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A capability map for implementing the circular economy in organizations

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Abstract

The circular economy (CE) plays a vital role in transforming our current economic system into a more sustainable one. However, effectively implementing circular strategies and actions within organizations is a complex endeavor. It requires managing or developing diverse capabilities across the organization and its entire ecosystem, including the purposeful use of digital technologies and data, investment decisions, and knowledge sharing about products and materials. Drawing on more than 600 min of expert interview recordings and an analysis of 37 sustainability reports from the automotive industry, this paper examines the dynamic capabilities that support the implementation of circularity in organizations. We propose a framework in the form of a capability map that includes 74 specific microfoundations that help organizations to engage, manage, and reflect while implementing circular activities. This paper complements existing tools for organizational transitions, contributing to the growing body of knowledge on circularity strategy implementation, and lays the foundation for more effective CE practices in the industry.

KEYWORDS
circular economy, dynamic capabilities, digital sustainability, ecosystems, green IS, microfoundations

1 | INTRODUCTION

Excessive greenhouse gas emissions, overconsumption of finite resources, and geopolitical crises underscore the urgent need for a fundamental transition of our economic systems to foster sustainability in industrial ecosystems (Dirr, 2016; Elia et al., 2020). It only seems plausible to rethink our common production and consumption behaviors when facing the limits of growth and resources provided by the Earth. In contrast to the traditional linear model, the circular economy (CE) aims to optimize product utilization and extend resource lifecycles through closed-loop strategies such as reuse, recycling, and remanufacturing (Ellen Macarthur Foundation, 2012; Geissdoerfer et al., 2017). CE is widely regarded as one of the most promising paradigms for reshaping global supply chains and networks (Aguilar Esteva et al., 2021; Elia et al., 2020; Ferreira et al., 2023; Upadhyay et al., 2023). It is a system-oriented approach that enables collaboration across industries by exchanging materials and by-products (Ferreira et al., 2023). While the transition toward a CE is especially needed in sectors with a harmful environmental impact (Saccani et al., 2023), scholars and practitioners have identified a discrepancy between theory and the implementation of circular actions and strategies within organizations. This lack can be attributed, for example, to organizational and regularity barriers (Kirchherr et al., 2018), adoption issues (Jaeger & Upadhyay, 2020), and structural implementation obstacles (Corvellec et al., 2022). As a result, there is even a falling global circularity rate (CGR, 2024).

To respond effectively to these emerging challenges and uncertainties, a comprehensive understanding of the organizational capabilities required for the CE transition becomes essential. Dynamic capabilities (DCs) enable organizations to adapt and reconfigure their resources to achieve long-term advantages in rapidly changing environments (Teece et al., 1997). They are described as *"the firm's potential to systematically solve problems, [...] make timely and market-oriented decisions, and to change its resource base"* (Barreto, 2010, p. 271). Additionally, DCs allow organizations to free themselves from the constraints of the linear economy (Hart, 1995; Lacy & Rutqvist, 2015; Wu et al., 2013). In a CE, where organizations are required to continuously reconfigure their resources to evolving regulations, shifting market demands, and technological advancements, the development of appropriate DCs and underlying microfoundations (activities, skills, and processes) is crucial. Without a clear understanding of the DCs needed in a CE, organizations risk falling behind in the circularity transition. This may lead to inefficient resource utilization, compliance and regulatory issues, missed innovation opportunities, and the failure to achieve sustainability targets. Thus, systematically identifying and organizing DCs is imperative for organizations seeking to navigate the transition to a CE successfully.

Existing research on DCs in the CE explores how DCs drive circular supply chains (Chari et al., 2022), enhance waste circularity (Wade et al., 2022), and integrate digital technologies into circular processes (Meier et al., 2023; Neri et al., 2023). While prior work has established the foundations for DCs in a CE, empirical studies that integrate a more holistic perspective, along with socio-technical transition aspects required for the CE, remain underdeveloped. Therefore, we formulate the paper's objective as follows: *Identify and structure dynamic capabilities for implementing CE within organizations.* By articulating DCs in an actionable framework, this study enables different actors (e.g., sustainability managers, data engineers, and product designers) involved in a collaborative CE environment to make informed decisions.

To ground this research in a high-impact context and to gather empirical data, we engaged with the automotive industry. This has global significance (German Association of the Automotive Industry, 2020) and substantial environmental impact (Williams & Blyth, 2023). In 2022 alone, European car manufacturers emitted over seven million tons of CO_2 (ACEA, 2023a) and utilized approximately 29.67 million m^3 of water (ACEA, 2023b). Implementing circularity in this industry is particularly challenging due to the intertwined supply chains, complex products comprising over 30,000 parts (Motorway, 2024), and a global network of 275,000 organizations (Ganser & Otto, 2023).

To overcome these challenges and identify relevant DCs for the CE transition of organizations, we performed a series of qualitative interviews and a structured analysis of sustainability reports. To collect data and gain empirical insights, 17 expert interviews, including more than 600 min of audio recordings, and 37 sustainability reports were analyzed to arrive at a capability map comprising 74 specific microfoundations. This map supports organizations in managing their efforts toward circularity by shaping awareness of potential DCs, enabling assessments of existing resources and competencies, and crafting purposeful strategies to recruit or develop what is needed. Our results contribute to existing research by adding empirical insights from a socio-technical perspective, highlighting the interplay between organizational and technical demands, and paving the way for exploring the impact of certain DCs in a CE.

The remainder of this paper is structured as follows. Section 2 outlines the fundamentals of the CE and DCs. Section 3 explains our multi-phased research design. Section 4 presents our results synthesized into a capability map. Section 5 elaborates on contributions, limitations, and future research avenues. Section 6 concludes the paper.

2 | EXPLORING DYNAMIC CAPABILITIES FOR CIRCULAR ECONOMY

2.1 | Prior research on circular economy

The CE offers a sustainable alternative to the traditional linear economic model (Ellen Macarthur Foundation, 2015). The concept was first introduced by Boulding (1966), who proposed a circular material flow, considering both open and closed systems, to better understand the economic implications of resource use. Today, the CE is widely recognized as a model that addresses sustainability challenges by balancing the economy and environment (Haas et al., 2015; Schroeder et al., 2019; van Schalkwyk et al., 2018) while gradually decoupling economic growth from the consumption of scarce resources (Ellen Macarthur Foundation, 2023). Kirchherr et al. (2023, p. 7) defined CE as a "*regenerative economic system [with] the aim to promote value maintenance and sustainable development [...] enabled by an alliance of stakeholders [...] and their technological innovations and capabilities.*"

In industrial ecology, the CE paradigm has a long tradition and is recognized as a pivotal economic model driving the transition toward sustainability (Geisendorf & Pietrulla, 2018; Merli et al., 2018). Implementing a CE is expected to achieve decarbonization and reduce global GHG emissions up to 40% by 2050 (UNDP, 2023). Additionally, it presents new ways for value creation and revenue growth (Gebhardt et al., 2024) while fostering the creation of new jobs (European Parliament, 2023).

Despite these benefits, organizations continue to encounter difficulties in developing internal and external capabilities required to innovate products and services in line with CE principles. They must identify, refine, and develop both new and existing capabilities that drive sustainable offerings (Saari et al., 2024) and facilitate the implementation of CE activities in practice. Given the complexity of this transition, organizations also struggle to determine which capabilities to prioritize and how to integrate them into their CE practices (Kristoffersen et al., 2021).

2.2 | The relevance of dynamic capabilities for circular economy

Organizational capabilities can be categorized into *ordinary* and *dynamic capabilities*. Ordinary capabilities focus on the effective execution of an organization's current operations, whereas DCs enable organizations to purposefully adapt and reconfigure resources in response to changing environments, thereby achieving long-term advantages (Teece et al., 1997). DCs are defined as *"the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments"* (Teece et al., 1997, p. 516). They represent repeatable patterns of action for utilizing assets (O'Reilly & Tushman, 2008). While ordinary capabilities maintain the current status of organizations, DCs drive strategic transformations and thus are especially relevant for this paper's purpose of CE transitions, where organizations must adapt to novel challenges.

According to Teece (2007), DCs can be classified into three distinct categories:

- Sensing: Activities to identify and influence opportunities and threats; related to cognitive processes, including scanning, learning, interpreting, and concentrating on customer requirements, market growth, and responses from suppliers and competitors (Khan et al., 2020; Teece, 2007).
- Seizing: Opportunities identified as a competitive advantage; involves the organization's ability to make responsible investment decisions, create innovative business models, enhance technological competencies, and maintain physical or digital assets (Khan et al., 2020; Teece, 2007).
- Transforming: Competitiveness is maintained through enhancing, combining, protecting, and reconfiguring intangible and tangible assets of organizations (Teece, 2007). They enable the orchestration and renewal of resources and competencies, addressing fast-changing environments.

In addition, Teece (2007) proposed the concept of microfoundations to explain the underlying activities, skills, and processes of DCs. Given their ability to consider dynamic circumstances, we infer that the framework proposed by Teece (2007) serves as an appropriate lens to investigate evolving CE phenomena, which are subject to constant changes driven by the global market, policymakers, and technological disruptions.

Building on this, scholars have explored how DCs and microfoundations facilitate the transition to a CE across domains such as corporate sustainability (Wu et al., 2013), circular business model innovations (Bocken & Geradts, 2020; Lüdeke-Freund et al., 2019), circular business models (Santa-Maria et al., 2022), their strategic implications (De Angelis et al., 2023), and scaling practices in the fashion industry (Sandberg & Hultberg, 2021).

In contrast to strategic or digital transformation processes, the CE transition is centered on material flows and supply chains. This phenomenon gives rise to the emergence of DCs playing a pivotal role in promoting circular advantages, for instance, within the textile industry (Coppola et al., 2023; Elf et al., 2022). The importance of DCs in enhancing waste circularity has been underscored by Wade et al. (2022). DCs relevant to the accounting costs of circular material flows have been investigated by Aranda-Usón et al. (2024). Deeply rooted in the manufacturing sector, Chari et al. (2022) investigated how DCs can drive the transition toward resilient and circular supply chains, identifying five categories of microfoundations.

From a managerial viewpoint, routines and microfoundations have been shown to support CE implementation (Castro-Lopez et al., 2023; Hoppe et al., 2024; Khan et al., 2020, 2021; Seles et al., 2022). Prieto-Sandoval et al. (2019) address specific challenges for small and medium-sized enterprises in becoming more circular and highlight related DCs.

The CE transition is highly dependent upon the integration of digital technologies. This is evidenced by Neri et al. (2023), who examined digital-enabled DCs that support the CE (e.g., cloud technologies, cybersecurity, and big data analytics). Meier et al. (2023) investigated DCs relevant to blockchain technologies, which facilitate the management of circular supply chains. Bag et al. (2021) indicated the pivotal role of data analytics capabilities, while Al-Khatib (2023) emphasized the influence of DCs related to industrial Internet of Things devices on CE outcomes.

Some scholars have expanded Teece's (2007) framework of DCs by incorporating new capabilities to address domain-specific challenges in the CE transition. For example, Nacchiero et al. (2024) identified four supply chain capabilities (triggering, envisioning, navigating, and stabilizing), while Köhler et al. (2022) introduced two novel CE-related capabilities, namely remapping and reaping. Although these extensions refine Teece's (2007) DC framework by structuring capabilities within specific domains, the fundamental DC dimensions of sensing, seizing, and transforming remain essential for navigating the broader socio-technical spectrum of organizational CE transitions.

Despite the growing body of research on DCs in CE transitions, existing studies tend to focus on domain-specific capabilities rather than a holistic, socio-technical perspective (see Supporting Information S1 for a detailed comparison of microfoundations). In particular, organizational and technical/digital DCs require further exploration in light of the ongoing environmental, geopolitical, and economic crises, thus enabling organizations to act with resilience and flexibility.

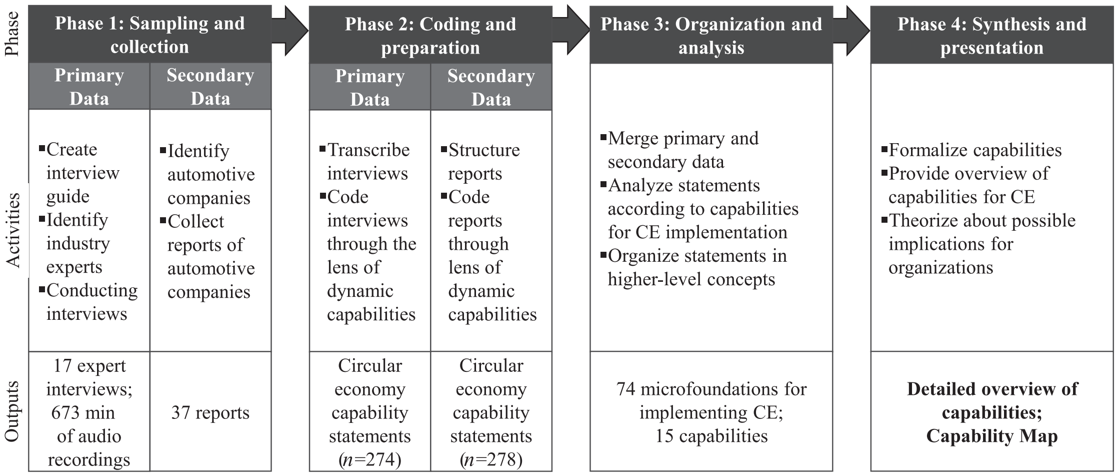

FIGURE 1 Research procedure. CE, circular economy.

3 | METHOD

To investigate relevant DCs for CE implementations in organizations, we follow a four-phase qualitative research procedure (see Figure 1). The integration of primary data collected from expert interviews and secondary data derived from published sustainability reports allows us to build upon a comprehensive foundation to address this paper's overall goal.

3.1 | Phase 1: Sampling and data collection

A combination of semi-structured interviews (primary data) and a sample of sustainability reports (secondary data) was used to extract the DCs and microfoundations driving the CE implementation on an organizational level. In general, qualitative interviews provide researchers with the opportunity to gain insights into previously unidentified information and examine subjects that may not be immediately apparent (Myers & Newman, 2007). The primary instrument utilized for the collection of data during the interviews was an interview guide comprising 15 questions, multiple warm-up inquiries, and in-depth questions. We conducted a preliminary trial with scholars to guarantee the guide's structure and clarity (Patton, 2015). To identify potential interview candidates, we reviewed the official organizational websites and sustainability reports of major German automotive organizations. Those who highlighted CE actions in their sustainability reports or on their websites were selected for further consideration. We invited domain experts representing a diverse range of educational backgrounds and professional positions within CE in the automotive value chain (e.g., sustainability experts and engineers). The interviews were conducted online. Our final sample comprises 17 interviews with domain experts from 14 organizations, resulting in a cumulative duration of more than 600 min of audio transcripts (see Table 1).

The interview data were complemented with secondary data in the form of sustainability reports, which were systematically identified through internet-based research and by Meyer Industry Research (2021). Reports not written in English or German and those not mentioning CE actions were excluded. The final sample comprises 37 sustainability reports from official automotive websites, including 22 reports from Europe, 12 reports from Asia, and 5 reports from the United States.

3.2 | Phase 2: Coding and preparation

The interview data were processed and coded following Mayring (2000). By transcribing and coding each interview, we ensured deep engagement with the data while minimizing the inherent volatility of spoken language and spontaneous note-taking. All statements and identities were anonymized for confidentiality purposes. The coding underwent multiple iterations: First, a review of the transcribed data was conducted, whereby pertinent statements were identified and marked using MaxQDA. Second, we focused on DCs and microfoundations as a theoretical lens. In contrast to ordinary capabilities, the dynamic view enables us to explore actions relevant to transformation in particular. While some of our findings could also be interpreted as rather routine design, depending on the organization and context, we focus on the transition and thus underpin our research with DCs. Finally, a Microsoft Excel database with 274 atomic statements related to DCs within the automotive sector was developed.

Regarding the collected sustainability reports, we applied the search terms "circular economy," "circular," and "circularity" to identify relevant statements. This resulted in a total sample of 278 statements recorded in a Microsoft Excel database.

TABLE 1 Expert interviews overview.

#ID	Expert description	Expert experience (years)	Expert role in the CE context	Interview duration (min)
01	Lead Project Manager	2	Recycler	34:45
02	Lead Engineer	15	Supplier	25:00
03	R&D Engineer	10	OEM	41:35
04	Sustainability Expert	10	OEM	25:23
05	Head of Sustainability	15	OEM	25:23
06	Sustainability Consultant	15	Consulting	41:44
07	Aftermarket Expert	16	Aftermarket	43:33
08	Manager Reverse Logistics	20	Recycler	30:00
09	Employee Reverse Logistics	2	Recycler	30:00
10	Sustainability Director	15	Aftermarket	53:31
11	Senior Project Manager	7	OEM	53:04
12	CEO	30	Supplier	58:01
13	Expert Standards and Norms	5	Public	56:04
14	Head of Pollution	20	Supplier	25:00
15	Employee Public Affairs	8	Supplier	25:00
16	Product Manager	5	Technology	54:11
17	CEO	25	Supplier	53:36

Abbreviation: CE: circular economy.

TABLE 2 Examples of the Gioia analysis procedure.

Source	Statement	Microfoundation	Dynamic capability	Dynamic capability dimension
BMW Group (2022)	"We are convinced that the future of the BMW Group is electric, digital, and circular—and it has already begun!"	Future CE focus (M0302)	Future planning	Sensing
Expert interview P06	"A basic [data] understanding is still lacking because [CE-related] data is not yet being used. I'd say that's the biggest shortcoming."	CE data knowledge (M1003)	Knowledge-building activities	Seizing
Geely (2022)	"We track and collect real-time data on key components [...] to improve the accuracy of carbon footprint calculations and establish end-to-end product traceability management."	Data-driven CE decisions (M1107)	Data usage	Transforming

Abbreviation: CE, circular economy.

3.3 | Phase 3: Organization and analysis

The analysis of both the statements derived from the interviews (n = 274) and sustainability reports (n = 278) followed an inductive approach (Gioia et al., 2013). In the initial stage, all statements were reviewed to craft open low-level codes closely aligned with the original statements (i.e., dynamic capability). Second, we extracted microfoundations by analyzing the DCs through logical reasoning and iteratively organizing them according to comparable subject areas. Six iterations were conducted to explore each quote from the sustainability reports and interviews and assign them to the DC dimensions of sensing, seizing, and transforming (see Table 2). During the analysis, we recognized some overlaps between the microfoundations, particularly in the intersection of organizational and technical. Through multiple rounds of discussions among the authors, it was ensured that each concept was placed in its most representative category.

3.4 | Phase 4: Synthesis and presentation of the results

The results of our paper are presented in textual form and have been synthesized into a capability map (see Figure 2). The capability map enables the management and systematization of a set of organizational and technical DCs and microfoundations. The clustering and differentiation between organizational and technical/digital DCs and microfoundations emerged from the synthesis of the interviews and sustainability reports. They were clustered according to their primary function. DCs involving changing processes and structures (e.g., market monitoring, strategic planning, and knowledge sharing) were assigned along the *Organizational* axes. DCs involving digital technologies and data (e.g., technology adaptation, data usage) were assigned along the *Technical/Digital* axes. Overall, our synthesis expands the current body of knowledge concerning the relevant DCs and microfoundations when implementing a CE on an organizational level.

4 | A CAPABILITY MAP GUIDING CIRCULAR ECONOMY TRANSITIONS

The capability map conceptualizes the essential DCs and microfoundations necessary for implementing a CE on an organizational level. It offers a structured framework and strategic guidance to support organizations in their CE transition, promoting a more effective and efficient resource utilization (van Riel & Poels, 2023). To facilitate navigation of practitioners, the map is organized along the horizontal axes of *Organizational* and *Technical/Digital*, and the vertical axes of *sensing*, *seizing*, and *transforming*. Each identified DC and microfoundation is assigned to the axes and categorized as either *ecosystem*-level or *firm*-level, reflecting the fact that such complex transition endeavors are often conducted within a system of actors. While ecosystem-level DCs involve multiple actors collaborating within the CE, firm-level DCs focus on the organization. This conceptualization empowers practitioners (e.g., sustainability managers, product designers, data engineers, process managers, or technical staff) to make informed decisions within a CE environment, ultimately guiding organizations toward a successful CE implementation (see Figure 2).

4.1 | Sensing microfoundations for the circular economy

The sensing DCs identify both opportunities and threats in implementing the CE. *Awareness* (M01) refers to the microfoundations associated with the organization's overall understanding and awareness of the CE. This includes, for example, recognizing the value proposition of CE for the organization (M0101), evaluating the potential of sustainable packaging (M0102), and reflecting on CE-related factors that may influence business models (M0103). Our analysis highlights the necessity of detecting greenwashing (M0105), understanding sustainability indicators (M0106), and acknowledging geopolitical dependencies (e.g., conflicts affecting supply chain reliability) (M0107), as well as addressing data security concerns regarding circularity metrics (M0108). In addition, we extracted microfoundations related to the *commitment* of organizations (M02). These are demonstrated through the ability to implement circular processes and products (M0201), reduce waste (M0202), and enhance the proportion of secondary materials (M0203). Given that the CE holds significant transformative endeavors, organizations must develop *future planning* (M03) microfoundations, such as forming alliances (e.g., through communication with stakeholders in circular supply chains) (M0301). *Market monitoring* (M04) enables organizations to assess changes in regulatory development, secondary markets, and the design of circular solutions viable in real-world applications. Organizations must continuously identify CE opportunities and challenges while developing innovative solutions for emerging problems (e.g., new circular business processes) (M0403).

4.2 | Seizing microfoundations for the circular economy

Seizing DCs, which focus on mobilizing resources to generate sustainable value from opportunities, are categorized into five distinct categories. *Investments* (M05) involve microfoundations allocating resources to technologies (e.g., data infrastructure, machinery) (M0501) and specialized personnel (e.g., engineers, computer scientists, environmental specialists) who can facilitate the advancement of the CE (M0502). It is also crucial to consider the microfoundations that *promote* (M06) advanced organizational CE ambitions (M0601), initiatives, and subjects (e.g., circularity goals, internal CE working groups) (M0602). The *strategic planning* (M07) microfoundations involve, for instance, defining clear strategic CE objectives (M0701) and developing circular ownership models (M0707). Additionally, organizations must establish or restructure circular business models (M0703) and units (e.g., aftermarket) to align with CE principles (M0704). In the context of digital technologies, organizations must analyze existing IT processes to ensure compliance with circular practices (M0706). Additionally, various microfoundations are associated with the *collaboration and participation* (M08) of organizations regarding the CE. This encompasses the ability to collaborate with diverse stakeholders (e.g., politics, customers) (M0801), participate in circular networks (M0803), and cross-organizational CE projects (M0804). The *adaption of technologies* (M09) has the potential to enhance the efficiency of circular processes by utilizing digital resources (M0901). Technological advancements play a crucial role in realizing CE solutions—for example, by developing recycling solutions or defining technical CE concepts (M0905). Considering *knowledge-building*

FIGURE 2 Capability map guiding circular economy transitions of organizations. CE, circular economy.

activities (M10), microfoundations in emission calculation and reporting (M1001), as well as enhancing data knowledge (M1002), must be developed. Additionally, organizations must develop competencies in understanding CE regulations (M1004).

4.3 | Transforming microfoundations for the circular economy

Finally, to reconfigure and transform organizational structures and to capitalize on opportunities, we have categorized the transforming DCs. *Data usage* (M11) involves microfoundations for circular data lifecycles (M1104). Additionally, organizations must implement standardized data models to facilitate seamless communication and collaboration across organizational boundaries (M1101). A fundamental understanding of data is also essential to ensure compliance with CE regulations (M1103). Considering the sharing of circular data, organizations must facilitate data infrastructure (M1105) and define data quality criteria (M1106) to ensure the reliability and integrity of data in a CE. In addition, *knowledge sharing* (M12) microfoundations are identified: for instance, the exchange of CE expertise to foster collaboration and innovation (M1201), the implementation of acceleration programs focused on circularity start-ups (M1202), the formation of strategic alliances dedicated to CE initiatives (M1203), and the establishment of internal CE working groups (M1204). In the context of *organizational reconstructing* (M13), the identified microfoundations focus on integrating CE principles into new revenue streams (M1301), aligning existing linear business models with circular ones (M1302), and establishing new reverse logistics processes (M1306). Additionally, our analysis highlights the need to develop microfoundations regarding the design of *circular processes* (M14) to enhance efficiency in CE operations. This includes the extended use of factory equipment (M1403), establishing new circular manufacturing systems (M1404), operating recycling systems for resource circulation (M1405), and repurposing technologies after their initial implementation (M1406). Moreover, redesigning existing processes to enhance circularity (M1407) and adapting software solutions to align with CE principles (M1408) must be considered. To fully embrace circularity, organizations must also develop microfoundations in *circular product design* (M15). This includes utilizing recycled materials (M1501), increasing the proportion of sustainable materials (M1502), and redesigning products with a circular focus (M1503). Additionally, integrating secondary materials into new products (M1504), applying design principles (M1505), and introducing a CE label that facilitates a circular product life cycle (M1506) are essential microfoundations that foster more sustainable practices.

5 | DISCUSSION

Undoubtedly, there is a need to manage today's interconnected sustainability problems as well as the growing sustainability pressure arising from policymakers and the market (Dirr, 2016; Elia et al., 2020). Thinking and acting circularly are auspicious to boost a fundamental shift from our current economic system toward a more sustainable one (Blomsma & Brennan, 2017; Schroeder et al., 2019). However, since the CE transition highly depends on circular material flows, digital technologies, and resilient supply chains, the implementation is associated with a multitude of challenges. Given this, organizations are required to reconfigure existing DCs or even develop completely new ones for implementing the circular paradigm (Hart, 1995; Lacy & Rutqvist, 2015; Wu et al., 2013). This paper explored the DCs and associated microfoundations necessary for implementing the CE. It presents a capability map based on first-hand data collected through expert interviews and secondary data derived from a sustainability report analysis. Our final data set allowed us to identify CE actions derived from real-world applications and gain an in-depth understanding of the DCs. While our empirical data were drawn from the automotive industry, the DCs identified are not limited to this sector. We derived them with attention to managerial challenges that are common across industries undergoing a CE transition. Thus, while the findings are sector-informed, they remain broadly relevant to organizations across various sectors undertaking CE transitions. However, there are some boundary conditions. Take, for instance, domain- and context-specific boundaries. While certain capabilities are motivated by the automotive industry and specific to the manufacturing sector (e.g., M1404 circular manufacturing systems), other capabilities can be transferred and applied beyond the manufacturing sector (e.g., M1201 CE expertise sharing).

From a **scientific perspective**, our findings validate and extend existing research on DCs in the context of a CE. First, consistent with Khan and colleagues (2021), our paper demonstrates that the established DCs of sensing, seizing, and transforming, and their microfoundations (Teece, 2007) play a pivotal role in CE transitions (see Supporting Information S1 for a detailed comparison). Organizations aspiring to transition toward CE must integrate them into their operational and strategic processes. Take, for instance, *market monitoring (M04)*. It is a common microfoundation in organizational transformation processes and thus also plays a significant role in the CE by monitoring the circular market demands, regulations, and new opportunities.

Second, we contribute an empirical perspective to existing research on DCs, which has largely remained conceptual and often focuses on either technical or organizational dimensions. By adapting a socio-technical lens (Sarker et al., 2019) and examining real-world data, specific DCs and their associated microfoundations could be elaborated. For example, concerning *organizational and management* DCs, our findings reveal both similarities and differences with prior studies. Commonly cited microfoundations include market monitoring, strategic planning, and the development of circular business models (Khan et al., 2021). Newly identified microfoundations emerging from our empirical data include a CE-aligned sales department (M0705) and circular IT processes (M0706) (see Supporting Information S1).

Third, we extend the DC model proposed by Chari et al. (2022) by integrating circular process design microfoundations, such as recycling and take-back systems (M1405), and extended use of equipment (M1403). In line with Chari et al. (2022), we observe microfoundations related to internal motivation and commitment, including a strategic orientation toward a future CE focus (M0302). In addition, our analysis emphasizes *technical* DCs reflecting the increased importance of data-related microfoundations. These include the development of a circular data strategy (M1102), the use of standardized data models (M1101), and the establishment of supporting data infrastructure (M1105) as critical enablers of circular transitions. We also complemented existing microfoundations by highlighting the role of production data monitoring (e.g., Neri et al., 2023). These findings align with those of the OECD (2015), which reported that organizations investing in data DCs can experience productivity growth rates. However, in contrast to Meier et al. (2023), we found no evidence in our sample that the implementation of blockchain technologies is fundamental for advancing circularity.

In addition to the academic contribution, our research yields **implications for practitioners**. First, our *capability map* structures a total set of 74 microfoundations of DCs empirically derived from the automotive sector. This uncovers relevant DCs that support managers and change agents across industries in making more informed decisions and guiding their organizations through the circularity transition. The map serves as a tool for navigating, adapting, or training the necessary CE DCs from an ecosystem and firm-level perspective. We infer that it represents a strategic asset with the potential to facilitate the implementation of CE in organizations and industrial ecosystems.

Second, in line with broader shifts toward digitalization, our findings *emphasize the digital component* of CE transitions. Our paper contributes to emerging research streams such as twin transformation (Christmann et al., 2024) and digital sustainability (Schoormann et al., 2025), aiming to leverage data and digital technologies to support sustainability goals. Our results suggest that the implementation of CE is enhanced through the use of data and novel technologies, resulting in significant changes to organizational structures (Hoppe et al., 2024; Zeiss, 2019). In this context, the capability map offers a valuable reference for identifying the DCs and microfoundations required for a digital CE transition. This is particularly relevant for the industrial sector, which faces the intertwined challenges of digitalization and sustainability (Winkelmann et al., 2023), as well as for other sectors undergoing similar transitions.

Third, this paper enables organizations to assess their current *strengths and areas for improvement*, providing a comprehensive checklist of their DCs. To make the proposed DCs more tangible for managers and other practitioners, a detailed, five-step exemplary journey through organizational CE transition processes is provided. Guided by the capability map, this practical walkthrough serves to support decision-makers in identifying, understanding, and activating relevant DCs throughout their CE transformation efforts (see Supporting Information S2). To identify and prioritize both organizational and technical DCs across various maturity levels, distinguishing between ecosystem-level and firm-level microfoundations, the capability map serves as a valuable tool for diverse stakeholders. For example, managers can focus on firm-level microfoundations to restructure their organization, such as implementing circular business logic (M1302) or engaging in strategic planning to set CE targets (M0701). In contrast, consultants and IT-specialists may concentrate on ecosystem-level DCs to adapt data infrastructures (M1105) along the circular value chain, or implement CE standards (M0902). By leveraging the capability map as a strategic tool and systematically implementing the identified DCs and microfoundations, organizations can develop more informed, adaptive, and resilient CE strategies. Ultimately, our findings help to align organizational actions with CE principles and support them on their circularity journey.

Overall, our findings contribute to the growing body of research on DCs by deepening the understanding of how DCs and their associated microfoundations support the implementation of CE actions within organizations. The utilization of a capability map as a tangible artifact enhances the visualization and structuring of relevant DCs, offering a more integrated and actionable perspective on CE transitions.

However, the paper's findings are based on our interpretation and experiences, which are subject to certain **limitations**. Nonetheless, they lay the foundation for **future research**, guiding the industrial ecology community in identifying the DCs required for effectively implementing CE strategies at an organizational level. First, our results are constrained by the number of organizations and expert interviews analyzed. Further investigation could yield additional insights by expanding the paper's scope to include experts from the same industry or other industries, as well as from different countries and continents. Further research could also expand the capability map through empirical analyses in additional industrial sectors. This would support a more comprehensive representation of DCs and microfoundations beyond the manufacturing domain, for example, in service-oriented businesses. This enhances their applicability to CE implementations across diverse contexts. Second, this paper is primarily concerned with extracting and organizing DCs without assessing the relevance of a single one. Future research could investigate the interrelationship (e.g., which DCs are typically developed jointly) and maturity levels (e.g., how to assess the current state of the development), as well as explore more concrete microfoundation development options (e.g., training programs). Third, given our socio-technical lens and the aim to provide a capability map as both an overview and a guide to relevant CE DCs, some of the identified DCs and microfoundations may appear generic. To address this, we explicitly highlight its concrete contribution to circularity. Additionally, future studies could focus on identifying and analyzing DCs or ordinary capabilities that are explicitly and uniquely relevant for specific CE approaches (e.g., circular supply-chain communication). Fourth, the time-varying scope of our research may have constrained the generalizability of our findings. Given the rapid transition of the automotive industry toward digitization and circularity, the reporting may have already precipitated changes that have not yet been reflected in earlier reports and thus are not incorporated into our research. Lastly, one pillar of the data corpus is extracted from sustainability reports, which are criticized as overly complex and optimistic in their performance representation (Pucker, 2021). Their results may be influenced by greenwashing, which involves hiding unfriendly practices under the guise of friendly ones (Kurpierz & Smith, 2020). Nevertheless, even if sustainability reports represent an idealized state, they can serve as a basis for mapping relevant DCs and microfoundations for the CE transition.

6 | CONCLUSION

This paper investigated the DCs required for implementing a CE within organizations. Our research was motivated by the practical challenges faced by our interviewees, the need to bridge theoretical insights with actionable strategies, and the necessity for a comprehensive overview of the DCs beyond academic disciplines. To gather in-depth insights on relevant DCs and collect valuable data on how to implement CE in practice, we conducted a series of interviews with 17 leading experts from the automotive industry (i.e., more than 600 min of interview data) and performed a qualitative analysis of 37 sustainability reports (i.e., more than 552 statements). Based on these data, we synthesized a set of 74 DCs and organized them into a capability map designed to navigate managers and decision-makers in steering their organizations toward circularity. Ultimately, we aim to foster a sustainable economic system at the intersection of technological and management DCs, guiding organizations in preparing for tomorrow.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict 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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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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