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Bottom-up dynamics in circular innovation systems

The perspective of circular start-ups

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Abstract

The concept of circular economy (CE) is proposed to lead humanity toward a sustainable future. Public authorities increasingly build on CE narratives. The progress of private sector actors is key to enable more circular resource flows. Still, the world falls far short from becoming circular and large-scale implementation of CE in actual problem–solution spaces is scarce. This study sheds light into the external strategies of circular start-ups (CSUs) in building an adequate socio-institutional embedding for circular business models (CBMs) and puts the findings in the context of CE and sustainability transformations research. CSUs are a distinct group of CE-oriented actors that build and implement CBMs wholistically and from scratch. Thereby, they can directly and indirectly contribute to the creation of circular innovation systems. This study defines the common CE mission of CSUs, sets it in context of respective socio-political CE missions, and scrutinizes the roles that CSUs adopt to drive systemic CE implementation. We observe that CSUs' strategic interventions go further than only novelty creation. This article proposes and elaborates on four roles that CSUs adopt: *conveners*, *reinforcers*, *pioneers*, and *champions*. The roles differ according to the CSU business models, stakeholders, the institutional elements that are addressed, as well as the directionalities that CSUs set. The findings are discussed considering the governance, policies, and strategic management of various directionalities in which CE innovation develops. It sheds light on inadequacies and limitations for bottom-up CE innovation in existing norms and cognition, policy, and network governance.

KEYWORDS
circular economy, environmental policy, industrial ecology, innovation systems, institutional theory, mission-oriented innovation

1 | INTRODUCTION

The circular economy (CE) is a much-discussed concept in sustainable development literature. CE has evolved from literary fields of industrial ecology and ecological economics in the 1950s/1960s (Boulding, 1966; Henry et al., 2021; Persson, 2015). CE's goal is to implement resource loops in economic systems so that environmental impacts (emissions, energy leakage, and resource depletion) are minimized, and the retained value and utilization of resources are maximized (Merli et al., 2018; Murray et al., 2017). The literature body on CE provides a wide array of business model

typologies (Nußholz, 2017; Pieroni et al., 2019; Santa-Maria et al., 2021), implementation approaches (Fischer & Pascucci, 2017; Lieder & Rashid, 2016), and concept definitions (Kirchherr et al., 2017; Reike et al., 2018).

Large-scale, real-world implementation of CE is barely tested (Babbit et al., 2018; Haas et al., 2015; Hopkinson et al., 2020). CE is critiqued for little definitional consensus, inharmonious assessment criteria, little outcome orientation, and "greenwashing." The desired outcome of CE is a wide-spread goal but the approaches of how to collectively move toward and measure the success of large-scale circular practices are ambiguous (Corvellec et al., 2021; Helander et al., 2019; Kopnina, 2019). Inefficient crowding of actors could derail CE transformation as the resulting lack of progress may discourage investment (Kirchherr et al., 2023).

CE needs to be further established as an institutional field for which regulatory frameworks and behavioral norms are commoditized based on insight into circular practices and enabling institutional environments. For this, CE can benefit from a stronger connection to its "parent research field" of industrial ecology where CE's key strategies and applications (reduce, reuse, and recycle) have been extensively studied (Cullen, 2017; Gregson et al., 2015; Moreau et al., 2017; cf. Saavedra et al., 2018; Wiprächtiger et al., 2022). The complexity behind neo-classical, capitalistic, and growth perspectives dominating ecological concerns can be partly debunked by (re-)focusing on bio-physical roots of economic activity when transforming linear to circular systems (Martins, 2016).[1]

We apply the concept of mission-oriented innovation (MI) to examine the complex dynamics of CE transformation processes (Elzinga et al., 2023; Hekkert et al., 2020; Mazzucato, 2018). In the existing literature, most work relates to mission-oriented innovation systems (MISs) in their entirety, that is, the focus lies on structure, mission arenas, and systems functions (Jørgensen, 2012; Wesseling & Meijherhof, 2021). Scientific publications that address actual problem–solution spaces in MISs (and in CE transformation) find that clear missions may lead to a combination of various solution pathways. It is key to understand the relevant solutions, actors, and interactions to define system boundaries and examine progress toward the mission achievement (Elzinga et al., 2023; Hekkert et al., 2020).

Little is known about the insider perspective of how to operationalize and govern MISs with circular missions while the need for action is high. Progress toward higher levels of circularity in sustainability transitions is most likely to appear on local and regional levels. "Empirical data on the individual dynamics within mission pathways" is needed to inform and guide systems actors' influence on innovation dynamics, mission formulation, and (policy) interactions (Chertow, 2000; Wallner et al., 1996a, 1996b; Wanzenböck et al., 2020). To address this research gap, this study scrutinizes the micro-level and bottom-up dynamics in ISs that follow a CE mission (Naustdalslid, 2014). We examine the network interactions and system building activities of circular start-ups (CSUs).

CSUs are young, innovative ventures that implement for-profit circular business models (CBMs). CSUs are frontrunners in circular innovation as they tend to pursue more preferred CE strategies than corporate actors for which they create a socio-institutional embedding (Bocken et al., 2017; Henry et al., 2020, 2021; Zhang et al., 2022). Thereby, CSUs may open new visions about the future, create legitimacy for innovative solutions, and form new knowledge (Kopnina & Poldner, 2021; Närvänen et al., 2021). By understanding the external strategies and network interactions of CSUs, insight into systemic unlocks for CE solutions can be provided, and the interactive dynamic between network governance (bottom-up self-organization) and public governance (top-down policy instruments) can be strengthened (Cramer, 2022; Hajer et al., 2015; Mazzucato, 2018).

This study addresses the need for understanding transformative processes and actual problem–solution spaces in both mission-driven innovation as well as CE innovation. For this, we explore the dynamics that are required for bottom-up circular innovation to unfold. This study follows the research question:

- What are CSUs' activities and roles in building circular innovation systems?

The study uses a data sample of 40 CSUs and studies their roles in systems building as well as institutional interactions when advancing their common CE mission. This study is useful for the strategic management of the various directionalities in which CE is currently developing. Furthermore, inadequacies and limitations for CE innovation in norms and regulation, policy, and governance evince. CE value chains and circular ISs are currently in a "formative" stage wherefore this research can be relevant for the transition to a "growth" stage (Hekkert et al., 2020; Smith & Raven, 2012).

Section 2 of this paper provides a literature review and introduces the underlying theoretical framework. Section 3 describes the research design and methodology. Section 4 presents the results and proposes a typology of roles that CSUs adopt when scaling circular innovation. Section 5 summarizes the findings and answers the research question. Sections 6 and 8 discuss the findings with a broader reflection, lay out the main contributions and limitations of this article, and propose potential future studies.

2 | LITERATURE REVIEW

2.1 | Innovation systems and system dynamics

The dominant frameworks to conceptualize IS and sustainability transitions—technological innovation systems (TIS), strategic niche management (SNM), and multi-level perspective (MLP)—are mostly applied to scrutinize changes to one type of technological innovation (Geels, 2002, 2011;

Hekkert et al., 2007; Schot & Geels, 2008). Studies that go beyond one technological solution focus on solutions related to a technological regime or domain such as food security, transport, and low-carbon energy (El Bilali, 2019; Elsner et al., 2023; Geels, 2014; Hess, 2016; Hoogma et al., 2002; Kivimaa, 2014; Raven, 2007; Smink et al., 2015). The dominant niche-regime dichotomy in MLP and SNM is contested and described as too rigid to capture multi-faceted innovation dynamics (Raven et al., 2016; Ruggiero et al.'s, 2021).

MI originated in transitions literature and "transformative," mission-oriented innovation policy (MIP). MIP builds on transformational government intervention that co-shapes ISs to address structural changes within societal systems to address complex societal challenges such as climate change, poverty, or resource depletion. Therefore, MI provides directionality for a wider addressable base (Elzinga et al., 2023; Hekkert et al., 2020).[2] Mission-based public intervention utilizes far-reaching, explicit objectives related to economic or societal transitions to steer fundamental transformation processes that are prone to a complex set of failures (cf. Boon & Elder, 2018; Hekkert et al., 2020; Kattel & Mazzucato, 2018; Weber & Rohracher, 2012). Out of the three dimensions of MIP strategic orientation, policy coordination, and policy implementation, this study mostly addresses the former and the latter. Strategic orientation addresses legitimation and directionality; policy implementation includes systemic reflexivity and business innovation (Larrue, 2021). MIP is contested because accountabilities are not clearly assigned, and assessment of failure and success is hardly possible (Borrás & Edler, 2020; Larsson, 2022). We examine IS dynamics where knowledge about top-down/state intervention in MIP is scarce.

The goal of this study is to discover circular innovators' systems building activities that are consistent across regional/technological scopes and go beyond novelty creation only. CE transformation builds on a portfolio of technological and non-technological innovations and reaches across historically disconnected domains under common CE principles. CE is conceptually oriented and considers societal dynamics (Defra, 2020; DMIE, DMEA, 2016; European Commission, 2021; Konietzko et al., 2020; Mies and Gold, 2021). MI allows for the inclusion of multiple solution directions across different socio-economic levels while maintaining mobilizing and aligning effects. MISs follow time-bound, large-scale societal objectives such as achieving a full circular economy by 2050 set by public and private actors. Strong missions based on shared problem recognition, strong directionality, and vision are a promising tool to mitigate actor misalignment and enable transformative CE innovation (Elzinga et al., 2023; Mazzucato, 2017; Meijer et al., 2006; Table 1). However, when public instruments increase endorsement of innovative CE principles, established private sector actors engage in similar practices so that truly transformative processes are barely traceable and not reflexive. Such lock-ins of incumbent structures and processes can result in transformational failure (Schot & Steinmueller, 2018; Weber & Rohracher, 2012; Wesseling & Meijerhof, 2021). Knowledge about the direction of (radical) innovation helps to understand scaling options and prevent the uncoordinated crowding out of alternative solutions (Larsson, 2022).

2.2 | Circular start-ups' role in innovation systems

MI and CE transformation need to be nurtured by bottom-up developments (Bauwens et al., 2021; Hekkert et al., 2020; Sabel, 2012). Evidence from innovative entrepreneurial activity under a common CE mission can improve the mission formulation, governance, and coordinated implementation of large-scale CE innovation (Bickerstaff & Walker, 2005; Loorbach, 2010; Smith et al., 2005). However, there is a lack of insight into bottom-up dynamics and radical interventions of individual agents that could steer the co-creation of public value (cf. Henry et al., 2021; Ranta et al., 2020). Such an insight into bottom-up innovation processes is particularly relevant in ISs that follow a CE mission[3] because of (1) missions' dependency on bottom-up processes to achieve success, (2) the necessity to better understand and govern the balance between top-down and bottom-up interactions, and (3) the lack of established feedback loops (Corvellec et al., 2021; Mazzucato, 2018; Rodrik, 2004).

Business model innovation is considered a key pillar for both a transformation toward CE and MI (Geissdoerfer et al., 2018; Mazzucato, 2018). CBMs tend to address market demand and wider societal needs. They can be understood as strategic tools on the micro-level that market actors valorize by creating the required systemic acceptance and demand for circular solutions (Bidmon & Knab, 2018; Nailer et al., 2019; Sorbacka & Nenonen, 2015; Zucchella & Previtali, 2019). So, value creation in CBMs has a reciprocal character because various market actors must co-create circular innovations to realize the value potential (Bertassini et al., 2021). CSUs are considered pioneers that create a value proposition and institutional legitimacy for CBMs from scratch.

In MISs, the function *entrepreneurial experimentation* would capture entrepreneurial activity and business model innovation (Elzinga et al., 2023; Hekkert et al., 2007). The focus on *entrepreneurial experimentation* is too myopic to capture the full transformative potential of circular grassroots entrepreneurship. CSUs "are continuously disrupting established assumptions and norms and create new, better institutions" (Närvänen et al., 2021, p. 10). As such, even technology-focused CSUs tend to combine their core innovations with normative and cognitive interventions. CSUs combine a common "how-to" (circularity or R-strategies) and system-transcending technological variety in their business models (Henry et al., 2020; Morseletto, 2020a; cf. Zvolska et al., 2019). They allow us to *zoom in* on the micro-level of CE transformation (Köhler et al., 2019; Rosenbloom et al., 2020). Through the implementation and monetization of innovative circular solutions, CSUs may influence their institutional environment, provide legitimation for broader transformational interventions, and provide insight into the operationalization of CE which can inform overall programmatic solution development and governance in circular MISs (Braams et al., 2021; Daimer et al., 2012; Horbach & Rammer, 2019).

TABLE 1 Circular economy mission formulation and goals across study sample regions.

	CE program since		Cross-sector policies (nat/reg)	CE policy items	Exemplary CE targets and mission formulation (non-exhaustive)
	National	Regional			
EU	2015	2015	Yes/yes	Yes	Eco-design guides to increase circularity for 31 product groups 70% recycling for municipal waste by 2030 Significantly reduce total waste generation and halve the amount of residual municipal waste by 2030 80% recycling of packaging waste by 2030 Landfill bans from 2025 for plastics, metals, glass, paper, card, and biodegradable waste Single-use plastic ban (cutlery, plates, and straws) Recyclable and long-lasting design for all new fashion products entering EU market Reduce food waste by 30% by 2025 and 30% increase in EU resource productivity by 2030 Add €900 billion of value to the European economy and create an extra three million jobs by 2030
BER	2017	1999	Yes (focus on waste and recycling)	Yes	Reduction of 65% of municipal waste by 2035 (national) Maximum of 10% of municipal waste going to landfill (national) Textile waste separation from 2025 onward (national) Single-use plastic ban (cutlery, plates, and straws) (national) Reduction of 20% of municipal waste by 2030 (regional) Increase of mineral waste recycling rate to 64% (regional)
LDN	2017	2019	Yes/no	Yes	Methodical guides for CE enablers in six focus areas such as eco-design, waste, and resource efficiency (national) Single-use plastic ban (cutlery, plates, and straws) (national) Double resource productivity and achieve zero avoidable waste by 2050 (national) Recycling of 65% of municipal waste by 2030 (regional) and 2035 (national) 100% net waste self-sufficiency by 2026 (i.e., keeping waste from landfill but within city; regional)
AMS	2016	2015	Yes	Yes	Use 50% less new raw materials by 2030 Reduce overall consumer goods consumption by 20% by 2030 Be 100% circular by 2050 10% of the City's procurement to be circular by 2022 All invitations to tender in the built environment to be circular by 2023 50% fewer primary resources use (minerals, metals, and fossil fuels) by 2030 (national) Single-use plastic ban (cutlery, plates, and straws) (national) A waste-free economy that runs as much as possible on sustainable and renewable raw materials, and in which products and raw materials are reused by 2050 (national)
RDM	2016	2018	Yes	Yes	Reduce primary use of raw materials by 50% until 2030 Be 100% circular by 2050 Increase in the percentage of household waste separation to 45% in 2023 Increase in circular behavior of population of Rotterdam to 30% in 2023 Increase the clean plastics and drink packaging streams from residual waste to 64%
MBN	2018	2019	Yes (focus on waste and recycling)/no	Yes	Reduce the volume of litter by 40% by 2020 (regional) Increase recycling rates to: – 70% for municipal solid waste – 70% for commercial and industrial waste – 80% for construction and demolition waste Single-use plastic ban (cutlery, plates, and straws) (regional) Meet or beat 80% recovery rate of waste by 2030 (national) Halve food waste by 2030 (national)

(Continues)

TABLE 1 (Continued)

	CE program since		Cross-sector policies (nat/reg)	CE policy items	Exemplary CE targets and mission formulation (non-exhaustive)
	National	Regional			
SDY	2018	2019	Yes (focus on waste and recycling)/no	Yes	Reduce of littering by 40% by 2020 (regional) Divert 80% of waste from landfill by 2030, 72% by 2025 (regional) Cut total waste generation by 15% per capita by 2030 (regional) Halve the volume of organic material going to landfill until 2030, 20% reduction by 2025 (regional) Access for every Victorian household to food and garden organic waste recycling services or local composting by 2030 (regional) Single-use plastic ban (cutlery, plates, and straws) (regional)

Sources: Australian Government et al. (2018), BMUV (2020), Defra (2020), Gemeente Amsterdam (2020), Gemeente Rotterdam (2018), Hill (2016), Monier et al. (2014), SenUVK, 2020a, 2020b), UK Environmental Services Association (2019), Yullie et al. (2022).

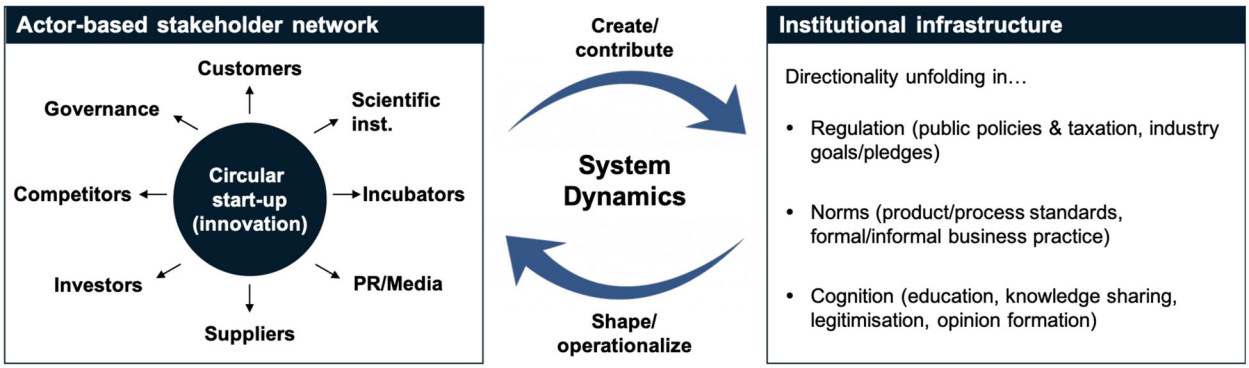

FIGURE 1 Theoretical framework—"Minimum viable" circular innovation system.

2.3 | Theoretical framework

Including institutions literature will allow this analysis to systematically explore how CSUs navigate institutional elements as they implement CBMs and external strategies (Beunen & Patterson, 2019; Geels, 2004; Ranta et al., 2018).[4] Institutional theory builds on three elements (Raven et al., 2017) that actors must navigate when gaining legitimacy:

- regulations (legal framework, policies, formal standards, and rules),
- norms (social values, behavioral norms, and role expectations),
- and cognition (beliefs, culture, and meaning; Scott, 2008).

Thereby, this research adopts an inside perspective that is oriented toward co-constituting ISs versus an objective outside perspective. The analysis provides qualitative insight into CSUs' influence on, interplay with, and conveyance of regulation, ideas, values, and beliefs (Kern et al., 2020; Lawrence et al., 2013; Schot & Kanger, 2018; van der Vleuten, 2019). Socio-economic networks which are formed based on CSUs' business models can be considered "minimum viable" circular IS on the micro-level in which institutional interventions that enable circular innovation are shaped, tested, and proven ("islands of rules"; Fischer et al. , 2021, p. 122; Mazzucato, 2018; Närvänen et al., 2021; Figure 1).

3 | RESEARCH DESIGN

3.1 | Sample selection and regional scope

Forty CSU case studies were scrutinized in-depth through founder interviews. This approach was chosen as it allows for theory building for relatively new phenomena within the context they occur in during the critically important early stages (Eisenhardt & Gräbner, 2007). CSUs are defined as new (max. 5 years), legally independent and active organizations that operate for-profit CBMs. CBMs are defined as circular operations on the

micro-level that aim at *closing* material loops, increasing resource efficiency (*narrowing* of loops), and increasing resource/product longevity (*slowing* of loops). CSUs apply so-called R-strategies to achieve these goals:

- regeneration of natural ecosystems,
- reduction of resource inputs,
- reuse,
- recycling,
- and energy recovery (Bocken et al., 2016; Henry et al., 2020).

All case studies either formulated their mission statements according to R-strategies, and explicitly mention the creation of circular products and the closing of resource loops as organizational objectives (Appendix 1 of the Supporting Information). The regional scope spans Western metropolitan areas (cf. Luo et al., 2020). Several CSUs were organized and partly co-located in eco-industrial parks, circular incubators, and participated in circular awards. These CSUs were targeted because they show higher levels of systems engagement, originality, and survival rates (Amezcua, 2010; Bøllingtoft, 2012; Eleveens et al., 2017; Hallen et al., 2016). As such, CSUs in beverage production, gastronomy, plastic recycling and 3D-printing, and retail services are co-innovating by using industrial symbiosis and knowledge exchange in Rotterdam-based CSU hub BlueCity. Several Berlin-based start-ups are co-located or connected via incubators such as CRCLR Haus and circular BERLIN which facilitate knowledge exchange, rally actors for policy intervention, and establish educational collaborations.

Amsterdam, London, Berlin, Sydney, and Melbourne are among the world's top start-up hubs (Campos, 2020; European Startup Initiative, 2017; Startup Blink, 2019) and the national and municipal governments define CE missions and establish CE policies (McDowall et al., 2017; NSWG, 2019; VSG, 2019; Table 1).[5] CE policy artifacts in all regions under scrutiny mention a variety of sectors. European CE policy lacks elements of scale and local experimentation. It remains relatively vague in terms of transition regions, sectors, and approaches to upscale CE implementation (cf. Doranova et al., 2016; McDowall et al., 2017; Regueiro et al., 2021). While most CE policies focus on product end-of-life (cf. Bianchi & Cordella, 2023), some regulations focus on design, production, and consumption which can have positive effects on CBMs and consumer behavior (Arranz et al., 2023).

3.2 | Data analysis and coding

Most questions of the in-person founder interviews were open-ended and focused on the entrepreneurial process and status quo (Kvale, 1983; Appendix 2 of the Supporting Information). Interviews lasted 60 min and were recorded and transcribed verbatim. A transcript database was compiled to allow for analysis and operationalization. Arising key concepts were mostly derived from the interviewees' responses to questions on their circular mission and systemic interactions. The information was separately coded following conventional content analysis and an initial set of coding rules (Hsieh & Shannon, 2005). Common themes in CSUs' mission formulation (Section 4.1) and first-order coding dimensions regarding CSUs' systems building activities (Table 2) were identified inductively and based on the empirical data (themes with >5 appearances were included, e.g., *raising consumer awareness* or *exploring regulatory limits/grey areas* as roles/activities). Theoretical satisfaction was reached after evaluation of ~35 interviews (Figure 2).

Literature review articles, recent publications, and work from highly cited authors were used to structure and deepen the analysis. Sensitizing concepts to analyze CSUs' roles were identified and led toward the bundling of the first-order codes into second-order codes (Blumer, 1954). Primarily, recent studies on functions and dynamics in MISs were consulted (Cappellano et al., 2020; Jütting, 2020). Elzinga et al.'s (2023) study of relevant functions to assess MISs was one of the key references in this process. For instance, CSUs' activities aimed at *building awareness* and *improving consumer perception of circular solutions* were linked to Elzinga et al.'s *Provision of solution directionality* and *Creation of legitimacy* (second-order code *reinforcers*). All search terms that were used to structure and connect the sample data to existing MIS and institutional literature can be found in Table 2. Due to the relative novelty of the MIS concept and the lack of studies of structural elements and definitions, more established innovation systems and institutional literature was pulled in. MIS can be considered as an evolution of other frameworks while these provide the base for MIS research (cf. Elzinga et al., 2023; Hekkert et al., 2020). The approach took on a deductive character because the analysis of the interview data was further amended with existing theory to explain and build on the observed phenomena (Alvesson & Kärremann, 2007; cf. Henry et al., 2022; van Maanen et al., 2007). Thus, the inductively identified operationalization of key concepts was embedded in the theoretical context of innovation systems and institutional literature (Gioia et al., 2012).

4 | RESULTS

4.1 | Circular start-ups' mission formulation

While CE innovation requires radical systemic shifts, CSU founders tend to lack disruptive ambition (Henry et al., 2022). Therefore, we examine CSUs' indirect impacts on bottom-up innovation, systems building, and systemic transformation processes. First, we inventory the problems and

TABLE 2 Circular start-up archetypical roles in building circular innovation systems.

CSU role second-order code)	Coding keywords (first-order code)	Related MIS functions[a]	Role description	Institutional elements
Convener (27/40 CSUs)	*Supply chain, suppl-, share, connect, collaborat-, knowledge sharing, network, system, relation-, open*	Market creation	Reconfiguration of supply chains and fundamental changes in production processes and delivery models	Normative, evaluative, governance
Reinforcer (19/40 CSUs)	*Consumer behavior, awareness, perception, societ-, public educat-*	Creating legitimacy Providing solution directionality Unlearning	Public consensus building, unlearning of linear practices, and customer empowerment	Cognitive, socio-cultural, values, beliefs
Pioneer (11/40 CSUs)	*Regulat-, experiment, expectation, policy, tax, government*	Market destabilization	Legitimization and justification of transformative change and new normative baselines by exploring regulatory limitations	Regulation/policy, governance, norms
Champion (7/40 CSUs)	*Role model-, inspire, educat-, universit-, student*	Knowledge development Resource mobilization	Role modeling of circular entrepreneurship	Socio-cultural, normative (subjective)

[a]Beyond entrepreneurial experimentation; cf. Elzinga et al. (2023).

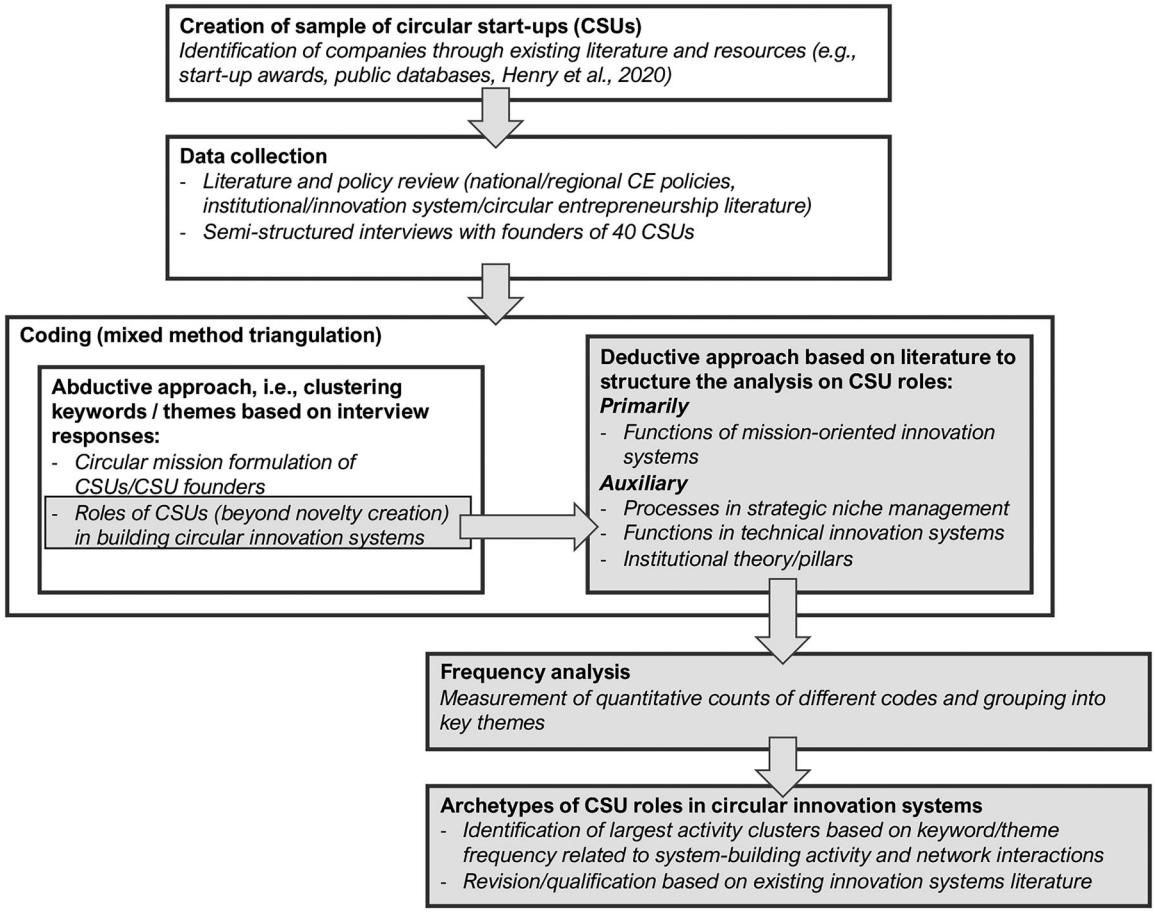

FIGURE 2 Methodological procedure and research design. Figure adapted from Henry et al. (2020).

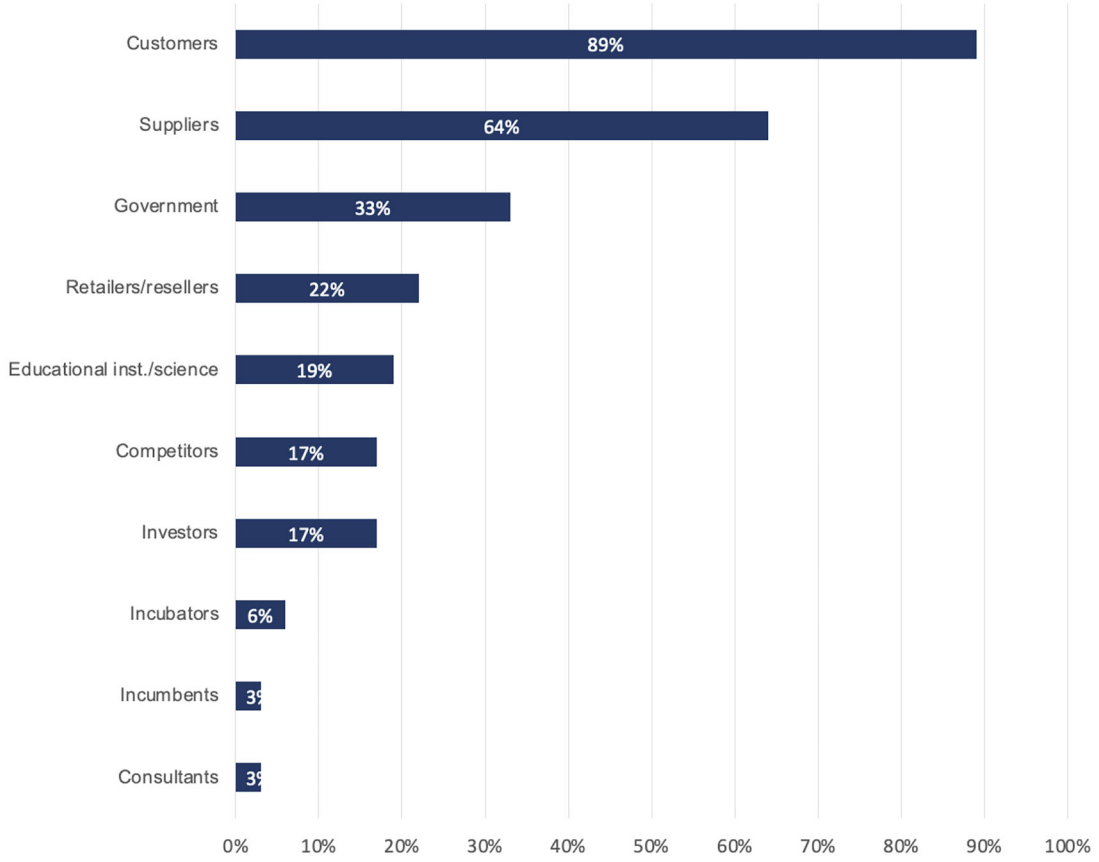

FIGURE 3 Relevance of innovation system actors for circular start-ups (mentioned by % of sample). Multiple answers possible, $n = 36$; underlying data for this figure are available in Appendix 3 of the Supporting Information.

solutions that constitute CSUs' common mission across the entire sample and discuss the missions' resonance with CE missions in CSUs' socio-political systems. Then, we scrutinize the roles that CSUs adopt to build circular IS following their mission and reflect on CSU business models.

Most common themes in CSUs' mission formulation are related to the societal problem of *anthropogenic environmental degradation* ("problem directionality"; Wesseling & Meijerhof, 2021, p. 6). Problem facets include increasing anthropogenic emissions, excessive waste, high resource inefficiencies, overconsumption, lack of customer awareness, and unequal value allocation to marginalized groups. The solutions that CSUs relate to the mission mostly lead to the *closing of resource loops* which was proposed by CSUs from all sectors that are represented in the sample (cf. Bocken et al., 2016). The necessary conditions (i.e., "solution-directionality") are defined by CSUs as changes in the value perception of businesses and customers, redefinition or eradication of waste/landfill, resource/biodiversity conservation, re-imagination of source materials and supply chains, and mobilization of various levels of society. While CSUs rarely include temporality in their missions (a key characteristic of MI), some CSUs connect the mission finality to the phase-out of environmentally harmful practices.[6] National and regional policy documents cover similar facets to CSUs' missions such as minimization of landfill usage, resource efficiency, and resource conservation. Key differences lie in the temporary dimension which is stronger represented in policy artifacts than in the CSUs' missions and in formulations around the inclusion of various societal levels which is more apparent in CSU mission formulation.

4.2 | System building activities and role of circular start-ups in circular innovation systems

CSUs are mostly engaged with their direct supply chain in building the adequate institutional environment for their circular innovations (Figure 3). Governance and management of previously disconnected resource flows were mentioned frequently by the CSU founders when asked for their system interactions. Dominant keywords in this context included *supply chain*, *suppl-*, *share*, *connect*, *collaborat-*, and *knowledge sharing*. Furthermore, the education of customers and creation of societal awareness for the quality and availability of circular solutions could be identified as a distinct system building task via keywords such as *behavior*, *awareness*, *perception*, *and societ-*. In total, we could categorize four distinct archetypical roles that CSUs take on in circular IS: *conveners*, *reinforcers*, *pioneers*, and *champions* (Table 2; Section 3).[7]

4.2.1 | Conveners: Changing normative associations through new forms of collaboration

CSUs' business models often include multiple, radical innovations that combine various resource flows and revenue models. Thereby, they change established normative associations. CSUs' innovations require a deep understanding of upstream supply chain partners' value-in-use (e.g., replacement of source materials, process standards) and radical downstream changes as need fulfilment and secondary logistics come to fore (Mayer et al., 2018; Ranta et al., 2020). *Conveners* create and govern the technical, monetary, and cultural foundations that are required for functioning circular innovation systems—particularly, through vertical integration and by (re-)connecting existing supply chains (cf. Hansen & Revellio, 2020; Tseng et al., 2020).

Conveners strive for balancing of collaboration and competition to address interconnected, systemic issues. Their approaches root in novel forms of collaboration and value co-creation that deviate from traditional "siloed" cost–benefit analyses (Table 3; Brown et al., 2021; Henry et al., 2021; Jesus & Jugend, 2023). Circular, reciprocal value propositions that are mutually determined by relevant system actors could help to establish a fair value share between disconnected or competing parties (Aminoff et al., 2017; Dagnino, 2007; Ritala & Tidström, 2014). However, due to the lack of existing institutional infrastructure *conveners* often need to develop the necessary networks from scratch (circular.berlin, 2021; NewsDesk, 2021). Governmental grants and network building evinced as enablers. Recent findings emphasize the relevance of supply chain relationship management in building CE capability (Centobelli et al., 2020; Zeng et al., 2017). The asset-light character of platform-based business models and the retained value in linear "waste" products creates relatively lower entry barriers for *conveners* (cf. Henry et al., 2020). Broker facilitation, traceability solutions, and platform and blockchain technology are relevant vehicles to manage the tensions that arise in circular systems while maintaining transparency, confidentiality, and trust in market exchanges (Cramer, 2020; Kouhizadeh et al., 2020; Narayan & Tidström, 2020; Rejeb et al., 2023).

4.2.2 | Reinforcers: Behavioral change and customer empowerment

Reinforcers apply forms of circular innovation that require customers to engage and change consumption patterns. We find that CSUs seek to change their normative and cognitive institutional environments directly and indirectly (Beunen & Patterson, 2019). Service- and platform-based CSUs purposefully engage with customers to empower them and convey a mindset that is open toward circular practices. Berlin-based start-up mundraub created a supply–demand matching application that guides users toward freely accessible, edible landscapes. Thereby, they mitigate perceived risks of differentiating from typical grocery shopping patterns and provide agency as they routinize the yielding of publicly available, idle resources (Fuentes & Sörum 2019; cf. Hanumante et al., 2022; Hobson, 2015).

Reinforcers offer free engagement and education opportunities to circular transformation processes. CE initiatives are often criticized for building rather ideal than "real" scenarios as societal dynamics and inclusiveness are not considered (Bianchi & Cordella, 2023; Niero et al., 2021). CSUs attract public interest in circular innovation by adapting new ways of working based on higher flexibility, higher circular ambitions, and more impactful CE strategies than large corporations (Henry et al., 2020; cf. Temesgen et al., 2021). *Reinforcers* raise the bar for other market actors as they holistically include circular practices in successful, competitive, for-profit businesses. Dutch Finch Buildings conducted a construction noise pollution test with local communities to prove the superior sound performance of their wood-based modular residential and office units.

4.2.3 | Pioneers: Pushing boundaries and legitimizing transformative policy intervention

Particularly, those CSUs that work with residual resource streams face regulatory challenges due to required licenses for waste material handling. All CSUs that work with residual resource streams mentioned this barrier—independently of the sectors they operate in.[8] CSUs resist ambiguity and neglection in regulatory frameworks (Awana et al., 2023) and thereby establish new norms and disrupt standards, assumptions, and beliefs (cf. Lawrence & Suddaby, 2006). With their beyond-compliance behavior, *pioneers* help circular practices to gain institutional legitimacy and contribute to a more inclusive approach toward environmental and sustainable policy (Lifset & Graedel, 2002; Schmidheiny, 1992; Socolow et al., 1994).

So far, individual or collective extended producer responsibility (EPR) and recycling schemes that are supposed to drive circular transformation processes largely miss their purpose of large-scale resource recovery (Atasu, 2018; Circle Economy, 2021; Kunz et al., 2018; Maitre-Ekern, 2021; Morseletto, 2020b). This is partly because collective coordination across industries and innovative governance for cross-sector CE innovation is still lacking (Schultz & Reinhardt, 2022). Systemic technological variety could be guided more strategically through dedicated cross-sector and upcycling incentives/subsidies, product standards, and revised waste processing laws inspired by *pioneer* activities. CSU innovations that could serve as such cases can be found in product design (Kees, fashion label), in recycling (Charopy, consumer goods; Bygen, chemicals company), and in platform technology (Rethink Resource, B2B platform for residuals).

Normative justification, legitimation, and knowledge building for transformative governmental intervention are currently missing from CE and sustainability transitions literature (Mazzucato & O'Donovan, 2016; Susur & Engwall, 2022). The evidence of CSU business models could help

TABLE 3 Coding dimensions/circular start-up roles and example interview references.

CSU role	Exemplary activities	Exemplary quotes
Convener	- Standards and contracts development for circular systems	- "Basically, we helped our suppliers to establish standards"—E12 - "We have put the right agreements, contracts and commercial terms in place with our distribution partners around how we expect the relationship to unfold and what they can and cannot do"—E38
	- Open innovation	- "We try to actively promote the ecosystem and not only partake in something existing. We work with 15–16 other companies to find ways on how to develop ecosystems"—E4 - "We try to 'cross-pollinate' and to connect people from different supply chains that benefit afterwards"—E31 - "We are also in close interaction with our competitors or other platform solutions like sharing economy platforms"—E4 - "Expansion is about spawning so that everybody does it without the founder being in charge. So, we like open source and knowledge-sharing across value chains"—E18
	- (Advanced) technology for supply–demand matching, matchmaking, and brokerage - Track and trace, network governance	- "None of the relationships already existed, so we worked on connecting the dots. […]. Our suppliers want to build their new factories along [their secondary] material flows and thus are interested in our hubs' locations"—E19 - "We had to make a lot of stuff ourselves and find a lot of things that are not necessarily affiliated with our market. We looked at existing models and put the things to place in a different manner"—E28
	- Value co-creation and strategic deliberation - Upcycling	- "We analysed the workstreams of [public and private] supply and what the mutual costs and environmental benefits of doing business with each of those streams were"—E34 - "We started talking to other start-ups that we know that could be useful for other ones. Because this also creates network and trust. […] We don't just jump in and offer our services, but we can recommend things to check out"—E32 - "So, in terms of connecting the ecosystem of farmers, to waste remediation, to doing something with the waste product to help the environment… I guess we did build that"—E33
Reinforcer	- Unlearning of harmful linear behavior and beliefs	- "We focus mainly on [changing the minds of] people who are not interested [in circular economy] because the ones that already are, find us anyways"—E7 - "Everyone living in a city should […] be less focused on products and the market"—E15 - "[We] want to inspire people to rethink the usage of their waste […]. We want to trigger a transfer thinking from our products to other products that our customers use"—E3
	- Gamification and digital platforms for increased end-user agency	- "Everyone living in a city should be able to [harvest local, accessible food] once a year to understand the neighbourhood"—E15 - "We want to take this "annoying" part out of living according to circular principles and show that it is not a trade-off but fun and rewarding"—E30
	- Free, public workshops, education, and libraries - Relationship marketing and storytelling	- "There are many start-ups around Europe trying to come up with new ideas and new ways of doing things. […] this transition is made very sympathetically. People like those different approaches and sympathise with us"—E8 - "We did a lot of videos, show and tell, to bring it alive. We invited people to the research [and pilot] facilities to see what we do. We built deep relations, people trust us"—E34 - "People need to smell and see it. They want to see the facts, no pollution, no smell, no odours"—E35
Pioneer	-Challenging and (partly) breaching of policies and standards to increase market efficiency, e.g., oUpcycling of industrial/agricultural waste oBio-/waste-based innovations in material and process design	- "Waste material sourcing requires specific licences and the tax on it is too high in my opinion"—E14 - "We deal with material streams which are officially categorised as waste and therefore we need special permits to handle them; the old rules are killing innovations […] and are not suited for the new solutions"—E11 "There is a lack of regulation in terms of declaration of waste material and how to handle it"—E18 - "[Even though I only work with material that others threw away] I am taxed in the luxury item department, like Louis Vuitton bags, which I do not consider fair"E14 - "At the end of the day governments are slow and they always are"—E38 - "[Governmental] work is promoting what we are doing but they do it with a completely different focus, so it does not necessarily fit. So, we need to follow our own regulation"—E40
Champion	- Public–private educational collaborations to exchange expert insight, collaborate on research projects, and attract and inspire talent	- "We organised hackathons and invited students and universities to build [our production machines] together"—E12 - "We offer skills training through relationships with universities and technical experts […]; these are also sources of members"—E10 - "We also want to drive [knowledge and inspiration sharing] through giving workshops or speeches at universities"—E6

avoiding lengthy, politically laden processes but justify normativity in integrated, transformational mission-oriented policy by forming higher levels of structuration, encouraging collaboration, and thereby "picking the willing", for example, through taxation, public procurement, and producer responsibility (cf. Alhola et al., 2018; Mazzucato, 2018, p. 805).

4.2.4 | Champions: Role modeling circular entrepreneurship and encouraging talent

Scientific institutions were repeatedly mentioned as relevant for the CSUs' success. Various CSUs originated in university research projects (e.g., Australia-based Bygen, UK-based AEROPOWDER). Also, the diffusion of science-based knowledge on circular innovations is considered critical. A few CSUs establish more structural collaborations with scientific institutions to advance their topical agendas and attract talent. Such forms of collaboration between scientific institutions and CSUs can be the foundation for systemic impact and direct benefits for CSUs. Particularly, in the field of design and engineering education—the dominant backgrounds among circular entrepreneurs (Henry et al., 2022). Examples of CSU founders who successfully combine design and engineering backgrounds with entrepreneurial intentions can help counteract the negative effects of subjective norms on students' entrepreneurial orientation (Maresh et al., 2015; Sun & Lo, 2012). Thereby, CSUs do not only contribute to the strengthening of the circular entrepreneurship community in their respective IS but also to the access to and availability of talent for their own ventures.

5 | CONCLUSIONS

We set out with the objective to analyze the roles and activities of CSUs in building circular innovation systems (IS), and to qualify resulting institutional dynamics. Based on the insights gained from CSUs, we aimed to delineate implications for the formation of circular IS. CSUs' network interactions are purposeful and driven by CSUs' strong circular missions, high ambition levels, holistic approaches to CE, and a lack of institutional support. This article creates a better understanding of CSUs' missions and engagement strategies to inform the operationalization of CE on the micro-level and contribute to the reflexive governance of transitions (Voß & Bornemann, 2011; Wiarda et al., 2023). This insight can serve as base for inclusive and aspirational mission formulation that appeals to impactful solutions in CE transformation processes and address the demand for innovation.

We identified four archetypical roles that CSUs adopt in circular IS: *conveners*, *reinforcers*, *pioneers*, and *champions*. *Conveners* connect supply chains and provide new models of collaboration and delivery; *reinforcers* empower circular consumption and drive awareness; *pioneers* challenge linear practices by breaching regulatory boundaries; *champions* role model circular entrepreneurship and lower entry barriers for talent. CSUs' system interactions impact their direct value chain, for instance through co-creation of value, new normative associations, joint standard setting, and customer empowerment. Other CSU interactions have more indirect implications—particularly for policymakers—because CSUs push regulatory boundaries. Thus, their activities reveal insufficiencies in existing policy and bring opportunities for directionality and normativity in transformative regulation.

6 | DISCUSSION

This study offers theoretical contributions to the scientific fields of CE and CBMs, and literature on IS and MI. It is one of the first studies to scrutinize the agency perspective in MISs based on empirical evidence of private sector players with a common mission. The testing of distinct, functioning business models that manage CE's systemic challenges, contributes to the scientific perspective departing from abundant classifications and descriptions toward the study of CE operationalization in problem–solution spaces. This study provides insight into the stakeholders and activities that are relevant for bottom-up circular innovations to spread. We call the respective stakeholder networks that form around CSUs' business models "minimum viable" circular ISs. Thereby, this study takes a step toward closing the research gap on the connection of CE, business models, and sustainable transition literature; helps in understanding the role of bottom-up innovations in circular transformation processes; and adds to the agency and governance perspectives in MIS (Bidmon & Knab, 2018; Boons et al., 2013; Loorbach, 2010; Schaltegger et al., 2016). We identify examples of how systemic acceptance for CE innovation can be achieved through institutional work, mobilization of supply chains, and new forms of collaboration.

We propose to contribute to the exchange between CSUs and other systems actors. Policymakers can use evidence from CSUs to legitimize transformative CE policy instruments and co-shape circular innovation systems. Furthermore, the formulation of CE missions in governmental or public policies should include the insight on mission formulation of CSUs to strengthen the link between top-down and bottom-up governance and increase legitimacy of the mission. Besides the mission formulation, also the management of CE missions by public actors and therefore implementation of CE can benefit from the results of this study. The four archetypes of CSU roles serve as guardrails when assessing CE solution portfolios in terms of their inclusiveness and comprehensiveness in addressing relevant functions to nurture bottom-up innovation.

TABLE 4 Circular start-up business model types and roles in circular innovation systems.[a]

	CSU business model type				
CSU role	**Design based (15/40)**	**Waste based (8/40)**	**Platform based (9/40)**	**Service based (7/40)**	**Nature based (1/40)**
Convener	8	6	9	3	1
Reinforcer	5	5	5	4	0
Pioneer	4	4	1	1	1
Mentor	1	2	1	3	0
Roles/business model type	*1.2*	*2.13*	*1.44*	*1.57*	*2*

[a]The CSU sample that was analyzed for this study was mapped according to the CSU typology based on 128 CSU business models by Henry et al. (2020). A partly similar dataset was the base for this study.

Guided by insight from CSU's system building activities, policy actors can intervene in systemic innovation processes. For instance, engaging in *convener* activities may catalyze industrial symbiosis between two non-adjacent sectors, or an observed aggregation of *pioneers* in a circular innovation could induce the targeted build-down of policy barriers. Established corporations trying to leverage external entrepreneurship can identify the systems functions and activities that may be particularly relevant for circular innovators and thereby build high-quality partnerships, strategies for mergers and acquisitions,[9] and CE innovation programs. Beyond that, they can create competitive advantage when adapting to the forms of collaboration and systems intervention that are demonstrated by CSUs to create societal value based on CBM innovation. This could mean to develop the technical and contractual infrastructure that allows joint value creation and fair value allocation or build on CSUs' supply chain mobilization activities to actively shape future resource flows in alignment with corporate strategies.

When looking at the roles that CSUs adopt and the types of CBMs that they pursue (Table 4) we notice that waste-based CSUs adopt several different roles simultaneously while design-based start-ups are more focused. The conscious efforts of waste-based CSUs to act as *conveners*, *reinforcers*, and *pioneers* shows that the exploitation of inefficiencies in linear ecosystems is associated with high levels of systemic complexity and implies the lock-in of established ecosystems in partly inefficient practices (Christensen, 1997; Hill & Rothaermel, 2003). Even though waste-based CSUs in the sample are half in numbers compared to design-based CSUs, the number of *pioneers* in both groups is the same. Given that design-based CSUs' business models are often based on (core) technological innovation, for example, in source material or process engineering, there could be a potential for "disruption" of existing policies and direction setting for new regulatory baselines related to their activities. Policymakers could, for instance, offer simplified processes for innovators to submit regulatory proposals and support CSUs.

7 | LIMITATIONS AND FUTURE RESEARCH

A limitation to this study stems from the novelty of the concept of MIS and the limited empirical and analytical work that has been conducted to study IS with a circular mission. It was laid out in this work why this phenomenon deserves further scholarly attention particularly in the context of CE where (undirected) efforts can be found on all IS levels. Furthermore, the study took a rather generic approach in terms of mission formulation and regionality which may overlook some of the intricacies around systems building that occur in specific clusters of solutions or regions.

Future research on this topic could focus on the identification of gaps between various actors' framing of CE mission's problems and solutions to allow for necessary coordination between actors. Additionally, the development of problems and solutions in relation to each other could be scrutinized with longitudinal studies. This would allow for a better understanding of the temporality of CE missions and can serve as input to establish reflexive governance processes to help scaling circular innovation. Future studies could take contextual factors (e.g., regions and sectors) more into consideration and deal more in-depth with the phase-out of legacy solutions. Last, we propose to combine the increasing insight and data from (sectoral) material flow analyses and large-scale CO_2 tracking with the findings from this study. Such analyses can serve as a base for dedicated governance interventions, prioritization of sectors, and definition of cross-sector responsibilities.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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NOTES

[1] The identification of limits to economic growth was one of the key drivers for industrial ecologists to turn toward a closer examination and conceptualization of circular resource flows in industrial processes (Boulding 1966; Lifset & Graedel, 2002; Temesgen et al., 2021).

[2] All three frameworks TIS, MLP, and SNM were developed with a distinct research question in mind. The perspective of MLP was to explore how to shift systems to higher levels of sustainability and the unit of analysis is the socio-technical system; TIS tries to capture how innovation systems emerge around focal technologies; SNM was introduced to understand how experimentation (portfolios) can help to create and scale niches (Hekkert et al, 2007; Geels, 2002, 2011; Schot & Geels, 2008). The research question of this paper does not link directly to the respective frameworks but explores a distinct group of actors that operationalize a common concept (CE) to address societal challenges through various technical and non-technical solution pathways (cf. Wiarda et al., 2023). Mission-oriented innovation systems (MISs) emerged from a partly similar research paradigm as TIS, MLP, and SM (Hekkert et al., 2020) but are related to societal (and not only technological) problems wherefore the concept was considered well suited as theoretical foundation for this study.

[3] We define circular ISs as "networks of agents and sets of institutions that contribute to the development and diffusion of innovative solutions with the aim to define, pursue and complete large-scale/systemic CE transformations" (cf. Hekkert et al., 2020).

[4] Zvolska et al. (2019) and Närvänen et al. (2021) provide comprehensive frameworks to grasp the types of institutional works conducted by urban sharing organizations and circular food start-ups.

[5] All interviews with Europe-based CSUs were conducted in 2017 and 2018. The interviews with Australia-based founders were conducted in 2020. CE experienced an upswing and appeared on municipal policy agendas in Berlin, Amsterdam, and London in 2017/2018 while this upswing happened in Australia in 2019/2020 (Table 1). Due to the similar trajectories in the respective regulatory development, little systematic bias is expected to result from this timely difference in data collection periods.

[6] Typical founder statements in this context included: "*we are always guided by keeping textiles out of landfill and not compromise on that.*"—E54; "*My vision is that there won't be any food waste anymore even if that means that my own business models will be destroyed*"—E37

[7] Table 3 at the end of this section contains a selection of interviewee replies that were coded in the respective archetypical roles.

[8] CSUs consider governmental bodies as the third most relevant stakeholder, and regulatory interventions as one of the most important institutional elements. At the same time, our data showed that regulatory barriers are perceived as one of the major obstacles to growth for CSUs.

[9] Examples for of CSU acquisitions and investments by larger corporations are Dutch water storage start-up Metropolder which was acquired by Wavin, Volvo's investment in track & trace CSU Circulor, and Visa's collaboration with London-based CSU Twig in a behavioral insights lab (Hampel, 2020; Ndure, 2023; TU Delft Campus, 2022).

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SUPPORTING INFORMATION

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