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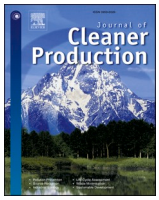

Exploring the role of dynamic capabilities in digital circular business model innovation: Results from a grounded systematic inductive analysis of 7 case studies

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ABSTRACT

There is already extensive literature that focuses on the leading role of digital technologies in fostering circular business model innovation. However, little attention has been paid so far to the dynamic capabilities involved in the digitally enabled transition from linear to circular. We contribute to reducing this gap by proposing an empirically grounded theoretical framework on the role of dynamic capabilities in digital circular business model innovation. Our contribution is grounded on the systemic inductive analysis based on the Gioia methodology of 7 in-depth semi-structured interviews with managers in charge of digital circular business model innovation. Companies were selected for their SASB materiality index and levels of technological intensity. Our findings highlight the role of dynamic capability in sensing and seizing digital circular business model innovation and, in particular, supply chain collaboration, lean methodologies, and project management.

1. Introduction

Circular business models aim to enhance sustainability by decoupling firms' economic growth from resource exploitation through closing, narrowing, and slowing resource flows (Bocken et al., 2016). Digital and smart technologies are critical in fostering decoupling between economic growth and resource exploitation (Pagoropoulos et al., 2017). Those technologies enable both companies and consumers to reduce their waste of resources through more careful monitoring of the usage of those resources while products and services are produced, consumed, and disposed of (De Sousa Jabbour et al., 2019; Bressanelli et al., 2018; Ingemarsdotter et al., 2020). Furthermore, those technologies enable the opportunity to rethink the boundaries separating activities both within and between firms along the value chain (Velter et al., 2022) with major advantages in terms of efficiency in the use of environmental resources and extension of the life cycle of products, components, and materials (Ranta et al., 2021). To picture the entrepreneurial opportunities arising from the integration of digital transformation and sustainable development, in a recent paper, George et al. (2021) coined the term digital sustainability to signify all the organizational activities seeking to advance sustainable development goals through the creative deployment of digital technologies.

Even if the literature has extensively recognized the role played by those technologies in fostering digital circular business model innovation (Ranta et al., 2021; Uçar et al., 2020), little attention has been paid so far to the role of dynamic capabilities. Dynamic capabilities are key in enabling business model innovation (Teece, 2018). Their role has been found critical in successfully transforming firms' business models to capture the value generated by integrating new digital opportunities (Li et al., 2017; Oyon et al., 2019). Their role resulted equally relevant in enabling companies to make their business models more circular and contribute to sustainable development (Santa-Maria et al., 2022; Sandberg and Hultberg, 2021; Bocken et al., 2019). However, there are not yet studies addressing the role of dynamic capabilities in exploiting business opportunities associated with digital sustainability.

The need for developing specific dynamic capabilities in the management of business model innovation based on digital sustainability is explained by the peculiar nature of this innovation. As suggested by Hellemans et al. (2022), digital sustainability has a dark side as it is a source of unexpected tensions and paradoxical effects, which may risk the creation of values for societal actors. It produces rebound effects that lengthen rather than shorten our path to sustainable development goals. The combination between digitalization and sustainability expands the search landscape so much that makes it difficult for many companies to

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manage the trade-off between knowledge breadth and depth. Finally, the wide variety of competencies involved and the larger access to information may spur even more conflictual relationships between stakeholders in the management of business model innovation based on digital sustainability.

More specifically, we know very little about what drivers impact the capacity of firms to sense and seize the opportunity driven by digital technologies to initiate circular business model innovation (de Sousa Jabbour et al., 2018). Furthermore, we lack knowledge of what capabilities are involved in managing the digital transformation from linear to circular business models (Ranta et al., 2021). Finding solutions to those issues is critical because enhancing environmental sustainability through digital circular business model innovation requires the unique capacity to combine digital and environmental competencies within a process of business model innovation. Therefore, in this paper, we aim to reduce this gap by proposing an empirically grounded theoretical framework highlighting the role of dynamic capabilities in digital circular business model innovation

Our framework is grounded on the systematic inductive analysis of 7 case studies of digital circular business model innovation. Case studies have been selected for their SASB materiality index (high versus low) and technological intensity. For each of the case studies, we interviewed the managers in charge of the digital circular transition. Interviews have been coded according to the Gioia methodology with the support of ATLAS software. Two cycles of interpretation and refinement have been conducted leading to 9 s-order themes, which have been, in turn, reduced to 3 aggregated dimensions corresponding to Teece's (2007) classification of dynamic capabilities. Our outcome is a map of the dynamic capabilities involved in the management of digital circular business model innovation.

The structure of the paper is the following. In the next section, we review the relevant literature. We focus on two issues. First, we introduce the notion of digital circular business model innovation. Second, we review the existing literature on the role of dynamic capabilities in circular business model innovation and digital business model innovation. Section 3 is about methodology. We define how case studies have been selected and how data has been collected and processed. In section 4.0, we present our major results, whose significance and implications are discussed in section 5.0. The main conclusions are summarized in section 6.0.

2. Background literature

Digital technologies are a key enabler in circular business model innovation (Nascimiento et al., 2018). Even if, as a highly quoted literature review states (Zott et al., 2011), there is not yet full agreement on what a business model is (Zott et al., 2011), for this paper, this is defined as the rationale of how an organization creates, delivers, and captures value (Osterwalder and Pigneur, 2010). Business model innovation (BMI) implies changes in this rationale. That is, changing the existing resource base of a firm to develop new capabilities, changing the organizational and value chain structure, and developing new revenue models and value propositions (Demil and Lecocq, 2010). Building on Palmié et al. (2022), digital business model innovation can be defined as a novel and non-trivial change to the key components model of a firm's business embodied in or enabled by digital technologies. Following Bocken et al. (2019), circular business model innovation regards changes in the business model to embed, implement and capitalize on circular economy practices, such as product durability and design for product life extension to slow resource loops, and recycling approaches to close the loop. Therefore, combining those two definitions, digital circular business model innovation can be defined as novel and non-trivial changes in a firm's business model embodied in or enabled by digital technologies to capitalize on circular economy practices.

The implementation of digital technologies enables three critical functions for the effective implementation of circular business model innovation: data collection; data integration, and data analysis (Pagaropoulos et al., 2017). IoTs alike technologies enable the closing and slowing of resource flow (Ingemarsdotter et al., 2020; De Sousa Jabbour et al., 2019; Bressanelli et al., 2018) through reverse logistics based on real-time data collection on the usage and location of products and data-driven maintenance (Pagaropoulos et al., 2017). Cloud technologies and Product Lifecycle Management Systems (PLM) enable the narrowing down of resource flows (Ranta et al., 2021) all along the value chain through extensive sharing and integration of collected data (Pagaropoulos et al., 2017). Finally, AI (Artificial Intelligence), machine learning, and big data analytics (Pagaropoulos et al., 2017) enable the narrowing, slowing, and closing of resource flows through improved product design, predictive maintenance, and remanufacturing capabilities (Ranta et al., 2021; Uçar et al., 2020; Bressanelli et al., 2018).

The existence of new technologies enabling the opportunity to create, extend and modify firms' resources, and competencies to embody circular practices in their business models is not sufficient to capture the value and stay ahead of the competition. Dynamic capabilities are also needed (Teece, 2018). This is because those digitally enabled circular opportunities need to be sensed and seized, and resources and competencies reconfigured before competitors (Teece, 2007; Helfat and Peteraf, 2015). Furthermore, seizing and exploiting digitally enabled circular opportunities cast additional burdens on firms (Hellemans et al., 2020). The need to deal with a larger number and variety of stakeholders with often conflictual interests. The need to find optimal trade-offs between knowledge breadth and knowledge depth in a significantly widened search landscape as a consequence of the combination between digital and sustainability. Therefore, to understand the dynamic capabilities mobilized by circular digital business model innovation is useful to look at those mobilized by digital and circular business model innovation.

There are already studies looking at the dynamic capabilities leveraged in circular business model innovation. Those contributions are systematized in Table 1 according to the specific category of dynamic capability addressed. In circular business model innovation, sensing relates to how firms become aware of CE issues and about understanding and appraising these as potential business opportunities (Bocken and Geradts, 2020; McWilliams and Siegel, 2011). For example, sensing for circular business model innovation can involve cooperating and sharing ideas with entities outside the firm to discover innovative solutions for complex sustainability challenges (Bocken and Geradts, 2020; Adam et al., 2018; Inigo et al., 2017). Seizing is about mobilizing the right resources to address identified CE opportunities and threats and capture value from doing so, by turning them into circular business model innovation opportunities (Bocken and Geradts, 2020; Teece, 2018).

For example, seizing circular business model innovation opportunities may entail channeling clean technologies learned from third parties into the main business operations of the firm (Inigo et al., 2017), dedicating separated budgets and incentive schemes to sustainability initiatives (Bocken and Geradts, 2020), or developing sales capabilities for selling services instead of products (Kanninen, 2017; Coreynen et al., 2020). Transforming is about continuously renewing the organization's capabilities towards those needed for the ongoing implementation of circular business model concepts (Bocken and Geradts, 2020; Teece, 2016). For example, transforming the firm's assets for circular business model innovation may involve building decentralized sustainability-oriented innovation teams to incentivize circular business model innovation in different departments, making the firm more resilient to future change (Inigo et al., 2017).

There is also literature looking at the dynamic capabilities leveraged in digital transformation (see Table 2). This literature distinguishes between digitalization, which regards the exploitation of digital opportunities, and digital transformation, which is the process through which organizations are restructured at the system level (Materazzo et al., 2021). Westerman et al. (2012) define digital dynamic capabilities

Table 1
Dynamic capabilities for CIRCULAR BUSINESS MODEL INNOVATION.

	Dynamic capability	Author
Sensing	Increasing employee innovation competencies	Coreynen et al. (2020), Scarpellini et al. (2020).
	Collaborative innovation competencies and supply chain management	Bocken and Geradts (2020). Adam et al. (2018), Inigo et al. (2017), Hong et al. (2018), Kumar et al. (2018)
	Strategic focus on SBMI	Bocken and Geradts (2020).
	Anticipate and respond to regulations	Inigo et al. (2017)
	Customer-oriented organizational culture and mindset	Kanninen et al. (2017), Adam et al. (2018)
	Systematic-Problem Solving	Mohaghegh et al. (2021)
Seizing	Dedicating resources to SBMI	Bocken and Geradts (2020).
	Collaborating with third parties	Adam et al. (2018), Inigo et al. (2017); Kumar et al. (2018)
	Integrate clean technologies and sustainability-oriented methodologies	Inigo et al. (2017)
	Sharing SBMI knowledge throughout the organisation	Inigo et al. (2017), Kanninen et al. (2017)
	Sales capabilities for services	Kanninen et al. (2017) Coreynen et al. (2017)
	Integrating front and back offices for services	Kanninen et al. (2017)
	IT tools for selling services	Kanninen et al. (2017)
Transforming	Strategic focus on SBMI	Bocken and Geradts (2020).
	Recruiting and training for sustainability	Bocken and Geradts (2020),
	Defining performance metrics for sustainability	Bocken and Geradts (2020). Kaninnen (2017).
	Senior management measures and understands the long term profitability of the service business	Kanninen et al. (2017)
	Creating new knowledge from external networks	Adam et al. (2018)
	Flat hierarchies for organisational flexibility	Adam et al. (2018)
	Building decentralized sustainability-oriented innovation teams	Inigo et al. (2017)
	Agile culture and creating trust and commitment among internal teams and between team members	Inigo et al. (2017); Mohaghegh et al. (2021)
	Continuous improvements	Mohaghegh et al. (2021)

Table 2
Dynamic capabilities for digital technology adoption.

	Dynamic capability	Author
Sensing	Market scanning for technological opportunities	Matarazzo et al. (2021), Soluk and Kammerlander (2021), Warner and Wäger (2019)
	Customer scanning for technology requests	Tortora et al. (2021), Soluk and Kammerlander (2021), Chirumalla (2021), Matarazzo et al. (2021), Warner and Wäger (2019)
	Data-driven sensing capabilities	Tortora et al. (2021), Matarazzo et al. (2021), Chirumalla (2021)
	Digital scenario-planning	Warner and Wäger (2019)
	Digital mindset building	Warner and Wäger (2019)
Seizing	Assimilate and commercialize new information	Tortora et al. (2021), Soluk and Kammerlander (2021)
	Ability of employees to learn quickly	Soluk and Kammerlander (2021), Matarazzo et al. (2021)
	Hiring of new human resources	Matarazzo et al. (2021)
	Flexible root cause discovery of adoption problems	Chirumalla (2021)
	Structured opportunity assessment process	Chirumalla (2021)
	Management support	Chirumalla (2021)
	Rapid prototyping	Warner and Wäger (2019)
	Balancing digital portfolios	Warner and Wäger (2019)
	Strategic agility	Warner and Wäger (2019)
Transforming	Redesign internal structures related to digital	Matarazzo et al. (2021), Chirumalla (2021), Warner and Wäger (2019)
	Defining information push mechanisms	Chirumalla (2021)
	Training support	Chirumalla (2021)
	Brand management	Soluk and Kammerlander (2021)
	Strategic innovation partnerships	Soluk and Kammerlander (2021), Warner and Wäger (2019)
	Improving the digital maturity of the workforce	Sousa-Zomer et al. (2020), Warner and Wäger (2019)

as the building block to transform the customer experience, operational processes, and business model. Data are recognized as the main driving force in the process of digital transformation and the development of the associated dynamic capabilities (Tortora et al., 2021). Strategic agility, rapid prototyping, and balancing digital portfolios are addressed as key sub-capabilities extending the capacity of digital seizing and transforming in firms (Warner and Wäger, 2019).

A large part of this literature relies upon the dynamic capabilities framework based on sensing, seizing, and transforming to define the specific dynamic capabilities involved in digital transformation. The results of our review are systematized in Table 2. For seizing, the capacity to assimilate and commercialize new information in the firm (Tortura et al., 2021; Soluk and Kammerlander, 2021), employees' ability to learn quickly (Soluk and Kammerlander, 2021; Matarazzo et al., 2021), hiring digitally experienced human resources (Matarazzo et al., 2021), managerial support (Chirumalla, 2021), and rapid prototyping (Warner and Wäger, 2019). Finally, among the transforming capabilities, redesigning organizational functions and structures that relate to new digital technologies (Matarazzo, 2021; Warner and Wäger, 2019), the availability of procedures to communicate and manage change (Chirumalla, 2021), effective digital training of the workforce (Chirumalla, 2021) and strategic partnering for business model innovation to learn from best practices and identify strategic opportunities (Soluk and Kammerlander, 2021; Warner and Wäger, 2019) are among the most important.

Even if there is literature looking at dynamic capabilities related either to circular business model innovation or digital technology adoption, no study so far looked at how those two categories of dynamic capabilities come together in digital circular business model innovation. Managing digital circular business model innovation requires being able to build connections between contexts of opportunities and sets of competencies that are very distant from each other (Hellemans et al., 2020). For instance, developing circular business model innovation in the field of vertical farming requires firms to bring together competencies from very different fields such as biology, mechanics, informatics, artificial intelligence, and marketing (Van Delden et al., 2021). Therefore, the dynamic capabilities associated with combining knowledge from such a huge variety of distant technological fields cannot be reduced to the sum of the dynamic capabilities required to effectively operate with every single domain. This is also confirmed by the nascent literature on the development of dynamic capabilities associated with big data analytics (Wamba et al., 2017; Mikalef et al., 2019), which requires building specific competencies to managing, process, and analyzing the 5 V data-related dimensions (i.e., volume, variety, velocity, veracity, and value) to create actionable ideas for delivering sustained value, and open innovation management (Bogers et al., 2019; Teece, 2020), which requires to dynamically integrate a large variety of internal and external sources of knowledge. Therefore, the ambition of this paper is to contribute to the existing literature by exploring the additional dynamic capabilities associated with the management of

digital circular business model innovation.

3. Methodology

The objective of this paper is to explore the role of dynamic capabilities in digital circular business model innovation. The transition toward more circular business models is an emergent phenomenon (Diaz Lopez et al., 2019) and empirical data on dynamic capabilities linking circular business model innovation and digital technology adoption is in its early stages. Therefore, an explorative qualitative methodology comparing multiple case studies seems the best option for developing empirically grounded hypotheses on emerging patterns in the dynamic capabilities needed for digital circular business model innovation (Gioia et al., 2013).

To increase the likelihood of finding companies that provide the greatest insights into the research question (Devers and Frankel, 2000), we implemented a purposive research strategy. We were targeting companies that implemented digital technologies in their transition to a more circular business model. For this, we relied upon a database of companies partnering with either Rabobank's innovation department and/or Sustainable Finance Lab on the topic of transitioning to a circular business model. Rabobank is a major Dutch bank and a leading bank worldwide in the food and agricultural industries. A particular focus of its innovation department is on using digital technologies to enable pay-per-use models. Sustainable Finance Lab is a network organization connecting academics and industry practitioners in the field of sustainable finance. Both organizations are actively involved in knowledge partnerships with companies that implemented digital technologies to transition to a more circular business model. Therefore, the companies in their network were expected to be a population with relevant cases.

Project managers at Rabobank and Sustainable Finance Lab helped compile an initial list of 12 companies. The companies were selected based on 3 main criteria. First, their experience with the adoption of digital technologies from industry 4.0 to support the transition toward a more circular business model. Second, the technological intensity of the industry. This is because we expect the technological intensity of the industry to affect the capacity of firms to sense and seize business opportunities associated with the adoption of digital technologies and transform their business model to appropriate the value of those opportunities. Technological intensity has been defined based on the Eurostat technological classification of manufacturing industries. Third, the CE materiality of the industry. This is an indicator elaborated by the Sustainability Accounting Standards Board (SASB, 2021). It provides an assessment to "identify likely material sustainability issues on an industry-by-industry basis" and is used to identify and compare disclosure topics across different industries and sectors. It addresses a company's ability to manage these risks through product design, manufacturing, and end-of-life management, such as by using recycled materials and renewable materials, reducing the use of key materials, and maximizing resource efficiency in manufacturing (SASB, 2021).

We sent emails to these 12 companies with the request for an interview with a project manager involved in the digital circular business model innovation at the company. Over 2 months 5 managers at 5 of these companies accepted our request (company A-E). To increase the amount of data collected and corroborate findings from the 5 companies, we decided to arrange 2 more interviews at service companies specialized in helping manufacturing companies adopt digital technologies to transition to a product-as-a-service model (company F-G). This resulted in 2 more interviews with 2 senior managers with extensive experience in managing digital circular business model innovation projects for multiple industrial manufacturing companies. Even if their (F and G) perspective might be biased by their commercial scope, their experience with multiple companies in the industrial manufacturing sector may help to validate other mangers' perspective.

Table 3 provides a systematic representation of those seven companies based on their revenue, industry, digital circular business model innovation, and interviewee's role. Furthermore, those companies have also been classified for the technological intensity and CE relevance/materiality of their industry (Fig. 1).

Data on the seven case studies were collected through a semi-structured interview with key informants. Table 3 provides an

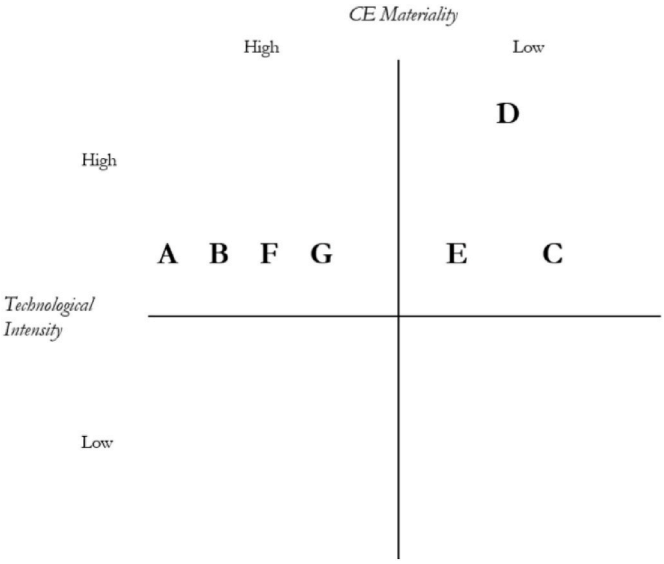

Fig. 1. Cases comparison matrix.

Table 3
An overview of the cases.

Company	Firm Size (revenue)	Industry	Main ways digital technology is used for CE	Interviewee role	Interview duration
A	600 MEUR	Industrial machinery	Produces milk robots and data systems for dairy farming. Provides information on resource efficiency through software applied to products.	Sustainability manager	51 m
B	10 MEUR	Industrial machinery	Produces fluid management solutions and industrial pumps. Smart products increase resource efficiency through predictive maintenance and increased process reliability.	Sales manager	61 m
C	10 MEUR	Engineering and construction	Produces entry gates. Smart products increase resource efficiency, extend product lifespan, and close material loops by enabling product as a service model.	Innovation manager	46 m
D	10 MEUR	Shared mobility	Operates a car-sharing fleet and application. Software increases resource efficiency, extends product lifespan, and closes material loops by enabling product as a service model.	Managing director	30 m
E	6.500 MEUR	Appliance manufacturing	Produces light systems. Smart products increase resource efficiency, extend product lifespan, and close material loops by enabling product as a service model.	Sustainability director	1 h
F	<2 MEUR	Industrial machinery	Project management for industrial manufacturing companies to transition to a service model through digital technologies.	Servitization manager	51 m
G	<2 MEUR	Industrial machinery	Manages supply chain solutions for industrial manufacturing companies through pay per use concepts and data management.	Supply chain manager	32 m

overview of the key informants interviewed in each case study. The interview guide used to conduct the semi-structured interviews can be found in appendix A. The interviews were divided in three parts described below.

1. The products and services offered and the adopted stock of Industry 4.0 technologies
2. How the adoption of Industry 4.0 technologies affects the resource flow and value creation
3. Identifying dynamic capabilities and their role in stimulating and supporting digital circular business model innovation.

Interviews were conducted online. Interviewees were informed and authorized the processing of personal data and the audio recording of their interviews. Interviewees were engaged in a free-flowing conversation on their experience with digital circular business model innovation to leverage an in-depth understanding of their meanings, beliefs, and perspective (Maruster, 2013).

The audio recordings of the seven interviews were transcribed and then analyzed following the steps outlined by the Gioia systemic inductive methodology for new concept development (Gioia et al., 2013). This is an iterative process based on multiple coding cycles in which the researcher merges and filters the emerging terms, themes, and dimensions to allow for more refined codes and, eventually, theoretical saturation (Saldaña, 2015; Gioia et al., 2013). We chose descriptive coding to analyse the data, summarising in a word or short phrase the basic topic of a passage of qualitative data (Saldaña, 2015). As the aim of this study is to objectively identify and describe the experiences of industry practitioners, descriptive coding is suitable. Our analysis has been supported by the software program ATLAS.ti, which allows for maintaining a codebook with registered codes and their relevant quotes and offers a tool to merge and group existing codes.

Two cycles of 1st order coding were conducted. These two cycles tried to adhere strictly to informant terms. The first cycle resulted in assigning 112 1st order codes to the data to describe the content. In the second cycle, by merging similar descriptions, this was brought down to 92. Next, the 92 1st order codes were grouped into 23 categories of 1st order terms based on similarities and differences. The 23 1st order terms were then divided over nine 2nd order themes. At this point, the analysis became more theoretical and the literature was also consulted to detect themes that might otherwise have gone unnoticed. Lastly, the themes were evaluated to fit the three categories of dynamic capabilities as defined in the literature: (1) sensing capabilities, (2) seizing capabilities, (3) transforming capabilities. Appendix B summarises the interrelations between the different coding cycles and provides an example of the coding process.

4. Results

Fig. 2 provides a systematized representation of the main results of our inductive analysis of the data collected in the seven interviews. Sensing opportunities for digital circular business model innovation are mainly associated with a focus on customer needs, market scanning, collaborative innovation, and internal knowledge generation. Seizing capabilities depend on IT project management, integration in the main business, supply chain collaboration, and strategic digital servitization. Finally, transforming capabilities requires a strategic orientation toward digital circular business model innovation.

4.1. Sensing capabilities

All interviewees pointed out customer orientation and the explicit focus on customers' needs as key dynamic capabilities to sense digital circular business model innovation opportunities. Initial consultation with customers allows companies to become aware of how digital technologies can be applied to offer circular solutions. As the innovation manager of company C claims *" I talked to clients about their experiences with using and maintaining our entry gates. […]. These customer consultations made me realize that we can create value with the remote maintenance of entry gates and with offering them as a service, all made possible by IoT."* Similarly, interviewees of companies F and E stress the importance of customer feedback. *"feedback data is enormously valuable to improve services and to accelerate and deepen your feedback cycle."* (Company F).

Many interviewees mentioned also the importance of market scanning. Company B highlights the importance of scanning competitor behavior in specific markets. *"If you look at businesses in Germany, actually all producers of industrial technology in our sector, they have all made the step towards Industry 4.0. That is how I got the idea of the circular possibilities that IoT can offer."* (Company B). Company A mentions the start-up market as a valuable source of information on new digital technologies for circular business model innovation. *"He [the start-up manager] screens the market for interesting start-ups developing relevant technology … often in the field of circularity because this is part of our business goals."* (Company A). Finally, company E calls attention to the need for a structured process to select and value opportunities. *"You need to screen the opportunities. […]. A structured process for identifying the demands in the market, then examining our potential solutions for those demands and the kind of business model we can implement to meet them. If it [the opportunity] is interesting enough you do it."* (Company E).

Collaboration is another dynamic capability interviewees consider critical for digital circular business model innovation. Company C and E underlined collaboration with research institutes. Company C collaborated with TNO (the Netherlands Organisation for applied scientific research) to develop a monitoring system to manage preventive maintenance on its product (a gate). Company E highlights the importance of partnering with the Ellen MacArthur Foundation to redesign its product according to the principles of the circular economy. Finally, company B mentioned the importance of initiating stakeholder meetings to develop a holistic perspective on technology as a source of digital circular business model innovation.

Finally, the internal generation of knowledge has been addressed as important to identify digital circular business model innovation opportunities. In this respect, some companies pointed out the importance of combining technical and business knowledge (Companies B and C). Other companies stressed the importance of instilling a diffused circular mindset in the company (Companies A and B). In doing this, top and C-level managers' commitment and example are critical (Company A). Company A also called attention to KPI. *"Having measurable circularity goals, such as our KPI's on reducing virgin inflow and reducing non-recyclable outflow, help promote a circular mindset … they provide a holistic frame in which employees are incentivized to contribute with ideas from their own work."* (Company A).

4.2. Seizing capability

One of the main issues that emerged in many interviews concerning seizing capability is the importance of IT project manager. This is because digital circular business model innovation implies an intrinsic conflict between the IT side and the business side. The IT side aims to develop technology that works. Differently, the business side is more concerned with technology that creates value. Finding the right alignment between those two perspectives is sometimes difficult. This is how the innovation manager of company C picture the result of this conflict: *"Our IoT software development went completely upside-down a number of times, likely because of the way we managed it."* Solving this problem requires aligning IT and business goals by undertaking a customer-centric approach (Company C and F). Furthermore, having a project manager with enough knowledge of business goals and technology development and enough experience with managing such complex and multidisciplinary projects may help out in finding an appropriate balance between those perspectives (Company C and F).

Furthermore, seizing digital circular business model innovation

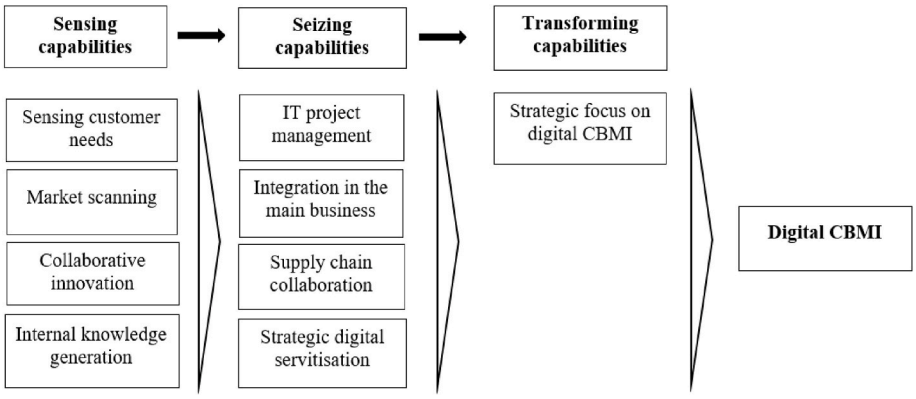

Fig. 2. Dynamic capabilities for digital circular business model innovation: a process model.

opportunities requires integrating those initiatives into the core business. To achieve this, it is important executives commit to those initiatives and constantly support their development. *"If the initiative is not carried by the C-level from the start, it is a waste of time. This is because, in the end, the interest of the core business always prevails so at some point the new initiative is going to perish."* (Company F). Senior managers should build a narrative around the importance of circularity for the future development of the company. *"Since this year the CEO often mentions circularity in his communications … engineers were previously enthusiastic about certain circular applications, but this year they felt the room to actually develop them. This is true for the majority of employees. People do the things they believe are expected from them."* (Company A). It is also important to allocate adequate resources to operationalize opportunities (Company G and B).

The development of digital circular business model innovation may suffer from the internal competition of the already established and functioning business model. To avoid this competition and support its integration into the core business of the company, interviewees strongly support the adoption of lean startup methodology. *"We always develop a new initiative using a lean start-up methodology in a separate incubator. The circular lighting initiative was also developed in this way."* (Company E). *"[…] the benefit of this methodology is that you can develop the initiative separate from the barriers of the status quo, from the processes present in the main business … in the form of MVPs it can then be made part of existing business processes"* (Company F). Furthermore, the introduction of digital circular business model innovation may drive change in the daily life of people working in the company (Company B and G). Therefore, to avoid resistance from those people, it is important that senior management identifies potential change barriers beforehand (Company F) and develop a change management strategy (Company B and G) that takes especially into account lower-level employees (Company G).

Among the most relevant activities in seizing digital circular business model innovation opportunities emerged is the redesign of information flow along the value chain (Kumar et al., 2018; Hong et al., 2018; Velter et al., 2022). Interviewees raised several relevant issues related to this activity. First, most ERP and CRM systems currently available in the market embody a linear view of the business. Therefore, the transition toward a more circular business model may often imply replacing those systems or making significant structural changes on their functioning. For instance, Company G suggests: *"You can't extract the data you need to realize a pay-per-use model in the industry."* Similarly, Company C argues that *"Pay-per-use or product-as-a-service cannot be dealt with in our ICT systems. The whole system needs to be replaced."* In particular, in B-to-B markets, switching to a product as a service[1] implies changing the relationship with your customers with the constant exchange of information between the information systems of the two companies. Therefore, *"in B2B markets you have to align ICT systems [of suppliers and clients]."* (Company B). Furthermore, data sharing in the B-to-B setting is also an issue that needs to be managed because it has significant strategic implications (Company G). The institution of cross-functional teams involving all the partners in the supply chain is highly recommended to appropriately manage all those issues. This is in line with what Velter et al., 2022 state about boundary management in a multi-stakeholder sustainable business model innovation.

Finally, many interviewees focused on the specific capabilities required to seize the opportunities associated with a particular business model: servitization (Kohtamäki et al., 2022; George et al., 2021; Bocken et al., 2016). This model, as we already pointed out, changes the nature of the relationship with customers and the nature of the competencies required to supply a high-quality service. Interviewees identify the following issues as relevant for seizing the business opportunities associated with this model. First, the scalability of the data infrastructure and the back-end (Company F). Second, the importance of training people in customer service on data management to offer efficient remote and predictive maintenance (Company B, C, and F). In this regard, a valuable solution is to rely on the training support offered by technological partners (Company B, C, and F). Servitization implies also a change in salespersons' capabilities (Company, E and F). Salespersons should be more involved with the customer and support them in realizing their value proposition. To this end, fee-based incentive schemes are strongly recommended to realize the shift in sales capabilities (Company, F).

4.3. Transforming capabilities

To prepare the company for ongoing digital circular business model innovation, a theme that emerged from the interviews was defining a long-term digital circular business model innovation vision. Defining such a vision provides a direction for innovation and helps companies prepare to mobilize the resources needed to seize future digital circular business model innovation initiatives. As a supply chain consultant put it:

"*Frontrunners have more of a vision [on digital technologies for circularity], they define future goals and invest more resources now to achieve them … and they also monitor what resources they might need in the future*" (Company G).

Elaborating on the need for a long-term perspective in digital circular business model innovation visions, interviewees emphasize that preparing the company to seize future digital circular business model innovation opportunities may require high up-front investments. A sustainability director emphasized the importance of investments in innovation:

"*Fundamental business model changes, like circular lighting was, take*

[1] For a recent review on how the intersection between digital technologies and servitization has evolved see Kohtamäki et al. (2022).

years to realize … you need a high innovation budget for that. We spend a lot more on innovation than the 2nd player in the market.'' (Company E).

Another up-front investment that interviewees mentioned as crucial for seizing future digital circular business model innovation opportunities, is replacing legacy ICT with ERP and CRM systems compatible with data-driven circular business models. As a supply chain consultant put it:

'' Companies that think short-term are less involved with data based circular business models. That is because it requires significant short-term investments. Correctly implementing ERP systems is expensive and requires consulting with a big team. They affect everything in the company, so it has to go right.'' (Company G).

5. Discussion

In this study, we explore the role of dynamic capabilities in digital circular business model innovation. The literature review highlights the existence of literature showing the importance of dynamic capabilities in fostering business model innovation driven by digital technologies or sustainable development. What is missing is an understanding of how those dynamic capabilities come together and are recombined in the development of projects aiming at enhancing sustainability through the adoption of digital technologies (de Sousa Jabbour et al., 2018). In this regard, our analysis highlights the prevalence of a summation logic. Therefore, the dynamic capabilities leveraged have been developed either in one of the two domains – digitalization or sustainable business model innovation – or were already in common between the two. However, areas of recombination between dynamic capabilities are also identifiable.

Several of the dynamic capabilities leveraged are in common between the two domains. The development of innovative business models requires the capacity to re-design the business scope of firms (Baldassarre et al., 2020). In this respect, the literature on sustainable business model innovation highlights the importance of placing the strategic focus on sustainability as a precondition for both sensing business opportunities associated with sustainability, reinterpreting and changing the overall dynamics underlying the functioning and development of the business models, and engendering the managerial support and commitment to integrate circularity in the core business of a company (Bocken and Geradts, 2020). Similarly, the literature on digital business model innovation highlights how those technologies drastically change the boundaries between sectors, the relationships with customers and suppliers along the value chain, and indeed the scope of the firm (Cennamo et al., 2020). Only by taking a strategic perspective on the role of those technologies is possible to trigger off a systemic change in the dynamic underpinning the development of firms' business model. Our results highlight that also in projects binding together sustainability and digitalization, the importance of this dynamic capability is strengthened providing companies with direction in innovation and the commitment required to bear the high upfront cost involved in seizing the value of digital circular business model innovation. Those issues are critical to shaping and sustaining firms' transformative capabilities and leveraging continuous digital circular model innovation.

Proposition 1. *The capacity to re-design the business scope of firms to include the combined effect of digitalization and sustainability as a key source of opportunities and competitive advantage is a requirement for circular digital business model innovation. It enhances sensing (H_{1a}) and transformative (H_{1b}) capabilities associated with circular digital business model innovation.*

Other dynamic capabilities in common between sustainable and digital business model innovation are customer orientation and collaboration. Collaboration plays a key role in this perspective (Pieroni et al., 2021). On the one hand, collaborating with customers is important both to sense and seize digital circular business model innovation opportunities. Collaborating with customers may turn critical to redesign products and supply chains to improve, at the same time, the overall quality and environmental efficiency of the product/service offered. However, maintaining a customer orientation is also important to prevent digital circular business model innovation from deviating from business and sustainability goals (Wang, 2020). On the other hand, collaboration with suppliers is critical to seize digital circular business model innovation (Kumar et al., 2018). Finally, it is equally relevant to leverage the competencies of external research partners and stakeholders in the phase of product/service design.

The development of collaborative dynamic capabilities is especially relevant for sustaining the transition toward sustainable supply chains (Hong et al., 2018; Kumar et al., 2018). The transition toward digitally-based circular business models triggers off a process of radical change in the internal and external organization of the value chain (Velter et al., 2022). Supply chain dynamic capabilities, such as collaboration with external stakeholders, have been already found relevant in leveraging the transformation of sustainable supply chain practices into superior sustainable performance (Hong et al., 2018). Furthermore, implementing CBM implies completely redesigning the flow of information along the value chain. It requires renegotiating data sharing and integration between ERP systems along the value chain. As suggested by Kumar et al. (2018), achieving such objectives requires leveraging on supply chain and collaborative dynamic capabilities and renegotiating boundaries along the value chain (Velter et al., 2022).

Proposition 2. *Supply-chain collaborative capabilities are critical for circular digital sustainable business model innovation. (H2a)Customer orientation and collaboration is critical to sense and seize circular digital business model innovation. (H2b)Supply chain collaboration capabilities are critical to seize circular digital business model innovation and transforming the supply chain accordingly*.

However, there are dynamic capabilities that are specific to one of the two domains. For instance, this is the case of IT project management. The transition toward digital circular business model innovation radically changes the business principles underlying the design of information systems and ERP systems in place (Ranta et al., 2021). This implies replacing existing information systems and/or integrating new modules meant to support new functionalities. In this perspective, the case of servitization is exemplary. It requires a radical change in CRM, the structure of the revenue stream, and data sharing with customers. Being able to manage such complexity requires holding significant IT project management capabilities to support collaboration between a large number of actors holding a wide variety of competencies and often conflictual objectives.

Proposition 3. *IT project management capabilities are critical to support the transformation in seizing circular digital business model innovation.*

Finally, there are areas of contamination and recombination in which dynamic capabilities coming from the two different fields are bridging together potentially giving rise to new forms of dynamic capabilities. This is the case of lean and agile methodologies to support digital and circular business model innovation. The concept of lean originated in field operations and supply chain management. It was mainly associated with the concepts of total quality and zero inventory. Lean production was already strongly intertwined with the domains of informatization and sustainability. On the one hand, it implied a reorganization and informatization of the flows of information along the supply chain. On the other hand, total quality and zero inventory already implied a significant reduction in the consumption of materials and the risk of failure in products and components. Finally, lean management is also associated with learning organization and indeed with a more sustainable approach to the management of human resources and stakeholders (Mohaghegh et al., 2021).

There are already studies looking at the relationship between lean management practices and sustainability with controversial results. Even if those studies are mainly focused on operations and supply chain

management, the most recent ones point to the key role of dynamic capabilities in turning lean management practices into sustainable competitive advantage based on sustainability. More specifically, in a recent paper, Mohaghegh et al. (2021) highlight that the capacity to transform lean management practices into superior sustainable performance depends on the moderating role of systematic problem-solving, agile manufacturing, and continuous improvement as specific second-order or dynamic capabilities.

The application of lean management principles has been extended to other processes. The management of innovative projects, the start-up of new companies, and the transformation of existing companies are among the most notable applications of lean principles to other business and organizational domains(Weissbrod and Bocken, 2017; Camuffo et al., 2020; Felin et al., 2019). In this respect, lean management is intended as a customer-oriented process of value co-creation based on the rapid, continuous collection of data to scientifically validate the hypotheses underlying an under-construction value proposition (Fellin et al., 2020). This methodology is already applied in the development of sustainable business model innovation (Weissbrod and Bocken, 2017). Even if the importance of dynamic capabilities in leveraging the capacity of firms to prototype their sustainable business model innovation (Weissbrod and Bocken, 2017) and, in so doing, also create a convergence between stakeholders' intentions has already been pointed out, most of the research has so far focused on the co-design of tools helping firms to implement this methodology (Baldassarre et al., 2020; Velter et al., 2022).

In this respect, our study highlights the adoption of lean start-up methodologies and competencies may significantly contribute to increasing the chance of success of digital circular business model innovation (Bocken and Snihur, 2020). More specifically, we highlight how this experimental approach contributes to lower down the initial resistance to change. Furthermore, the adoption of a lean startup methodology helps companies to increase their commitment to the project and support the integration of the new business model based on the results achieved through a process of continuous improvements triggered by the release of new and updated MVPs.

Proposition 4. *The adoption of lean practices strengthens the capacity of firms to seize circular digital business model innovation opportunities and transform the business model accordingly*

This paper also suffers from some limitations, which can be the starting point for future research studies. First, while the qualitative multiple case study is a promising methodology for exploring emerging topics, it must be noted that case study data might not be as transferrable as with other methodologies. To benefit the transferability of the findings, appendix C provides a detailed description of the 7 companies interviewed. It is important to note here that companies F and G are service providers supporting companies such as A-E in the process of digital circular business model innovation. While the extensive experience and expertise of interviewees F and G in managing digital circular business model innovation for manufacturing companies benefits the amount of data that the interviews produced, a limitation is that interviewees F and G can be commercially biased to advocate for the use of digital technologies in the transition to a circular business model. Therefore, given the varied and limited nature of data collected from the interviews further research is needed to test the inductive hypotheses made in this paper.

Second, we did not account for the specific CE business model implemented. However, there are different types of circular business models (Lüdeke-Freund et al., 2019) each requiring specific dynamic capabilities to be executed (Hart, 1995). Most of the interviewed companies implemented a servitization-like business model based on "repair and maintenance'' and "reuse and distribution''. Future research is recommended to investigate if the dynamic capabilities identified in this research are more important in the transition to some types of circular business models than others.

Third, we did not account for the nature (incremental versus radical) and degree of circular business model innovation (Ranta et al., 2021). There is a vast literature showing that the role of resources and capabilities changes with the nature of business model innovation (Demil and Lecocq, 2010). However, there is no evidence showing whether the dynamic capabilities executed are the same in the case of radical and incremental digital circular business model innovation. Therefore, further research is required in this direction. Third, our case studies are of companies in high-tech industries. Therefore, those companies may have developed a stronger attitude to deal with continuous and radical change and a greater capability to manage innovation and change both within and between organizations. Further research is still required to see whether our finding still holds in the case of companies in low-tech industries. For instance, we might expect those companies to be more dependent on external competencies and partners to sense and seize digital circular business model innovation opportunities. Finally, further research is required to investigate to what extent the presence of the identified dynamic capabilities leads to environmental and financial benefits when executing digital circular business model inovation initiatives.

6. Conclusion

The aim of this research was to understand the dynamic capabilities that support companies in circular business model innovation underpinned by Industry 4.0 technologies. In doing so, this study responds to calls in the literature for empirical research into the role of digital technologies in circular business model innovation from an organizational capabilities perspective (Rosa et al., 2020; de Sousa Jabbour et al., 2018). Drawing on seven semi-structured interviews with managers involved in circular business model innovation underpinned by Industry 4.0 technologies, the findings reveal nine dynamic capabilities and their microfoundations that support companies in leveraging the potential of Industry 4.0 technologies in the transition to more circular business models. The findings present new insights for the literature on organizational capabilities and circular business model innovation and a process model provides guidance for companies aiming to transition to circular business models with the help of digital technologies.

To advance this work, future quantitative research could prioritize the identified dynamic capabilities by measuring their environmental and financial contributions to the outcomes of circular business model innovation. Future research could also explore how dynamic capabilities change in the context of different types of circular business model innovation and digital technologies. Further studies are also needed to determine the role of the Lean Startup method in developing and implementing circular business models. Lastly, the field of circular business model innovation could also benefit from more research into the determining factors for companies to engage in circular business model innovation per industry.

All in all, this research on circular business model innovation, Industry 4.0 technologies and dynamic capabilities provides practitioners with a valuable framework for capability-building and a fruitful agenda for future research to guide companies in their transitions to circular business models.

CRediT authorship contribution statement

Thomas van Eechoud: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing. **Andrea Ganzaroli:** Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence

the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A

Table A
Semi-structured interview guide

Part	Themes	Questionnaire
1	General company information Type of Industry 4.0 technologies adopted	What industry is the company in? What is the size of the company? What products and services does the company provide? What is the customer group of the company? Which Industry 4.0 technologies has the company adopted?
2	Impact of Industry 4.0 technologies on the resource flow, Impact of Industry 4.0 technologies on the economic value creation	How does the adopted technology affect the resource flows of the company? For example, can effects be seen in: • Narrowing resource flows (i.e. using fewer resources per product/service) • Slowing resource flows (i.e. longer use of resources per product/service) • Closing resource flows (i.e. returning resources used in product/service after use) How can the firm benefit financially from the changes in resource flows? What circular product/service is supported by the adopted technology?
3	Identify the dynamic capabilities that contribute to improving resource flows with the help of digital technologies Identify how these dynamic capabilities contribute to improving resource flows with the help of digital technologies Reflecting on capabilities mentioned by other interviewees	**Sensing capabilities – how/what/how** How did the company become aware of the opportunity to use the digital technology for offering a circular product/service? What capabilities, activities and processes contributed to this awareness? How did these capabilities, activities and processes contribute to this awareness? **Seizing capabilities – how/what/how** How did the company create the identified opportunity into a product/service? What capabilities, activities and processes contributed to the opportunity becoming part of the business? How did these capabilities, activities and processes contribute to the opportunity becoming part of the business? **Transforming capabilities -how/what/how** How did the company change its existing capabilities, activities and processes to sense the opportunity and turn it into a product/service? What capabilities, activities and processes allow the company to remain flexible in the long term to change its established capabilities, activities and processes? How did these capabilities, activities and processes contribute to changing existing capabilities at the company?

Appendix B

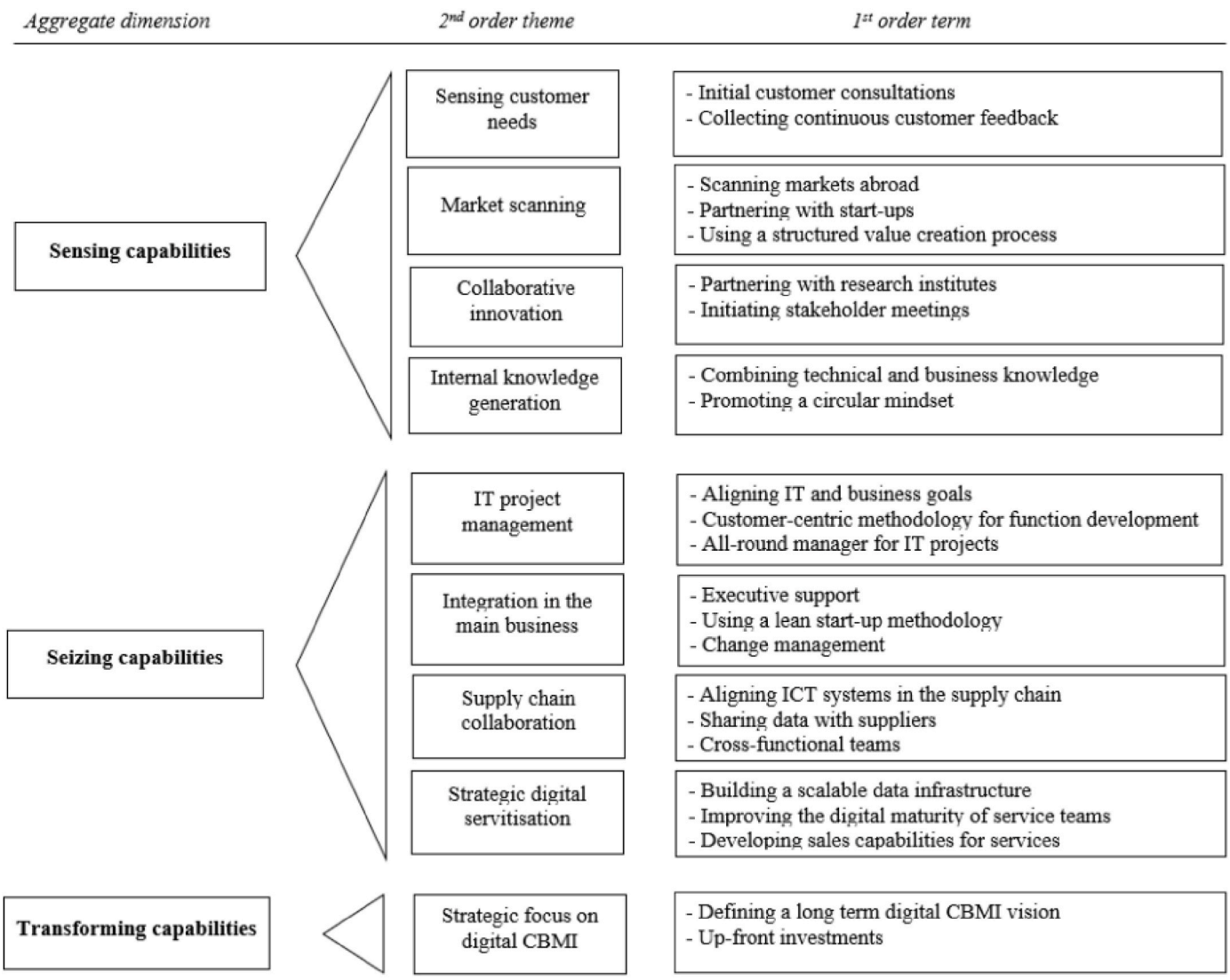

Fig. B. Overview of the data structure

Table B
Example of the coding process
Please find below the 2nd order theme of sensing customer needs as an example of the coding process:

Aggregate dimension	*2nd order theme*	*1st order term*	*1st order code*
Sensing capabilities	Sensing customer needs	Initial customer consultation (1,2)	1. Customer consultation to find business opportunities of digital technologies
		Collecting continuous customer feedback (3,4)	2. Personal conversations with customers for new product development
			3. Customer feedback to improve service
			4. Organisational structures for collecting customer feedback

After two 1st order cycles of coding in ATLAS.ti, 92 1st order codes were arranged into 23 groups of 1st order terms based on similarities and differences. At first, the 1st order codes Customer consultation to find business opportunities of digital technologies, Personal conversations with customers for new product development, Customer feedback to improve service and Organisational structures for collecting customer feedback were grouped together based on their shared characteristic of contact with customers. Later, the 1st order codes were divided based on their temporal aspect; those relating to customer contact before a digital CBMI initiative (Initial customer consultation) and those relating to customer contact during the operational phase of an existing digital CBMI initiative (Collecting continuous customer feedback). Then, as both 1st order terms relate to discovering new or improving existing business opportunities through understanding customer needs, they were brought together in the 2nd order theme sensing customer needs and ultimately the aggregate dimension Sensing capabilities.

Appendix C

Table C
Description of the case studies

Case study	Description
Company A	Makes use of Big Data and AI to make Life Cycle Assessments of the dairy machinery it produces. These Life Cycle Assessments provide detailed insight in the environmental impact of its products throughout their lifetime. By enabling targeted interventions that minimise the environmental impact of products and maximise resource efficiency, Big Data and AI help implement the CE strategy of narrowing resource flows.
Company B	Applies IoT technology to the industrial pumps it produces. Collected usage data is then stored and analyzed using Cloud Technologies so that clients can optimise the resource efficiency of their batches, supporting the CE strategy of narrowing resource flows. The collected usage data also allows for condition based and preventive maintenance which extends product lifespan, thereby contributing to the CE strategy of slowing resource flows.
Company C	Applies IoT technology to the entry gates it produces and stores the collected data using Cloud technologies. The ability to monitor their products in real time paved the way for the company to keep ownership of the entry gates and offer them to customers as a service. The product-as-a-service business model allows the company to keep products in use longer and return them at the end of product lifetimes, supports the CE strategies of closing and slowing resource flows.
Company D	Makes use of IoT technology to collect usage data on the vehicles in its car-sharing fleet. Cloud Technologies are used to store and analyse collected usage data. The real time monitoring of the vehicles is the driving factor behind the car sharing business model. As a form of the product-as-a-service business model, it supports the CE strategies of closing and slowing resource flows by keeping products in use longer and returning them after product lifetimes.
Company E	Applies IoT technology to light systems and uses Cloud Technologies to collect usage data and to offer additional data-based services. Again both technologies are key enablers of the product-as-a-service business model behind the circular offering of their light systems. As ownership of the light systems installed at clients remains with the company, it supports the CE strategies of closing and slowing resource flows by keeping products in use longer and returning them after product lifetimes.
Company F	Project management for industrial manufacturing companies to transition to a service model by adopting digital technology. Discussed the case of a manufacturer of industrial irrigation equipment using IoT technology to offer remote maintenance services.
Company G	Manages supply chain solutions for industrial manufacturing companies through pay per use concepts and data management. Discussed the case of a manufacturer of industrial equipment making use of IoT technology and Big Data to track and analyse its products, thereby enabling a pay per use model.

References

Adam, M., Strähle, J., Freise, M., 2018. Dynamic capabilities of early-stage firms: exploring the business of renting fashion. J. Small Bus. Strategy. 28 (2), 49–67.

Baldassarre, B., Schepers, M., Bocken, N., Cuppen, E., Korevaar, G., Calabretta, G., 2019. Industrial Symbiosis: towards a design process for eco-industrial clusters by integrating Circular Economy and Industrial Ecology perspectives. J. Clean. Prod. 216, 446–460.

Bocken, N., Strupeit, L., Whalen, K., Nußholz, J., 2019. A review and evaluation of circular business model innovation tools. Sustainability 11 (8), 2210.

Bocken, N.M., Geradts, T.H., 2020. Barriers and drivers to sustainable business model innovation: organization design and dynamic capabilities. Long. Range Plan. 53 (4), 101950.

Bocken, N.M., De Pauw, I., Bakker, C., Van Der Grinten, B., 2016. Product design and business model strategies for a circular economy. J. Indust. Product. Eng. 33 (5), 308–320.

Bocken, N., Snihur, Y., 2020. Lean Startup and the business model: experimenting for novelty and impact. Long. Range Plan. 53 (4), 101953.

Bressanelli, G., Adrodegari, F., Perona, M., Saccani, N., 2018. Exploring how usage-focused business models enable circular economy through digital technologies. Sustainability 10 (3), 639.

Camuffo, A., Cordova, A., Gambardella, A., Spina, C., 2020. A scientific approach to entrepreneurial decision making: evidence from a randomized control trial. Manag. Sci. 66 (2), 564–586.

Cennamo, C., Dagnino, G.B., Di Minin, A., Lanzolla, G., 2020. Managing digital transformation: scope of transformation and modalities of value Co-generation and delivery. Calif. Manag. Rev. 62 (4), 5–16.

Chirumalla, K., 2021. Building Digitally-Enabled Process Innovation in the Process Industries: A Dynamic Capabilities Approach. Technovation, 102256.

Coreynen, W., Matthyssens, P., Vanderstraeten, J., van Witteloostuijn, A., 2020. Unravelling the internal and external drivers of digital servitization: a dynamic capabilities and contingency perspective on firm strategy. Ind. Market. Manag. 89, 265–277.

de Sousa Jabbour, A.B.L., Luiz, J.V.R., Luiz, O.R., Jabbour, C.J.C., Ndubisi, N.O., de Oliveira, J.H.C., Junior, F.H., 2019. Circular economy business models and operations management. J. Clean. Prod. 235, 1525–1539.

de Sousa Jabbour, A.B.L., Jabbour, C.J.C., Godinho Filho, M., Roubaud, D., 2018. Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations. Ann. Oper. Res. 270 (1), 273–286.

Demil, B., Lecocq, X., 2010. Business model evolution. In search of dynamic consistency. Long. Range Plan. 43 (2–3), 227–246.

Devers, K., Frankel, R., 2000. Study design in qualitative research—2: sampling and data collection strategies. Educ. Health 13 (2), 263–271.

Diaz Lopez, F.J., Bastein, T., Tukker, A., 2019. Business model innovation for resourceefficiency, circularity and cleaner production: what 143 cases tell us. Ecol. Econ. 155, 20–35. https://doi.org/10.1016/j.ecolecon.2018.03.009.

Felin, T., Gambardella, A., Stern, S., Zenger, T., 2019. Lean startup and the business model: experimentation revisited. Long. Range Plan. 53, 1–6.

George, G., Merrill, R.K., Schillebeeckx, S.J., 2021. Digital sustainability and entrepreneurship: how digital innovations are helping tackle climate change and sustainable development. Enterpren. Theor. Pract. 45 (5), 999–1027.

Gioia, D.A., Corley, K.G., Hamilton, A.L., 2013. Seeking qualitative rigor in inductive research: notes on the Gioia methodology. Organ. Res. Methods 16 (1), 15–31.

Hart, S.L., 1995. A natural-resource-based view of the firm. Acad. Manag. Rev. 20 (4), 986–1014.

Helfat, C.E., Peteraf, M.A., 2015. Managerial cognitive capabilities and the microfoundations of dynamic capabilities. Strat. Manag. J. 36 (6), 831–850.

Hellemans, I., Porter, A.J., Diriker, D., 2022. Harnessing digitalization for sustainable development: understanding how interactions on sustainability-oriented digital platforms manage tensions and paradoxes. Bus. Strat. Environ. 31 (2), 668–683.

Hong, J., Zhang, Y., Ding, M., 2018. Sustainable supply chain management practices, supply chain dynamic capabilities, and enterprise performance. J. Clean. Prod. 172, 3508–3519.

Ingemarsdotter, E., Jamsin, E., Balkenende, R., 2020. Opportunities and challenges in IoT-enabled circular business model implementation–A case study. Resour. Conserv. Recycl. 162, 105047.

Inigo, E.A., Albareda, L., Ritala, P., 2017. Business model innovation for sustainability: exploring evolutionary and radical approaches through dynamic capabilities. Ind. Innovat. 24 (5), 515–542.

Kanninen, T., Penttinen, E., Tinnilä, M., Kaario, K., 2017. Exploring the dynamic capabilities required for servitization. Bus. Process Manag. J. 23 (2), 226–247.

Kohtamäki, M., Rabetino, R., Parida, V., Sjödin, D., Henneberg, S., 2022. Managing digital servitization toward smart solutions: framing the connections between technologies, business models, and ecosystems. Ind. Market. Manag. 105, 253–267.

Kumar, G., Subramanian, N., Arputham, R.M., 2018. Missing link between sustainability collaborative strategy and supply chain performance: role of dynamic capability. Int. J. Prod. Econ. 203, 96–109.

Li, J., Wu, F., Li, Y., 2017. Dynamic capabilities and digital business model innovation: a moderated mediation model. J. Bus. Res. 70, 51–60.

Lüdeke-Freund, F., Gold, S., Bocken, N.M., 2019. A review and typology of circular economy business model patterns. J. Ind. Ecol. 23 (1), 36–61.

Maruster, L. (Ed.), 2013. Qualitative Research Methods. Sage.

Matarazzo, M., Penco, L., Profumo, G., Quaglia, R., 2021. Digital transformation and customer value creation in Made in Italy SMEs: a dynamic capabilities perspective. J. Bus. Res. 123, 642–656.

Mikalef, P., Boura, M., Lekakos, G., Krogstie, J., 2019. Big data analytics capabilities and innovation: the mediating role of dynamic capabilities and moderating effect of the environment. Br. J. Manag. 30 (2), 272–298.

Mohaghegh, M., Blasi, S., Groessler, A., 2021. Dynamic capabilities linking lean practices and sustainable business performance. J. Clean. Prod. 322, 129073.

Nascimento, D.L.M., Alencastro, V., Quelhas, O.L.G., Caiado, R.G.G., Garza-Reyes, J.A., Lona, L.R., Tortorella, G., 2018. Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context: a business model proposal. J. Manuf. Technol. Manag. https://doi.org/10.1108/JMTM-03-2018-0071.

Oyon, D., Martín-Rojas, R., Gómez-Sánchez, E., 2019. Dynamic capabilities in digital business model innovation: an exploratory study. J. Manag. Inf. Syst. 36 (2), 515–547.

Osterwalder, A., Pigneur, Y., 2010. Business Model Generation: a Handbook for Visionaries, Game Changers, and Challengers, 1. John Wiley & Sons.

Pagoropoulos, A., Pigosso, D.C., McAloone, T.C., 2017. The emergent role of digital technologies in the Circular Economy: a review. Procedia CIRP 64, 19–24.

Palmié, M., Miehé, L., Oghazi, P., Parida, V., Wincent, J., 2022. The evolution of the digital service ecosystem and digital business model innovation in retail: the emergence of meta-ecosystems and the value of physical interactions. Technol. Forecast. Soc. Change 177, 121496.

Pieroni, M.P., McAloone, T.C., Pigosso, D.C., 2021. Circular economy business model innovation: sectorial patterns within manufacturing companies. J. Clean. Prod. 286, 124921.
Ranta, V., Aarikka-Stenroos, L., Väisänen, J.M., 2021. Digital technologies catalyzing business model innovation for circular economy—multiple case study. Resour. Conserv. Recycl. 164, 105155.
Saldaña, J., 2015. The Coding Manual for Qualitative Researchers. Sage.
Sandberg, E., Hultberg, E., 2021. Dynamic capabilities for the scaling of circular business model initiatives in the fashion industry. J. Clean. Prod. 320, 128831.
Santa-Maria, T., Vermeulen, W.J., Baumgartner, R.J., 2022. How do incumbent firms innovate their business models for the circular economy? Identifying micro-foundations of dynamic capabilities. Bus. Strat. Environ. 31 (4), 1308–1333.
Scarpellini, S., Valero-Gil, J., Moneva, J.M., Andreaus, M., 2020. Environmental management capabilities for a "circular eco-innovation". Bus. Strat. Environ. 29 (5), 1850–1864.
Soluk, J., Kammerlander, N., 2021. Digital transformation in family-owned Mittelstand firms: a dynamic capabilities perspective. Eur. J. Inf. Syst. 1–36.
Sousa-Zomer, T.T., Neely, A., Martinez, V., 2020. Digital transforming capability and performance: a microfoundational perspective. Int. J. Oper. Prod. Manag. 40 (7/8), 1095–1128.
Teece, D.J., 2020. Hand in glove: open innovation and the dynamic capabilities framework. Strategic Management Review 1 (2), 233–253.
Teece, D.J., 2018. Business models and dynamic capabilities. Long. Range Plan. 51 (1), 40–49.
Teece, D.J., 2016. Dynamic capabilities and entrepreneurial management in large organizations: toward a theory of the (entrepreneurial) firm. Eur. Econ. Rev. 86, 202–216.
Teece, D.J., 2007. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. Strat. Manag. J. 28 (13), 1319–1350.
Tortora, D., Chierici, R., Briamonte, M.F., Tiscini, R., 2021. 'I digitize so I exist'. Searching for critical capabilities affecting firms' digital innovation. J. Bus. Res. 129, 193–204.
Uçar, E., Le Dain, M.A., Joly, I., 2020. Digital technologies in circular economy transition: evidence from case studies. Procedia CIRP 90, 133–136.
Wamba, S.F., Gunasekaran, A., Akter, S., Ren, S.J.F., Dubey, R., Childe, S.J., 2017. Big data analytics and firm performance: effects of dynamic capabilities. J. Bus. Res. 70, 356–365.
Wang, C.H., 2020. An environmental perspective extends market orientation: green innovation sustainability. Bus. Strat. Environ. 29 (8), 3123–3134.
Warner, K.S., Wäger, M., 2019. Building dynamic capabilities for digital transformation: an ongoing process of strategic renewal. Long. Range Plan. 52 (3), 326–349.
Weissbrod, I., Bocken, N.M., 2017. Developing sustainable business experimentation capability–A case study. J. Clean. Prod. 142, 2663–2676.
Westerman, G., Bonnet, D., McAfee, A., 2012. The digital capabilities your company needs. MIT Sloan Manag. Rev. 1–5.
Zott, C., Amit, R., Massa, L., 2011. The business model: recent developments and future research. J. Manag. 37 (4), 1019–1042.