation of the Basque Eco-design Center was a major facilitator of knowledge sharing and projects between firms. A second structure-induced dynamic involved structures of sharing, which induced mutual adjustments by providing a shared vision or joint infrastructures. This is illustrated by the Devens case, as it was launched with the Devens Reuse Plan, which shaped the sustainability governance of the firms locating there. However, the Devens case was unique in its nature as a greenfield project, and results might be different for an existing business system. Similarly, working through the same platforms for sharing resources, such as the resource reprocessing hubs in several of the local networks in the FISS case, had allowed the participants to learn new ways of sustainable resource use from each other. Finally, in BCE, the Regional Strategy for CE, which had specified the main goals for waste and material reuse, facilitated novel relationships between actors and supported temporal adjustment and role reframing among them.

The Devens case illustrates how structure-led dynamics can catalyse the emergence of polycentric governance. The initial catalyst was the development of the Devens reuse plan, which outlined a detailed pathway for sustainable development. This eventually led to practices for collective agency in the form of decision-making groups and spaces for experimentation, as well as mutual adjustments in the form of supportive permit procedures for CE and the adoption of sustainability goals by firms.

DISCUSSION AND CONCLUSION

Collective action for sustainability is an area of keen interest in the field of interorganizational research, but the sustainable use of *privately owned residual resources* remains inadequately covered. Given the current pressures towards more sustainable use of material resources, we have sought to develop a theory of polycentric governance that supports this aim.

Taking inspiration from Ostrom (2010), we have here investigated the governance of *privately owned residual resources* within CE systems. The key contribution of our research is to illustrate how governing privately owned residual resources as a type of ‘virtual commons’ has potentially beneficial outcomes at the system level (e.g., information sharing

and collective agency). Our findings contrast with and therefore expand on Ostrom's (1990, 2010) previous theory. We found that actors collectively govern privately owned residual resources by developing polycentric governance in a process which involves recursive dynamics between mutual adjustment among actors, the forming of practices for collective action, and new structures for sharing these resources. Our findings also have important implications for the literature on collective action and governance for sustainability and interorganizational relations.

The primary contribution of our research is to enhance understanding of collective action for sustainability. We found that polycentric governance can enable actors to exchange privately owned residual resources, overcoming the current challenges of CE resource governance, such as the lack of resource information or multiple disconnected governance units. We propose polycentric governance as a *novel form of governance* alongside more established forms, such as industry self-regulation (Bowen et al., 2018; Levy et al., 2015), cross-sector partnerships and hybrid governance (Selsky and Parker, 2005; Quelin et al., 2017), or robust action principles (Ferraro et al., 2015).

Polycentric governance is distinct from industry self-regulation, which can be effective for collective action within single industries (Bowen et al., 2018). However, self-regulation models are not feasible when a sustainability issue calls for collective action across multiple industries and actors in the value chain (e.g., waste managers, industrial companies, recycling start-ups, or NGOs), such as in the case of CE. We expect forms of polycentric governance to emerge in contexts where novel cross-cutting ecosystems are necessary for the sustainable transformation of entire production-consumption systems (e.g., sustainable mobility, sustainable energy systems). As in the case of CE, there may already exist many potential solutions to the sustainability challenge, but these solutions are thwarted by systemic challenges such as mutual lack of information, the lack of scale of residual resources, and disconnected governance mechanisms. Systemic challenges also explain why the business case on a broader level is not necessarily immediately obvious, why we do not see dominant businesses (i.e., type of platform organizations) emerging to coordinate larger CE systems, and why public sector actors might have a relatively strong role. One important feature of the systems we studied was the relatively high goal alignment between actors and the voluntary nature of the action, which makes it easier for actors to collaborate.

Compared with traditional cross-sector partnerships (Selsky and Parker, 2005), which focus on how to sustain cross-sector interaction in the face of institutional complexity (Quelin et al., 2017), polycentric governance represents a more complex system of institutionalization for collective action with separate yet interconnected governance units from different sectors and multiple levels of jurisdiction (Ostrom, 2010). Rather than being coordinated through contracts or voluntary agreements in a formal partnership, a polycentric governance system involves distributed coordination of practices for collective agency, mutual adjustments among actors, and structures for sharing, all of which steer actors towards a collective goal. Polycentric governance thus has the potential to facilitate emergent order in broader complex systems of actors with independent but interconnected governance mechanisms, which may be beyond the scope of partnerships. Earlier studies of polycentricity recognize institutional diversity as a core feature of polycentric governance (McGinnis, 2016; Ostrom, 2005). Our work thus provides a

novel perspective on how institutional complexity can be managed in cross-sector collaboration (e.g., Villani et al., 2017).

Finally, compared with robust action principles, which focus on finding solutions in the face of considerable uncertainty (Ferraro et al., 2015; Porter et al., 2019), we expect polycentric governance forms to appear in response to sustainability challenges where both the nature of the issue and the potential solutions are relatively well known in terms of natural resource scarcity, but where inaction persists due to systemic friction caused by a mutual lack of resource information between actors, lack of scale, and disconnected governance units, for example. The focus is then on *coordination of the 'collective action problem'* (Ostrom, 1990) rather than the *generation* of solutions. Other possible contexts include sustainable, decentralized energy systems and new urban mobility systems. In both cases, there is clear agreement on the need to decarbonize these systems in order to improve sustainability, and many of the technologies to do so already exist. However, the fragmentation of such systems with many public and private actors makes collective governance difficult. We suggest that a polycentric perspective can offer new insights into governing these systems.

Second, our insights on how polycentric governance developed in the three cases studied here have important implications for understanding how collective agency develops in interorganizational relations. Research on interorganizational networks has for some time emphasized the need to study the systems level (Provan and Kenis, 2007) in order to understand how network participants develop collective agency (Wijen and Ansari, 2007). Our framework outlining the recursive dynamics between the elements of polycentric governance offers important insights into how a diverse set of organizations can develop collective agency. Our study sheds light on mutual adjustment processes between different organizations with diverse governance mechanisms, as critical enablers of collective agency in interorganizational collaboration.

We found that governance logic adjustment processes increase shared understanding, novel cross-industrial relations, and information sharing among public and private actors. In addition, we identified two other types of mutual adjustment processes, i.e., role adjustments and temporal frame adjustments, which strengthened collaborative capacities to overcome organizational self-interest. Role adjustments imply shifts in the actor's traditional role, which recent research has found to be an important component of cross-sector organizing (Valente and Oliver, 2018). The temporal adjustments we identified created shared beliefs of temporality among participants (e.g., Granqvist and Gustafsson, 2016) about transitioning to CE. Adding to earlier findings on the role of communication (Koschmann et al., 2012) and network structure (Provan and Kenis, 2007), then, this research adds the concept of mutual adjustment to our understanding of enablers of collective agency. We believe that our findings about temporal adjustments can also contribute to recent research on temporal coordination under uncertainty and complex work settings (Geiger et al., 2021; Kremser and Blagoev, 2021). More specifically, we saw that temporal and role adjustments can be related, such as public sector actors using expedited permitting in shifting towards a more facilitative role. This adds to our understanding of role-temporality linkages (Kremser and Blagoev, 2021) by highlighting organizations' rather than individuals' roles in complex interorganizational settings.

Moreover, we saw that collective agency can become embedded in interorganizational governance structures through the recursive dynamics between mutual adjustments, collective practices, and structures for sharing. More specifically, we identified how systemic knowledge management practices developed into structures for sharing resources, jointly increasing the capacity of actors to overcome differences in information availability and/or divergent CE goals. This also has implications for research on structuration theory, which also explores ‘the emergence of organization structures from distributed processes’ (Soderstrom and Weber, 2020: 259).

Third, our research further elaborates the theorizing around commons and polycentric governance in the organization and management literature, complementing existing studies on immaterial commons (e.g., Fjeldstad et al., 2012) and environmental commons (Ansari et al., 2013). Our study sheds light on a new important type of commons, i.e., *structures for sharing privately owned residual resources* in CE. These structures enable more efficient and sustainable use of material resources by extending their lifetime and rate of utilization, which is necessary for a more sustainable economic system. They include both immaterial elements in the form of resource information, traceability, and knowledge and physical elements such as common infrastructure for reprocessing and exchanging resources, allowing actors to overcome lack of resource information or lack of scale. Our study also emphasizes the collaborative dynamics between the public and private sector. In the three cases studied, public agencies supported private and non-profit organizations in setting up new practices for collective action or structures for sharing resources, providing new incentives for the private sector to cooperate and exchange these material resources. We found that the public sector preferred to assume an entrepreneurial role (Quelin et al., 2017), which was important for the initial emergence of action. In addition to public entrepreneurs, most of the private sector actors involved were interested in CE prior to joining the activities. Nonetheless, Ostrom’s ideas (Ostrom, 2014) and their applications in the management field (Ansari et al., 2013; Doh et al., 2018) have demonstrated that polycentric governance is also possible in the face of conflicting interests, where actors can adopt principles related to conflict resolution and graduated sanctions to achieve collective action (Ostrom, 1990).

Lastly, our work takes an important first step in expanding research on commons governance to a circular economic model. While Ostrom’s studies focused explicitly on the sustainable use of resources, they were based on a linear economic model. The shift to a CE implies important differences. The first is the shift in focus to market organizations with privately owned resources, which presents certain challenges for polycentric governance. Some of the stricter rules proposed by Ostrom (1990), such as monitoring and sanctioning mechanisms, are difficult to implement outside of governmental regulations. Instead, we found that a more effective way of achieving control and coordination was through ‘soft law’ and facilitative mechanisms, including voluntary information sharing, public sector intermediation, and collective learning spaces. Second, interorganizational relations, and specifically the capacity to achieve collective action through those relations, become important units of analysis, compared with early studies on commons which have focused more on relations among individuals and a resource system.

Implications for practice

Our findings have several implications for managers and policymakers involved in CE and the sustainable use of natural resources. First, polycentric governance implies a need to carefully consider competitive advantage in new emerging systemic business models. We found that polycentric governance involves activities which enable collective agency, allowing organizational systems to solve grand challenges by enhancing their capability to work closely in collaboration. Moreover, adjusting to the systemic view of the firm's activities helps to identify connections with the natural environment and can open up new avenues for sustainability management (Senge et al., 2008). Managers engaging in CE activities should give careful consideration to the benefits of building practices for collective agency. Sharing their resources in semi-open platforms can present new opportunities for managers, while limiting the risk of competitors gaining access to confidential information. Moreover, polycentric governance may also offer insights in other domains beyond sustainability. As new digital technologies move more deeply into domains of public sector influence (e.g., health care, city infrastructure), polycentric governance can offer a fruitful option for integrating private, public, and civic governance processes.

Our findings will also help policymakers design new programs for facilitating CE. Importantly, they demonstrate the potential of system-level governance and the polycentric integration of multiple governance units. We suggest that policymakers planning governance mechanisms for CE should consider the potential of polycentricity, especially in regard to two key aspects. First, overly homogeneous governance mechanisms can hinder the potential of some bottom-up initiatives. Policymakers should thus aim to strike a balance between achieving some integration with formal governance mechanisms while still retaining some flexibility that allows for bottom-up organizing and polycentricity. Second, polycentricity does not imply fragmented and disconnected governance mechanisms (McGinnis, 2016). Policymakers should also carefully consider connections to existing governance mechanisms and platforms when designing new mechanisms.

Limitations and future research

Our research involved some limitations that should be addressed by future studies. First, this study developed novel concepts for exploring collective forms of governance for privately owned resources: mutual adjustments, practices for collective agency, and structures for sharing. Our findings shed light on how these concepts play out in the context of CE systems, but the concepts themselves warrant further scrutiny. Future studies should explore how these processes unfold at the micro level and how they influence internal organizational structures and managerial decision-making. Moreover, as we identified new forms of 'virtual commons' in the structures for sharing, future research should further investigate the ways in which organizations 'create commons to manage commons' (Senge et al., 2008, p. 217). We think that closer interaction between polycentric governance theory and more established organizational theories has great potential. For instance, our findings on the interplay between practices and structures in the development of polycentric governance suggests

that interesting new insights might be gained by combining structuration theory (e.g., Soderstrom and Weber, 2020) and polycentric governance. Future research could also analyse polycentric governance in other countries with more diverse institutional environments.

Nonetheless, we think that the concepts we have developed and proposed here may be useful beyond the setting of our study, which offers an opportunity for future research. For example, as mentioned earlier, new energy and mobility systems include a mix of diverse actors – from the public to private sector as well as consumers. Similarly, base-of-the-pyramid initiatives in developing countries often involve multiple types of stakeholders from the public, private, and civil sectors. All these settings provide fruitful contexts for future research on polycentric governance. We hope that this study has furthered understanding of the polycentric governance of privately owned resources, and we encourage further studies into polycentric governance in organizational research.

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NOTE

- [1] The protocol was designed in English and tested with two real interviews to secure the quality of the questions. The interviews were done in the original languages of the non-English-speaking countries. The interview protocol was translated into the languages of these countries by native speakers.

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