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RESEARCH ARTICLE

Investigating digital technologies' implementation in circular businesses: Evidence from the going circular path

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Abstract
This research aims to unpack how digital technologies can facilitate the flourishing of circular business practices in small- and medium-sized enterprises by structuring a detailed *going circular path* that explains businesses' evolution toward circularity. In doing so, it outlines how the observed organizations have adopted – or are adopting – circular economy principles thanks to business digitalization. Following an inductive approach based on a multiple case study methodology, we investigated 16 small- and medium-sized enterprises operating in industries that put considerable pressure on the environment (e.g., manufacturing, chemical, construction, fashion, food, and beverage). Our findings confirm how digital technologies, as well as Industry 4.0 structures, play a fundamental role in *shaping, enabling, enhancing*, and *refining* circular products and processes development. Accordingly, we outline a generalizable step-by-step process to pursue circular economy by employing digital technologies. The present study represents a practical handout for guiding companies through their going circular path.

Keywords: circular economy; circular business model; digitalization; Industry 4.0; digital technologies; SMEs; going circular path

Introduction

The grand challenges to achieving a sustainable future encompass complex and interconnected issues that pose significant obstacles to businesses. These challenges often require global cooperation, interdisciplinary approaches, and innovative solutions to deal with climate change, carbon neutrality, biodiversity loss, sustainable resource and waste management, environment conservation, food security and sustainable agriculture, and people's health and well-being (Dzhengiz, Miller, Ovaska, & Patala, 2023; Howard-Grenville, Davis, Dyllick, Miller, Thau, & Tsui, 2019; Popkova, De Bernardi, Tyurina, & Sergi, 2022; United Nations, 2021). In pursuing a renewable production and consumption system, the circular economy (CE) approach has prompted considerable debate among researchers and practitioners about the fundamental role of businesses in driving environmental preservation and social well-being. It falls among the strategic initiatives that economic organizations can implement to promote corporate sustainability according to the broader economic, environmental, and social interpretation of the triple bottom line suggested by Elkington and Rowlands (1999). More specifically, CE in business management refers to the adoption of practices aimed at maximizing the efficient use of resources, minimizing waste and pollution, and supporting the regeneration of the natural environment (Antikainen & Valkokari, 2016; Centobelli, Cerchione, Chiaroni, Del Vecchio, & Urbinati, 2020; Ellen MacArthur Foundation, 2013; Salvador, Barros, da Luz, Piekarski, & de Francisco, 2020).

The sustainability challenge has increasingly seen the commitment of businesses and consumers (Frey, Bar Am, Doshi, Malik, & Noble, 2023; KPMG, 2020; McKinsey & Company, 2022; Winston, 2022). Indeed, more and more companies are gradually translating their sustainability goals into business practices by giving rise to circular business models (CBMs), yet the harsh reality proves that what has been done is not enough (Aranda-Usón, Portillo-Tarragona, Scarpellini, & Llena-Macarulla, 2020; Bocken, De Pauw, Bakker, & Van Der Grinten, 2016; Geissdoerfer, Pieroni, Pigosso, & Soufani, 2020; Ranta, Aarikka-Stenroos, & Mäkinen, 2018). Despite the visible effort of policymakers, academics, and managers, the world's economy is currently just 7.2% circular and, while this value is supposed to double by 2032 to avoid climate breakdown, it has even decreased in recent years. It means the global economy is still heavily relying on virgin materials extracted from the environment (Circle Economy, 2023; European Commission, 2020a; Pizzi, Caputo, Corvino, & Venturelli, 2020; United Nations, 2021). Although companies around the world are taking their first steps toward a regenerative production system, there is still a long and impervious road ahead. Countless challenges and opportunities stand in front of academia and businesses, including the chance to boost this sustainable shift by surfing the wave of digital transformation.

Among other drivers, the literature has highlighted digital transformation as having a critical role in supporting business sustainability and, more specifically, circularity (Biondi, Iraldo, & Meredith, 2002; Hina, Chauhan, Kaur, Kraus, & Dhir, 2022; Khan, Razzaq, Yu, & Miller, 2021; Kristoffersen, Blomsma, Mikalef, & Li, 2020; Liu, Trevisan, Yang, & Mascarenhas, 2022; Popkova et al., 2022). Digital technologies have proved to be crucial for transitioning from a linear to a more circular production, with demonstrably positive impacts on both the environment and the economy (European Commission, 2021; Pizzi, Corbo, & Caputo, 2021; Ranta, Aarikka-Stenroos, & Väisänen, 2021). Digital technologies can support companies in going circular by transforming CE principles into feasible activities (Chauhan, Parida, & Dhir, 2022; European Commission, 2023; Kerin & Pham, 2019; Pizzi, Leopizzi, & Caputo, 2021; Rusch, Schöggl, & Baumgartner, 2022). In practice, digital platforms can facilitate the exchange of resources, materials, and waste, enabling circular businesses to find new avenues for reuse, recovery, remanufacture, or recycling (Chauhan, Parida, & Dhir, 2022; Pizzi, Leopizzi, & Caputo, 2021). The Internet of Things (IoT) and sensor technologies for process monitoring, alongside additive manufacturing, work to improve resource efficiency while reducing negative externalities related to production and consumption activities (Centobelli et al., 2020; Gebhardt, Kopyto, Birkel, & Hartmann, 2022; Kerin & Pham, 2019). In addition, big data analytics and artificial intelligence (AI) provide insights into lifecycle assessments and support decision-making in circular businesses, analyzing large data sets filled with information related to material inputs, energy consumption, emissions, and waste generation (Bag, Pretorius, Gupta, & Dwivedi, 2021; Liu et al., 2022). Looking at the virtuous examples of well-known companies, the furniture retailer IKEA has embraced digital technologies to support circularity by launching its "Sell-Back Program," which enables customers to sell their used IKEA furniture back to the company in order for it to be refurbished and resold as second-hand items, thereby promoting resource efficiency and waste reduction (IKEA, 2023). Intuitively, the interplay of digitization and CE can also be observed in platform businesses such as Too Good To Go. This digital platform operating in several European countries aims to reduce food waste by connecting end consumers with restaurants, grocery stores, and food suppliers that offer surplus food at discounted prices before it goes to waste (Too Good To Go, 2022; Vo-Thanh et al., 2021). The Italian multinational energy company Enel also offers an inspiring perspective on how to implement digital solutions to optimize energy management and support renewable energy integration. Thanks to advanced data analytics and IoT technologies, the company can monitor and control energy consumption, improve grid efficiency, and enable the integration of renewable energy sources into the power system (Enel, 2023).

As the establishment of circular practices represent a disruptive change in production and consumption models, this process (supported by digital technologies) is typically addressed in circumscribed agile environments or ambidextrous formations (Bresciani, Ferraris, & Del Giudice, 2018; Chaudhuri, Subramanian, & Dora, 2022; Rialti, Zollo, Ferraris, & Alon, 2019; Shams, Vrontis, Belyaeva, Ferraris, & Czinkota, 2021). In this regard, small- and medium-sized enterprises (SMEs) offer an interesting point of view due to their fluidity and predisposition toward digitalization and sustainability, as well as their contribution to global production (Bartolacci, Caputo, & Soverchia, 2020; Dey, Malesios, Chowdhury, Saha, Budhwar, & De, 2022; Marrucci, Rialti, & Balzano, 2023; Santa-Maria, Vermeulen, & Baumgartner, 2022; Troise, Corvello, Ghobadian, & O'Regan, 2022). They represent 99.8% of economic organizations in Europe, which account for 53% of the whole industrial production, yet we still ignore many aspects of their approach to CE (European Commission, 2021). Previous studies on SMEs highlight how Industry 4.0 and digital technologies tend to favor the integration of CE practices (Ghobakhloo, 2020; Liu et al., 2022; Pizzi, Corbo, & Caputo, 2021), which suggests that digital platforms' have a role in supporting companies' transition to a CBM (Pizzi, Leopizzi, & Caputo, 2021) and that digital capabilities can provide more value to customers alongside CE (Chaudhuri, Subramanian, & Dora, 2022; Fernandez-Vidal, Perotti, Gonzalez, & Gasco, 2022).

Although digitization in CBMs is a rather debated issue, earlier studies have pointed to a lack of guidance in terms of leveraging digital technologies to improve business circularity (e.g., Kristoffersen et al., 2020; Neri et al., 2023). Chauhan, Parida, and Dhir (2022, p. 13) also echoed how "we have been lacking insights into the specific application of digital technologies for CE adoption." In this vein, to support the diffusion of sustainable practices among economic organizations, an in-depth exploration of agile entities is required to wisely address analogous situations and encourage SMEs to move toward a CE (Dalton, 2020; Dey et al., 2022; Zhu, Nguyen, Siri, & Malik, 2022). Crucially, a deep investigation that describes the SMEs' progression path through the implementation of key digital technologies to foster circularity is missing. Such an inquiry would offer new insights into the integration of different digital supports in circular businesses, illustrating how each stage of circular practice's development may require a specific job to be done in terms of a business' digital integration. Accordingly, this study is based on the following research question: *what is the role of digital technologies in effectively fostering business circularity in SMEs?*

In response, this study aims to unveil how digital technologies adoption can encourage the flourishing of CBMs in SMEs through a detailed *going circular path* that encompasses each business' dynamic evolution toward circularity. Structured as a qualitative empirical paper, abductive reasoning has been employed to investigate 16 businesses via a multiple case study analysis according to Eisenhardt's (1989) and Yin's (2003) recommendations (Piekkari, Welch, & Paavilainen, 2009; Timmermans & Tavory, 2012). Given the positivist philosophical tradition drawn from Eisenhardt (1989), we decided to investigate the advanced research question through a grounded theory approach (Corbin & Strauss, 2007; Glaser & Strauss, 2017; O'Reilly, Paper, & Marx, 2012). The present research builds on institutional theory to explore companies' isomorphism in adopting digital technologies to achieve circularity (Carmona-Márquez, Leal-Rodríguez, Leal-Millán, & Vázquez-Sánchez, 2022; DiMaggio & Powell, 1983; Do, Mishra, Colicchia, Creazza, & Ramudhin, 2022; Haunschild & Miner, 1997; Meherishi, Narayana, & Ranjani, 2019; Meyer & Rowan, 1977).

Through the observation of how business digitalization can foster the implementation of circular practices in SMEs, this research provides important insights to promote CE adoption in businesses and (hopefully) the further closing of the circularity gap over time, thereby addressing the UN's Sustainable Development Goals (Circle Economy, 2023; Dantas, De-souza, Destro, Hammes, Rodriguez, & Soares, 2021; Macht, Chapman, & Fitzgerald, 2020; Pizzi et al., 2020; United Nations, 2021). Thus, the contribution of our research is threefold: (a) it offers a more detailed scheme of circular business evolution in SMEs through a replicable step-by-step process; (b) it expands the CE literature by highlighting the four roles of digital technologies in circular businesses according to each step of the *going circular path*; and (c) it contributes to the integration of institutional theory in the CE domain by observing circular businesses' isomorphism in adopting digital technologies to achieve a higher level of circularity. In addition, our findings offer some practical implications for managers, specifically chief sustainability officers and sustainability specialists, in the form of recommendations on how to make the best use of digital technologies with respect to a company's circular business evolution.

Following this introduction, a brief literature review aimed at supporting the research question around which the paper has been built is provided. Then, the next two sections present the research design and the results of the multiple case study analysis. The manuscript concludes with a comprehensive discussion of our findings, followed by some concise reflections.

Theoretical background

Circular economy: outlining circular businesses

The concept of CE, which has arisen as a sustainable alternative to linear production systems, is prompting more and more interest in the scientific debate, as well as in everyday business realities and governments around the world (European Commission, Directorate-General for Environment, 2020a; Hina, Chauhan, Sharma, & Dhir, 2023; Murray, Skene, & Haynes, 2017; United Nations, 2021). CE offers a response to the limitations and negative impacts of the traditional linear economy, commonly described by reference to the sequence 'take, make, use, and dispose,' which emphasizes raw materials collection and transformation into marketable products meant to be ultimately discarded as waste. In contrast, a CE involves an imperative transition toward a new production and consumption paradigm in favor of environmental preservation and people's well-being (Bocken et al., 2016; Centobelli, Cerchione, Esposito, & Passaro, 2021; Circle Economy, 2023; Franzò, Urbinati, Chiaroni, & Chiesa, 2021). CE provides insights into a business strategy that companies can implement to promote corporate sustainability as a specific set of practices intended to address resource efficiency and waste reduction. The understanding of sustainability intuitively refers to the interpretation advanced by Elkington and Rowlands (1999) of the 'triple bottom line,' consisting of economic, social, and environmental perspectives. In a nutshell, this sustainable approach is based on a restorative and regenerative system where resources, energy consumption, and waste are minimized throughout the production and consumption stages (Antikainen & Valkokari, 2016; De Bernardi, Bertello, & Forliano, 2023; Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2020; Hopkinson, Zils, Hawkins, & Roper, 2018).

A CE approach is based on sustainable opportunities, where forward-looking businesses undertake a circular transition pursuing sustainable value creation, delivery, and capture (Averina, Frishammar, & Parida, 2022; Centobelli et al., 2020; Khan, Daddi, & Iraldo, 2020). Taking an idea or hunch about the redefinition of a product, practice or process, sustainability-sensitive companies implement business strategies designed to redefine their business model. According to CE principles, an increasing number of companies are reshaping their business models with processes and outputs based on common initiatives. Drawing on Bocken et al. (2016) and Geissdoerfer, Morioka, de Carvalho, and Evans (2018), CBMs can be defined as specific sustainability-driven business models predicated on slowing, closing, and narrowing resource and energy flows (Salvador et al., 2020). A circular approach complies with the 'cradle-to-cradle' economy advanced by McDonough and Braungart (2010), where materials and resources are included in a circular process of reemployment within a closed loop system (Franzò et al., 2021; Lüdeke-Freund, Gold, & Bocken, 2019; Stahel, 2010). Thus, a circular business is firstly characterized by its effort in extending or intensifying its products' fruition period through long-lasting design, reuse, repair, or remanufacturing practices aimed at slowing down the flow of resources (e.g., Hopkinson et al., 2018; Khan et al., 2021). Geissdoerfer et al. (2018) further emphasized the role of slowing practices in a circular business such as intensifying the use of products or dematerializing physical assets thanks to digital technologies and services. When the lifespan of a product comes to an end, as in the case of waste from the production process, the resource loop needs to be closed, aligning post-use scraps with a new production cycle. Consequently, CBMs involve recycling practices to minimize waste and enhance material and resource recovery in a regenerative cycle of production and consumption (e.g., Chaudhuri, Subramanian, & Dora, 2022; Wilts, Garcia, Garlito, Gómez, & Prieto, 2021). A third typical strategic approach that identifies circular-committed companies also concerns the reduction of resources' flow in production processes to promote energy and material efficiency by virtue of a responsible allocation of production inputs (e.g., Dantas et al., 2021; Franzò et al., 2021). As Bocken et al. (2016, p. 310) point out, the latest approach differs from slowing and closing strategies 'as it does not influence the speed of the flow of products and does not involve any service loops,' yet narrowing the resource loop plays a fundamental role in circular businesses. Although it was already in place in some realities' linear systems, recent studies reveal how this component is further emphasized and has acquired a fundamental role in pursuing input optimization for cleaner production and consumption (Gallego-Schmid, Chen, Sharmina, & Mendoza, 2020; Ranta, Aarikka-Stenroos, & Väisänen, 2021). Overall, these circular approaches allow organizations to undertake a closed-loop system through the rethinking of products and processes to maximize the life of goods, enhance waste recycling, and make efficient use of resources (Antikainen & Valkokari, 2016; Ellen MacArthur Foundation, 2013; Geissdoerfer et al., 2018). Specifically, common practices in CBMs involve activities such as reducing resource input or waste generation, durable product design and repair, reusing goods for the same original purpose, recovering materials or energy, remanufacturing products and components for new use, and recycling to convert waste into new resources (Ellen MacArthur Foundation, 2013; Geissdoerfer, Savaget, Bocken & Hultink, 2017; Lüdeke-Freund et al., 2019).

Digital technologies and Industry 4.0 for business circularity

Given that considerable number of studies have offered a conceptualization of CE practices within CBMs (e.g., Antikainen & Valkokari, 2016; Bocken et al., 2016; Geissdoerfer et al., 2018; Lüdeke-Freund et al., 2019), in recent years, researchers and practitioners have demonstrated a growing interest in the adoption of digital technologies alongside these peculiar sustainable business models (e.g., Chauhan, Parida, & Dhir, 2022; Dantas et al., 2021; Gebhardt et al., 2022; Hina et al., 2022; Khan et al., 2021; Liu et al., 2022; Neri et al., 2023; Ranta, Aarikka-Stenroos, & Väisänen, 2021). We refer to digital transformation as a groundbreaking process that involves the integration of digital supports into various aspects of an organization to redefine business processes, deliver value to customers, and create new business models (Fernandez-Vidal et al., 2022; Vial, 2019). More specifically, we also identify Industry 4.0 as a digital revolution of manufacturing processes, wherein digital technologies, such as cyber-physical systems, IoT, AI, and big data analytics are employed to create highly connected and automated production environments (Gebhardt et al., 2022; Kerin & Pham, 2019). Indeed, the wave of Industry 4.0 and digitalization represent a radical change for every business (Bresciani, Ferraris, Romano & Santoro, 2021; Ranta, Aarikka-Stenroos, & Väisänen, 2021), including CBMs. In this vein, digital technologies support the translation of CE principles into feasible activities that optimize and empower circular practices by improving their positive impact or reducing their negative externalities (Gebhardt et al., 2022; Ghobakhloo, 2020; Kristoffersen et al., 2020; Liu et al., 2022; Pizzi, Leopizzi, & Caputo, 2021). Chauhan, Parida, and Dhir (2022) inspected the link between CE and digital technologies in their literature review, highlighting how AI, blockchain, and big data can support management decisions in circular businesses and the establishment of a CE ecosystem. The study advance by Liu et al. (2022) also strengthened the relationship between these two spheres, outlining seven main mechanisms of digital functions based on automation, data analysis, data collection, and integration, which can enhance CE strategies. Rusch, Schöggl, and Baumgartner (2022) confirmed the role played by IoT, AI, big data analytics, and blockchain technologies in enabling CE strategies alongside sustainable product management activities. AI in association with digital systems can provide support to implement CE practices, for instance, by allowing recycling and remanufacturing through automatic waste recognition as described by Wilts et al. (2021). Drawing from earlier studies about digital technologies' impact on circular practices, Kerin and Pham (2019) observed how IoT, virtual reality, and augmented reality support the remanufacturing process in economic organizations. Utilizing a case study investigation, Gupta, Chen, Hazen, Kaur, and Gonzalez (2019) questioned big data analytics in data-driven decision-making in supply chain networks, where the improved interaction of members was shown to positively affect CE implementation. Jabbour, Jabbour, Sarkis, and Godinho Filho (2019) also supported digital technologies' virtue of leveraging large-scale data to enhance stakeholders' management of circular businesses. Industry 4.0 technologies thus enable collaboration in circular supply chains and circular ecosystems by fostering mechanisms, such as information sharing, joint planning, and decision-making thanks to IoT technologies, cloud systems, and the blockchain (Gebhardt et al., 2022). Coherently, Khan et al. (2021) deepened the understanding of Industry 4.0-related blockchain technologies adoption in circular businesses, demonstrating a positive effect on the circular practices of smart contracts and transparent information sharing with stakeholders along the supply chain. Besides, even organizational performance has been shown to be enhanced by reinforced circular practices. In SMEs, digital platforms have been observed as valuable tools to establish entrepreneurial ecosystems and enable the transition to a CE (Chaudhuri, Subramanian, & Dora, 2022; Pizzi, Leopizzi, & Caputo, 2021). In terms of business model innovation, Ranta, Aarikka-Stenroos, and Väisänen et al. (2021) explored resource flow reviewing alongside value creation and capture improvements catalyzed by digitalization. The value of data is emphasized through data collection, integration, and analysis processes considered radical or incremental business model changes by virtue of the adoption of CE strategies. For instance, digitalized sectors such as fintech also show a close connection between Industry 4.0 technologies and SMEs' circular transition, which has resulted in the improvement of CE practices and processes through the integration of fintech technologies (Pizzi, Corbo, & Caputo, 2021).

Overall, our literature review highlights how digital technologies have been recognized for their importance in driving CE adoption in businesses. Big data analytics, AI and machine learning, process automation, blockchain technology, additive manufacturing, IoT, and digital platforms are some examples of the rich set of tools that revolve around data collection and processing to allow more automated and efficient practices according to a renewable production and consumption system (Chauhan, Parida, & Dhir, 2022; Khan et al., 2021; Liu et al., 2022; Rejeb, Suhaiza, Rejeb, Seuring & Treiblmaier, 2022). The relationship between these two spheres (i.e., CE and digital transformation) collides with economic organizations' reality by facilitating their circular transition. However, only a few studies have empirically addressed the effective role of digital technologies in circular businesses, leaving a significant gap regarding their actual adoption and consequences (Chauhan, Parida, & Dhir, 2022; Hina et al., 2022; Liu et al., 2022; Neri et al., 2023). In particular, what is missing in the CE literature is a closer and more critical look at the way companies make use of digital tools during the planning, establishment, and growth of circular businesses.

Explaining circular transition through institutional theory

Through the lenses offered by institutional theory, it is possible to explain companies' isomorphism in adopting CE principles based on sociological and economic mechanisms (DiMaggio & Powell, 1983; Haunschild & Miner, 1997; Meyer & Rowan, 1977). Previous studies have supported how organizations' conversion toward a circular business can be understood as a reasonable reaction to deal with uncertainties by adapting themselves in the manner of counterparts perceived as rational, legitimate, or successful (e.g., Do et al., 2022; Jain, Panda & Choudhary, 2020; Meherishi, Narayana, & Ranjani, 2019; Ranta, Aarikka-Stenroos, Ritala & Mäkinen, 2018). According to the extended institutional theory, companies' practices and decision-making are affected by external sociological and economic variants that involve some mechanisms for legitimacy and efficiency-seeking to cope with uncertainty. Drawing on DiMaggio and Powell (1983, pp. 150–151) and Meyer and Rowan (1977), businesses' adaptive processes toward legitimacy achievement involve three mechanisms: (a) the 'formal and informal pressures exerted on organizations by other organizations upon which they are dependent and by cultural expectations in the society within which organizations function' (i.e., coercive pressure); (b) the isomorphism deriving from companies' attempts to 'model themselves on other organizations' to deal with uncertainties or due to ambiguous objectives (i.e., mimetic pressure); and (c) the pressure on professionals' homogeneity across organizations based on social norms and cultural characteristics (i.e., normative pressure). Therefore, the exploitation of sustainable opportunities by economic organizations may be observed as an isomorphic attempt to deal with uncertainties while facing the same environmental conditions (Averina, Frishammar, & Parida, 2022; Do et al., 2022; Eller et al., 2020; Hopkinson et al., 2018). For instance, more and more companies are transforming their business model into a renewable one based on CE principles due to restrictions or incentives advanced by policymakers. Economic organizations can also seek legitimation by imitating other companies' approaches to renewable production systems to deal with uncertainties, while meeting new consumers' needs or stakeholders' requirements (Camilleri, 2020; Camoletto, Corazza, Pizzi & Santini, 2022; Centobelli et al., 2021; Fischer & Pascucci, 2017; Tunn, Bocken, van den Hende & Schoormans, 2019).

In addition, companies' isomorphism has been shown to be triggered as a consequence of their attempt to cope with uncertainties while pursuing efficiency (Do et al., 2022; Haunschild & Miner, 1997). The extended institutional theory integrates the economic variant into the previous sociological one, introducing three more mechanisms that drive companies to adopt similar practices and processes. Researchers have outlined how economic entities tend to (a) imitate practices adopted by a considerable number of organizations when they reach a critical mass of adopters (i.e., frequency-based imitation); (b) implement practices legitimized by a smaller group of other companies deemed successful or with higher status (i.e., trait-based imitation); and (c) become inclined through the observation of other businesses' outcomes following a managerial decision or implemented practice to resemble successful realities by mimicking the same practices (i.e., outcome-based imitation) (DiMaggio & Powell, 1983; Haunschild & Miner, 1997; Zucker, 1987). In this vein, companies may aim at translating circular purposes into their business model to tackle uncertainties, taking inspiration from widely adopted practices or successful circular processes traced back to a virtuous set of sustainability-sensitive actors (Carmona-Márquez et al., 2022; Hopkinson et al., 2018).

Overall, institutional theory suggests that the more firms adopt CE practices and embrace circular businesses, the more the legitimacy of converging business models toward a renewable production system is consolidated to cope with uncertainties (DiMaggio & Powell, 1983; Ranta, Aarikka-Stenroos, & Mäkinen, 2018). Both sociological and economic external variants offer six plausible mechanisms that can explain businesses' assonant approach in converging toward a more sustainable business model. Considering specifically the frequency-based and the trait-based imitation mechanisms in inducing isomorphism in companies, this convergence has also been associated with technological factors (Do et al., 2022; Haunschild & Miner, 1997). In the CE domain, it means circular businesses' isomorphism can be accessed via the adoption of digital technologies to support the circular transition, as a consequence of the environmental conditioning imposed by other actors' legitimized conduct (Bag et al., 2021; Gupta et al., 2019; Pizzi, Corbo, & Caputo, 2021). Through the mechanisms offered by these theoretical lenses, this study thus aims at investigating companies' tendency to employ digital supports in new products or revised processes to achieve a higher degree of circularity and, in general, promote sustainability in enterprises.

Research design

In consideration of the research question to be answered, alongside the scant awareness regarding the effective role of digital technologies in supporting SMEs toward their CE transition, this study has adopted a qualitative design. When little is known about a specific phenomenon, it seems appropriate to participate in the scientific debate through an explorative approach based on the observation and interpretation of events described by actors in their social realities (Blaikie & Priest, 2019; Marshall & Rossman, 2014). The authors engaged various companies with positivistic lenses to build new grounded knowledge resulting from abductive reasoning applied to a multiple case study (Eisenhardt, 1989; Glaser & Strauss, 2017; Piekkari, Welch, & Paavilainen, 2009;

Timmermans & Tavory, 2012; Welch et al., 2022). Specifically, abductive reasoning offers a reiterative matching process of multiple sources of theoretical and empirical information, where contents from the extant literature and the factual world converge to enable the elaboration of plausible conclusions (Dubois & Gadde, 2002). The inquiry began with a comprehensive review of the previous literature on CE and businesses' digital transformation in preparation for the analysis of the empirical scenarios. Then, building on the integration of the researchers' expertise, the experiences actors ascribe to their economic realities, and supplementary material from auxiliary sources, the case researchers have been driven to a convergent answer to the advanced research question (Hofmann & Zu Knyphausen-aufseß, 2022; Howard, Hopkinson, & Miemczyk, 2019; Yin, 2003). In doing so, the case researchers can provide new insights related to digital technologies adoption and Industry 4.0 in circular businesses.

Case selection and data collection

In their intention to examine the establishment of newly developed or converted circular businesses while focusing on the role of digital technologies, the authors have chosen to investigate business realities characterized by distinct operational agility and flexibility, specifically SMEs (Centobelli et al., 2021; Pereira et al., 2022; Pizzi, Corbo, & Caputo, 2021). Small and medium companies are generally considered agile organizations due to their size and structure, which confers on them the ability to quickly respond to changing environments, adapt to new circumstances, and implement prompt changes accordingly (De Angelis, Howard, & Miemczyk, 2018; Troise et al., 2022). In this manner, the agile and flexible nature of SMEs can be a significant advantage in a CBM establishment, as it allows businesses to quickly adapt, engage stakeholders, and collaborate, experiment, and optimize resource utilization according to CE principles. These characteristics enable SMEs to effectively implement circular practices, creating value from waste and minimizing resource consumption, thus promoting sustainable and responsible business practices (Dey et al., 2022; Mura, Longo, & Zanni, 2020). Accordingly, purposeful sampling has been administered as an effective means to identify those cases that can offer the most coherent and representative information to achieve the study's objectives (Marshall & Rossman, 2014; Ranta, Aarikka-Stenroos, & Mäkinen, 2018). Hence, the sample selection was based on small and medium businesses established in Italy that operate in sectors with the potential for engaging with CE, such as manufacturing, construction, chemical, fashion, food, and beverage (see Table 1). In line with the European Union definition of SMEs (European Commission, 2020b), we only involved companies with fewer than 250 employees and an annual turnover of less than €50 million (or less than a €43 million annual total balance sheet; e.g., Dey et al., 2022; Scuotto, Santoro, Bresciani & Del Giudice, 2017). Both threshold values were verified through Aida, a Bureau Van Dijk database that collects accounting data on Italian companies, alongside companies' information on LinkedIn and data collected during interviews. This selection of cases represents a critical point in our study due to their significance on national and international productive systems, as SMEs represent 99.8% of European enterprises and 53% of the added value in the eurozone (Bertello, De Bernardi, Santoro & Quaglia, 2022; European Commission, 2021; Zhu et al., 2022). Moreover, SMEs provide a remarkable research context as they are characterized by a high level of agility and sustainable orientation (Caputo, Schiocchet & Troise, 2022; Chaudhuri, Subramanian, & Dora, 2022; Dey et al., 2022; Pizzi, Corbo, & Caputo, 2021).

The study adopts a qualitative approach in the form of 16 case studies of circular businesses (Eisenhardt, 1989; Yin, 2003) whose information was mainly collected from managers and employees through semi-structured interviews (e.g., Franzò et al., 2021; Hofmann & Zu Knyphausen-aufseß, 2022). This approach provides the opportunity for researchers to gather information about a business by keeping the conversation within chosen boundaries while leaving participants open to explore relevant aspects and experiences (Kvale, 1996; Timmermans & Tavory, 2012). Thus, data take shape from the interactions between the interviewer and the interviewee, undergoing a coding process based on the high level of reflexivity and the extensive knowledge possessed by the

Table 1. Descriptive information of the case studies

Company	Sector/business	Size	Interviewee's position	Duration
A	Building and Construction	Small	Chief executive officer (CEO)	38 min 23 min
B	Tanning/Fashion	Small	Chief executive officer (CEO)	67 min
C	Manufacturing/Machine Industry	Small	Chief executive officer (CEO) and co-founder, Business developer	50 min 38 min
D	Manufacturing	Medium-sized	Chief sustainability officer (CSO)	58 min
E	Manufacturing/Design	Medium-sized	Business process and people management	69 min
F	Fashion/Textile	Medium-sized	Special project manager	71 min 47 min
G	Fashion/Textile	Micro	Chief executive officer (CEO) and founder	52 min
H	Services/e-mobility	Micro	Chief executive officer (CEO)	49 min
I	Chemical/Cosmetics	Small	Chief executive officer (CEO), Production manager	41 min 65 min
J	Food and Beverage	Medium-sized	Chief executive officer (CEO), Production manager, Marketing manager	48 min 45 min
K	Food and Beverage	Small	Chief executive officer (CEO)	61 min
L	Furniture	Medium-sized	Chief executive officer (CEO), Chief sustainability officer (CSO)	45 min 60 min
M	Fashion	Small	Sustainability specialist	78 min
N	Manufacturing	Micro	Chief executive officer (CEO), Sales account	72 min
O	Fashion/Textile	Micro	Chief executive officer (CEO)	48 min
P	Pharmaceutical/Chemical	Medium-sized	Chief executive officer (CEO), R&D director	50 min 49 min

Source: Authors' elaboration.

researcher (Silverman, 2015). Table 1 indicates the interviewees' roles in the sampled companies. In practice, the interview guide addressed the research questions in the form of a structured conversation and included the questions listed in Table 2. Overall, 23 face-to-face interviews were conducted, either in person, by telephone, or through virtual meetings held between May and November 2022. The interviews lasted 53 minutes on average and were recorded with the companies' permission while interviewers were taking notes. Thereafter, the researchers listened to the recordings and complemented their notes to enable the subsequent process of decoding and analysis while keeping interviewer-related errors to a minimum (Eisenhardt & Graebner, 2007; Silverman, 2015; Timmermans & Tavory, 2012; Yin, 2003).

In line with the positivist tradition of this study, the case researchers sought new theoretical insights favoring replication toward a multiple case study design so as to strengthen the data analysis in providing analytical generalization (Piekkari, Welch, & Paavilainen, 2009; Welch et al., 2022). According to Eisenhardt (1989), a multiple case study can be considered reliable when it is based on 4–8 empirical cases. However, the case researchers ensured robust results by persisting with data collection until theoretical saturation was reached, that is, when additional data no longer provided any new insight in terms of refining the properties of the coding categories or the context of analysis (Corbin & Strauss, 2007; Marshall & Rossman, 2014; O'Reilly, Paper, & Marx, 2012). The coding process was carried out with the intention of ensuring the stability of the results over time, context, and research tools so as to represent the objective phenomenon coherently with the study's positivist

Table 2. Interview guide

Questions
1. In line with your sustainable vocation, have you implemented any processes, practices, or developed products inspired by circular economy principles? How circular do you think you are?
2. When did your company become circular? Was there a transition to a circular business model, or was your company founded on a circular model? Explain: a) How has the translation toward a circular model occurred? Is it still ongoing? **OR** b) How has the business start-up process been based on circular economy principles? Describes how the implementation of circular practices has contributed to the establishment of your circular business.
3. Have you adopted digital technologies to support your business activities? What kind? Even those not related to circular processes. How digitized do you think you are?
4. In this regard, what role have digital technologies played in establishing circular practices or processes? Which of the digital tools you employed have helped you to realize a specific circular practice? Explain your going circular path by focusing on new products, processes or practices development, highlighting the role played by digital technologies.
5. Would you have been able to implement a circular business model without technological support? How have digital technologies helped you in your circularity goal?
6. According to your vision, what advantages do you perceive as inherent to circular economy principles adoption in business processes? What are the main benefits that stakeholders (e.g., society, customers, supplier, partners) derive from the sustainable nature of your business?

Source: Authors' elaboration.

interpretation (Bauer, Gaskell, & Allum, 2000; O'Connor & Joffe, 2020). Thus, the authors envisaged an intercoder comparison and discussion in order to assess the accurate interpretation of the information gathered from the interviews. Intercoder reliability has been ensured through the convergence of case researchers toward an unambiguous interpretation of the data as suggested by Potter and Levine-Donnerstein (1999) and echoed by O'Connor and Joffe (2020) (e.g., Schwanholz & Leipold, 2020). Furthermore, we decided to take some supplementary precautions from previous studies' recommendations to ensure the validity and reliability of our study (Corbin & Strauss, 2007; Gibbert, Ruigrok, & Wicki, 2008; Marshall & Rossman, 2014). First, the interview guide has been structured by rephrasing questionnaires formulated in similar qualitative empirical analyses in the CE domain (i.e., Aranda-Usón et al., 2020; Franzò et al., 2021; Hofmann & Zu Knyphausen-aufseß, 2022). Secondly, participants in the research project were involved in validating the themes and interpretations during the interviews. Then, the overall process of data collection comprised a triangulation phase where empirical observations from participants were combined with various sources of information (i.e., company websites, sustainability reports, newsletters, and databases) to allow a better comprehension of the circular business development and increase trustworthiness (Gibbert, Ruigrok, & Wicki, 2008; Marshall & Rossman, 2014; Yin, 2003). Finally, we employed pattern matching by comparing our results with previous research observations (Eisenhardt, 1989; Eisenhardt & Graebner, 2007).

Data analysis

In social sciences, the grounded theory refers to a systematic research methodology that involves data collection and analysis to build new theoretical insights 'grounded in empirical observations of words, actions, and behavior of the study's participants' (Corbin & Strauss, 2007; Glaser, 2007; Gligor, Esmark, & Gölgeci, 2016, p. 97). Accordingly, the case researchers attempted to answer the research question by processing information from empirical cases to provide a theoretical contribution to digital technologies applied in the CE domain. Thus, the data analysis has been carried out by drawing on the information gathered from interviewees, combining researcher notes with the transcribed interviews, and referencing supplementary data. The collation of different data sources was performed by the authors to elaborate converging lines of inquiry toward a single explanation in accordance with a positivist approach (Eisenhardt, 1989; Piekkari, Welch, & Paavilainen, 2009; Thomas, 2021; Yin, 2003). As the perspective of this study is to understand how and why digital technologies are applied in circular businesses, the data analysis process was shaped accordingly. Relying on the grounded theory framework to build new theoretical concepts from empirical observations (Corbin & Strauss, 2007; Glaser & Strauss, 2017; O'Reilly, Paper, & Marx, 2012; Timmermans & Tavory, 2012), the authors performed a cross-case analysis to uncover generalizable constructs in a two-step procedure, where the translation of circular principles into feasible activities has been observed through the support of digital technologies in establishing the circular process. In the first place, the case researchers examined the development of each circular business observed. Thanks to the information on the progressive evolution of each sampled company, it has been possible to carry out a retrospective and prospective investigation aimed at capturing the entire development process of circular-inspired practices and processes within companies (e.g., Wamba, Akter, Edwards, Chopin, & Gnanzou, 2015; Zucchella, Previtali, & Strange, 2022). A longitudinal observation offered an understanding of circular business establishment and growth, as changing elements were observed from a holistic perspective (Eller et al., 2020). It allowed the case researchers to capture the dynamic responses to sustainable opportunities by circular businesses unfolding under different conditions, in terms of digital technologies adoption. Therefore, an in-depth investigation of cases was performed to provide an evolutionary framework, a common development path within which digital tools and systems found common purpose lines in supporting CE principles adoption in business processes. Complementarily, in the second step we rationalized the actual use of digital technologies in the identified circular processes and products thanks to the Gioia methodology (e.g., Bocken & Konietzko, 2022; Troise, 2021; Zucchella, Previtali, & Strange, 2022). This approach builds upon the grounded theory and ensures methodological accuracy in qualitative studies through a precise and validated data structure (Gioia, 2021; Gioia, Corley, & Hamilton, 2013). Indeed, it has been developed as a complementary instrument of qualitative research to support procedural rigor in data analysis (Mees-Buss, Welch, & Piekkari, 2022). From the empirical investigation, the data have been analyzed and systematized into several first-order concepts by the case researchers, whose role is akin to a 'glorified reporter' that collects information in an unbiased manner, departing from the risk of 'going native' (Gioia, Corley, & Hamilton, 2013, p. 17–19). Then, these field facts are evaluated for similarities and differences to elevate them toward a theoretical understanding thanks to the experience and the researchers, who act as 'knowledgeable agents' (Gioia, Corley, & Hamilton, 2013, p. 17; Mees-Buss, Welch, & Piekkari, 2022). The structured theorizing process offered by the Gioia methodology thus outlines two different phases, where the researchers' role changes considerably from actors in charge of representing reality as truthfully as possible to expert analysts of the field capable of bringing the empirical evidence found in the case studies together. The development of second-order themes represents the processing of facts into constructs belonging to the theoretical realm (Corbin & Strauss, 2007; Glaser & Strauss, 2017; Gligor, Esmark, & Gölgeci, 2016; O'Reilly, Paper, & Marx, 2012), which can be further refined in new aggregate dimensions (Gioia, 2021; Gioia, Corley, & Hamilton, 2013). Therefore, the data structure realized by drawing on the Gioia methodology outlines the theorizing process' output in terms of results provided by the case researchers' ability to find assonances in the case studies and create logical relationships among categories from factual scenarios through grounded theory.

Findings

Building on the information collected during the empirical investigation, this research can offer some inspiring findings. Table 3 outlines the circular products or processes observed in the 16 case studies, alongside the digital technologies implemented in the observed CBMs. In general, the most common circular practices among the sampled SMEs have proven to be the recovery of waste as new resources to improve efficiency and reduce input provided by virgin raw materials. Some case studies showed integrated remanufacturing processes to collect and convert end-of-life products and scraps into new,

Table 3. Circular processes in sampled companies and digital technologies' role

Company	Circular product or process	Circular practices	Going circular stage	Digital technologies' function	Circular practices support
A	Promote the reuse of waste or excess materials from construction through an interconnected virtual marketplace	Reduce Reuse Recover Recycle	First steps	A digital platform, alongside an IoT system, to enable inter-firm communication, spatial localization, and resource exchange/collection	High
B	Recover agri-food industry waste into secondary raw material to realize natural, chemical-free, and durable leather that is easily compostable at the final product's end of life	Recover Reduce Long-lasting design Recycle	Circular maturity	Use of big data and AI to optimize waste reduction in terms of energy and resources during product development (reduced water use and impurities released, less cutting waste) Digital system to allow supply chain tracking and certified circular product identification from clients and suppliers while AI delivers product information as a replacement for analog media	Medium
C	High- and low-intensity extraneous object detection system to spot impurities in food products and allow action to be taken on the individual item to reduce food waste during the production process	Reduce	First steps	AI and machine learning, supported by automated systems, to enable object detection and immediately action to be taken to remove or sort elements with different densities; deep learning software to recognize different materials based on their composition	High
	High- and low-intensity extraneous object detection system employed to sort different types of waste and facilitate its recycling	Recycle			
D	Recover supply chain waste from customers to generate secondary raw material, which is employed into new eco-friendly-designed circular products that favor end-of-life recyclability	Reduce Recover Recycle	Circular climbing	Additive manufacturing to reduce energy and material use in circular production development IoT and sensors to allow data collection while AI exploits big data to enhance the transformation process, increasing the circular process rate of implementation and amplifying its scale	High
E	Recover plastic from post-consumption materials to generate new products almost entirely based on secondary raw resources employed in readily recyclable kitchen equipment production	Reduce Recover Recycle	Circular climbing	Additive manufacturing to enhance prototyping and production while saving energy and resources and reducing costs; in parallel, collaborative robots and warehouse automation through IoT to significantly intensify the circular products development rhythm	High

(*Continued*)

Table 3. (*Continued.*)

Company	Circular product or process	Circular practices	Going circular stage	Digital technologies' function	Circular practices support
F	Waste reduction through the acquisition of exhausted fabrics from clients, which are remanufactured into virgin-equivalent fabric in terms of performance, durability, and appearance	Recover Remanufacture Reduce	Circular climbing	Digital platform and IoT systems to enhance garment collection by providing a direct connection channel with clients	High
	Production process from renewable sources with very low environmental impact, minimal use of chemicals and water, and low energy consumption	Reduce	Circular maturity	Production process and storage automation to allow activities optimization alongside waste and energy reduction	High
G	Collect and process of end-of-life garments into secondary raw materials from which new, easily recyclable circular products are manufactured	Reduce Recover Remanufacture	Circular climbing	A digital infrastructure to connect all stakeholders of the company, facilitating the collection of waste materials and their processing; utilizing the company's website to enhance worn clothes collection	Medium
H	Engineering, testing and validation services to support the development of sustainable and circular processes and products based on resource and material employment reduction	Reduce	Idea generation	AI, machine learning, and IoT to shape circular processes and product development in terms of increasing productivity, trend analysis, and obsolescence prevention	High
I	Development of circular cosmetic products with zero environmental impact, made using natural ingredients recovered from the food and beverage industry waste	Recover Reduce	First steps	IoT systems and digital platforms to facilitate the flow of information among the actors of the supply chain for the benefit of circular product development	Low
J	Through an upcycling process, recovery of waste from beer processing by partner companies to generate new secondary raw materials that are used in circular food and beverage products	Reduce Recover	First steps	Digital platforms and IoT supports to ensure real-time information exchange between different actors, enabling local circular ecosystem coordination during waste recovery and transformation into new resources	Medium
K	Collection and recovery of surplus bread from the food industry to produce new secondary raw material (i.e., yeast) employed in premium beer production	Recover Reduce	Circular climbing	An information system available to partners to improve waste collection from large and small players in the agro-food industry; automated processes supported by real time data collection to enhance the transformation process in terms of scale and efficiency	High
L	Waste and raw material reduction through a take-back process of end-of-life furniture products that can be disassembled and remanufactured into new circular products based on recovered components	Reduce Recover Refurbish Remanufacture	Idea generation	Tracking technologies and IoT to allow furniture recovery and offer support for consumers to proactively return an exhausted product; digital support such as an near-field communication (NFC) or QR code to offer product information, which can be retrieved from an AI to explain the automatic disassembling process	High

(*Continued*)

Table 3. (*Continued.*)

Company	Circular product or process	Circular practices	Going circular stage	Digital technologies' function	Circular practices support
M	Animal-free outerwear made from secondary raw materials obtained by recycling waste and designed to be long-lasting and easily recyclable	Reduce Recover Recycle	Circular maturity	Big data, AI, and machine learning to make production processes more efficient and optimize business circularity; IoT to support partner interaction and circular product development by connecting actors from the value chain	Low
N	Circular product designed for food preservation made entirely from natural materials with no environmental impact as a replacement for disposable plastic film; end-of-life take-back process allowing remanufacturing to restore the product's properties so as to re-enter the market	Reduce Remanufacture	Idea generation	IoT and digital platform assisted by tracking systems to allow information sharing and facilitate customers during the take-back process	High
O	Animal-free circular fashion products made from secondary raw materials derived from agricultural waste and recycled plastic	Reduce Recover	Circular maturity	IoT systems, big data analytics, and AI supports to allow data collection and analysis to monitor carbon footprint and production externalities so as to offer a cleaner transformation process and product development	Medium
P	Processing of food industry waste to generate new secondary raw materials, which are used for new circular products in the form of food supplements	Reduce Recover	Idea generation	IoT to support circular product development through real-time information exchange between different partners, enabling waste recovery and secondary raw material use in circular products	Medium

Source: Authors' elaboration.

secondary raw materials. With the intention of recovering scrap from the demolition of buildings, company A has set up a system for collecting its own (and other construction companies') waste in order to produce secondary raw materials that can be used in the realization of future buildings. Another example comes from B, a company focused on the production of leather, whose raw materials are mainly made up of waste from the agro-food industry (goat, lamb, calf, or mutton hides). The chief sustainability officer of company D, which specializes in accessories manufacturing, supports these circular practices, noting that they '*apply circularity in the logic of symbiosis, which means to recover waste from our customer's supply chain to generate secondary raw material for our supply chain*.' Companies L and E, which, respectively, produce furniture and tableware, make extensive use of secondary raw materials from recycled plastic waste. Company M, on the other hand, is active in the fashion industry and manufactures outerwear made of polyester fiber that replaces the use of animal-derived inputs and product elements made of recycled plastic. Similarly, organization O also relies on the use of recycled raw materials recovered from agricultural industry wastage and renewed plastic to manufacture animal-free sustainable footwear. An excellent example of waste reduction through recovery strategies has been offered by the special project manager of firm F, who specified that it '*is nearly a zero-waste company that tries to recover 100% of the material we use, as at each stage of production there are companies in charge of recovering waste from the entire production process*.' Therefore, almost all of the investigated companies approach CE adoption in terms of resource or waste reduction, sometimes through recycling production wastage. That is the case of company G, which activated a recycling and remanufacturing process for end-of-life garments to obtain fabrics from secondary raw materials, with the aim of producing new apparel. An analogous perspective in the food and beverage sector sees the young company K embarking on a CBM that involves the recovery of unsold bread from the food industry to obtain yeast used in the production of premium craft beer. In the same industry, company J has established an upcycling process based on the extraction of nutrients from exhausted cereals used in the production of beer. This process is meant to save valuable nutrients from production scrap before being sold as feedstuff. These rich elements can be employed in new circular products as secondary raw materials. For instance, they can be utilized by companies such as I and P, which are committed to circular product development based on recovered nutrients from the food and beverage industry. Respectively, I and P are establishing their circular businesses based on input material reduction and waste recovery in the realization of sustainable cosmetics and food supplements derived from a circular ecosystem. Additionally, the case researchers observed the development of a circular business by company N based on a circular product that prevents the generation of plastic waste. Thanks to their sustainable packaging for food, it is possible to replace the plastic film used in kitchens with an all-natural product that can be taken back at the end of its life to be treated and put back again on the market. This product take-back initiative for remanufacturing has also been observed in company L, even though in both cases the businesses are still in the design phase of the circular process. In dealing with waste reduction and recycling, company C also offers a peculiar case of CE integration into a business model. It produces circular supports for industrial use to ensure waste reduction in the food industry through precise item detection by machines employed to sort mixed waste for recycling. Another interesting perspective in terms of circular principles adoption in economic organizations has been offered by H, a company focused on engineering, testing, and validating services to support resource and energy-reducing practices in circular businesses.

In our wide investigation of circular businesses, the case researchers observed that digitalization has played a key role in the majority of cases regarding circular processes or product development. Indeed, spokespersons for 14 out of the 16 circular companies testified that digital technologies have had a high or moderate role in supporting their CE practices adoption (see Table 3). The chief sustainability officer of company D clearly expressed his view, agreeing with most of the SMEs interviewed that '*the technological revolution represents a boost for circular processes, increasing the speed and breadth of circular practices. Digital technologies open up new possibilities for the future of the circular economy.*' As a consequence, the case researchers committed themselves to exploring the path through which circular practice and processes have been implemented in SMEs, focusing more specifically on circular business requirements alongside the specific functions carried out by digital tools.

Outlining the going circular path

At first, the longitudinal observation allowed us to gather information on the CBMs from a retrospective and perspective point of view, uncovering some common development patterns. It has been possible to observe how, over time, businesses acquire an increasing degree of circularity by taking into consideration: (a) the origin of resources fed into the production process (raw materials or recovered/remanufactured secondary raw materials); (b) the externalities deriving from the transformation process and auxiliary activities; and (c) the properties of production outputs in terms of recyclability, lifespan, and reutilization. Thanks to an accurate description of each circular process or product development, a recurring series of evolutionary stages have been identified as a *going circular path*. The authors identified four distinct phases of evolution in relation to the aforementioned degree of circularity of companies. In order, they are *idea generation, first steps, circular climbing*, and *circular maturity* (Table 3).

In the idea generation phase, the case researchers identified a preparatory process of developing a circular product or process, wherein a company attempts to apply concrete CE principles to create an economically sustainable business. Company L offers an example of this step through the preliminary definition of a take-back process for their products. In this case, the circular process design has started by considering the materials employed in their furniture to make circular product components that can be easily recycled and remanufactured. A similar condition has been found in company N, where the collection process of spent products is being developed and transformed by evaluating possible opportunities to remanufacture end-of-life products. Relatedly, company P was also observed in the very first step of their circular product development. The chief executive officer and the R&D director explained how their effort is actually related to the identification of what raw materials, in the form of nutrients, could be employed in the production of food supplements. Overall, it has been possible to outline a preliminary condition of idea generation where the management recognizes a circular opportunity and endeavors to design the circular initiative according to the firm's conditions.

Next, a circular business takes its first steps through the marketing of a finished circular product or service, behind which there is a structured process that incorporates the most common circular practices. The current situation of company A offers a practical example of this second step. After having accurately identified and set up the circular process it wants to put in place, the firm is concretely proposing an initiative to collect unused raw construction materials and demolition scrap from other stakeholders to activate the reuse and recovery process. Analogously, company C has identified a circular opportunity and realized mechanical support for circular businesses in its first step, and, at the time of the interview, the chief executive officer was actually considering the first industrial application of their machine for recycling processes and reducing waste. Meanwhile, the management of company I, after defining a circular cosmetic product based on nutrients derived from the agro-food industry, is dealing with the definition of the marketing mix and first commercialization of its circular product. Company J has also already designed the upcycling process through which they can extract resources from exhausted cereals previously used in brewing. Thus, it was possible to observe this company in the second step of its *going circular path* dealing with the employment of secondary raw materials in circular products (i.e., snacks and beverages) and their placement on the market. Based on these circular business experiences, the case researchers outlined this second step, where the circular process or product has been designed and developed by the company, and it is facing its first implementation or introduction onto the market. This first steps stage seems to be characterized by a slow increase of the circularity degree recognized in enterprises that can be substantially raised thereafter.

Indeed, the next step involves an increase in the adoption of the circular product, which corresponds to the greater breadth of a circular process by involving new stakeholders. In this third step, identified as circular climbing, the degree of recovered or remanufactured raw materials employed in circular businesses increases significantly, alongside the reduction of externalities from production and the utilization of a circular product. Expanding the production process of environmentally sustainable tableware goods made from recycled plastic, company E offers an example of circular business scaling through the launch of an entire line dedicated to circular products. This example shows how they went from defining a circular opportunity to prototyping an initial model of a home accessory made from recycled plastic materials to expanding the range of circular products sold. In this way, it was possible to observe the sudden rise in the degree of circularity of the company, which was associated with an increased recovery of waste in addition to the material and energy reduction inputs in the production of its table accessories. Similarly, companies G and F approached the circular climbing phase through the massive expansion of suppliers capable of providing them with the exhausted garments needed to enable the recovery of fabric filaments used to produce new clothes. After the design of the circular process and the circular business' first step into garments remanufacturing, the degree of circularity of both companies has seen exponential growth in terms of the amount of recovered waste from the fashion industry and the reduction of new materials used in their garments. Company K is also experiencing circular climbing through the considerable growth of unsold bread suppliers and the subsequent expansion of their yeast extraction process to produce craft beer.

Finally, the case researchers also observed how circular businesses tend to reach a state of circular maturity, where the circular degree growth slows down and stabilizes. Such is the case with company B, where the circular climbing step, represented by the intensification of leather recovery from food industry scraps, has been followed by an attempt to refine the circular business. In other words, B's chief executive officer testified that they are committed to further reducing material and energy inputs, as well as production externalities, to achieve a higher level of business sustainability. The special project manager at company F agreed with this circular strategy. In fact, company F's circular maturity can be observed in its commitment to further reduce its production process' environmental impact by avoiding chemicals and drastically reducing the employment of water and energy in garment thread recovery and garments manufacturing. Similarly, company O was attempting to perfect the circularity criteria of their business by increasing the amount of secondary raw material recovered for the production of sustainable sneakers along with reducing production-negative externalities. Thus, this last step of the *going circular path* provides the opportunity to refine a circular business by improving the environmental, social, and economic benefits of a renewable production and consumption system.

Four roles for digital technologies in circular businesses

Overall, our in-depth longitudinal investigation provided an evolutionary framework of circular business development, where digital tools and systems found common purpose lines. Thus, the empirical investigation was complemented by a cross-case analysis based on a transparent data structure, represented in Fig. 1. The results revealed four main roles of digital technologies in circular businesses that agile organizations pursue through the adoption of digital tools: *shaper, enabler, enhancer*, and *refiner*. Each aggregate dimension is supported by two second-order themes and several first-order concepts found in the case studies.

The four roles of digital technologies within circular businesses satisfactorily fit within the evolution described through the *going circular path*. During the idea generation step, digital technologies, such as IoT and tracking systems, or the possibility of recurring to AI, machine learning, and IoT, shape the definition of the circular practices themselves. This role is supported by the chief sustainability officers of company L, who stated '*considering available technologies, we intend to activate a take-back process using digital support to ensure traceability, as well as include intelligent elements within the blend that dialogue with our machine once they have to be disassembled*.' Indeed, L's take-back, circular process is being designed according to the tracking properties offered by digital

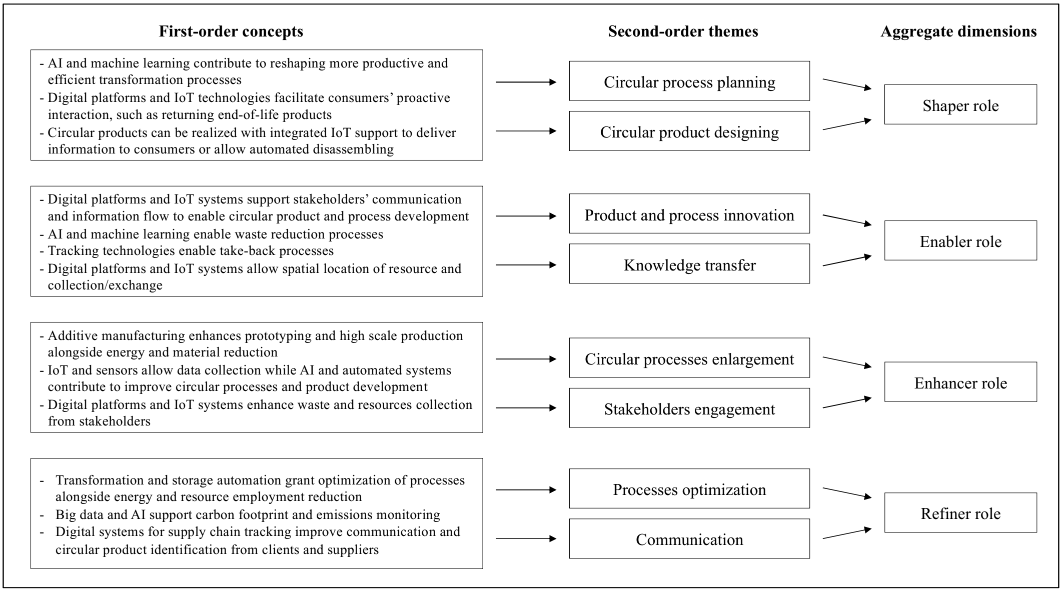

Figure 1. Data structure.
Source: Authors' elaboration.

tools. In this way, their *smart furniture* would integrate a QR code or near-field communication chip that returns information to the end consumer about how to contact the company to initiate the end-of-life take-back process of the product. Furthermore, it would be possible for L to have intelligent end-of-life products that can communicate to an AI about an item's material composition and how to disassemble it. The chief executive officer and the sales account of company N concurred with this role of digital technologies as their circular process for acquiring and remanufacturing end-of-life food-protecting cloth is being designed according to the opportunities afforded by digital technologies. Among the alternatives being considered is the use of a QR code alongside a digital platform to put the company in contact with the customer to arrange the collection of used items. In this vein, circular products tend to be shaped according to digital technologies implementation in circular businesses. As the chief executive officer of company H confirms, '*AI, machine learning, and IoT actively shape circular processes and product development in terms of productivity increasing, trend analysis, and obsolescence prevention*.' Through these examples, it was possible to outline the shaper role of digital technologies in terms of circular process planning and product designing oriented by the opportunities offered by business digitalization.

Secondly, companies in the first step stage have confirmed that the use of digital technologies enables them to initiate circular practices. As the chief executive officer of company A clearly explained, 'a*n interconnected system of exchange and sale of raw materials between players in the construction industry would not be possible without adequate technological support. Digital technologies offer interconnectivity, geographic identification, and information on raw materials (such as certifications) so that a company can directly acquire resources from the warehouse of someone else who does not use them, instead of buying a new one*.'

In company C meanwhile, AI and machine learning enable object detection and, with the support of automated systems, immediate action to be taken to remove or sort items with different densities. Deep learning software recognizes different materials based on their composition, enabling a circular processes aimed at reducing food wastage or recycling mixed waste. Likewise, the chief executive officer and the production manager of company J observed that '*certain circular processes need a digital component to enable stakeholders' coordination and information flow among the actors* *of a circular ecosystem.'* A similar function of digital technologies can be found in company I, where digital communication systems enable stakeholder coordination and waste material recovery to provide secondary raw materials used in cosmetics production. Overall, grounded observation of these economic realities has made it possible to outline the enabling role of digital technologies in circular businesses based on product and process innovation and knowledge transfer and communication among stakeholders.

In the expectation of accentuating the growth of their circular business, according to the circular climbing stage, the role of technologies becomes that of an enhancer that can further optimize and streamline the circular processes in place. As the special project manager of company F declared, '*we have enhanced waste recovery through a digital system, connecting our company with customers. Without digital technologies, we would not succeed in building the circular business we have today.'* From this experience, it was possible for company F to notice how sometimes digital technologies also work to enhance the circularity degree of a firm. Thanks to digital platforms and IoT systems, F's circular business entered the circular climbing stage through the engagement of several stakeholders and the enlargement of the circular process. In fact, both companies F and G have set up online collection systems for exhausted textiles directly aimed at end consumers, providing an incentive to recycle their garments. Furthermore, the critical enhancing role of digital technologies has been observed in the digital infrastructure built by organization G to organize garment collection from upstream stakeholders and optimize it by sharing information on the fabrics being processed. As such, the case researchers came to define enhancer as the third role of digital technologies, supporting the expansion of a CBM toward a circular climb.

Finally, in more mature circular businesses, digital technologies have been applied to optimize circular processes and further advance the degree of circularity. In this way, product development can be refined to become even more efficient, emphasizing the characteristics that tend to close the loop. As the chief executive officer of company F clearly stated, *'We aim to be a zero-waste company; we try to optimize each stage of the production process to use only natural products, reduce the use of energy and raw materials, and limit production waste as much as possible. In doing so, [company F] is pursuing to be 100% circular.'* This statement expresses company F's aspiration to constantly achieve a greater degree of circularity by reducing waste as much as possible and closing the loop. This goal requires aiming at the circular process optimization of renewable production and consumption systems in the fashion domain. Correspondingly, it was possible to investigate digital technologies implementation in company O in terms of data collection and analysis to support the monitoring of emissions and the carbon footprint of its sustainable sneakers. At the same time, in company M, circular maturity has been achieved through the employment of big data, AI, and machine learning technologies to make production processes more efficient and optimize business circularity, with IoT supporting partner interaction and circular product development by connecting actors in a circular value chain. The communication element of a CE strategy has also been observed in company B as a tool to optimize the value generated from a CBM. In this case, the employment of digital systems allows supply chain tracking and certified circular product identification from clients and suppliers, while AR delivers product information as a replacement for analog media. Company B's chief executive officer also mentioned their use of big data and AI to optimize the waste reduction of energy and resources during product development. In their circular maturity, the firm is still struggling to reduce water input in leather production and impurities released by the transformation process, along with the reduction of cutting waste through the use of precision technologies. As a result of these observations, we have therefore identified the role of refiner based on the needs and respective use of digital technologies by circular businesses facing circular maturity.

To summarize, we obtained a newly developed model that represents circular business development by parsing the different roles that digital technologies may assume to support each step of the *going circular path* (Fig. 2). Finally, we would like to point out that the *going circular path* is meant to be an explanatory model of the evolution of a circular business, where the various functions of digital

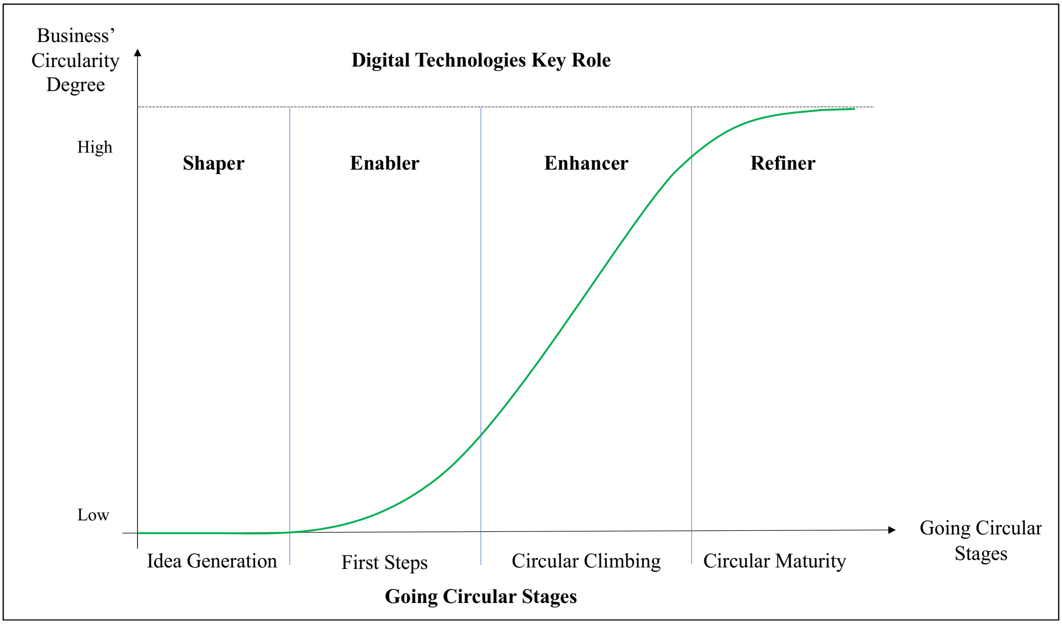

Figure 2. The going circular path and digital technology's role in circular businesses.
Source: Authors' elaboration.

technologies (i.e., shaper, enabler, enhancer, refiner) are embedded. Although these steps could overlap, for instance by pursuing an optimization strategy while a circular climbing process is in progress, they represent an attempt to model reality and are therefore subject to the heterogeneity of companies, the context in which they are located, and the complexity of CBMs.

Discussion and theory building

Through the theoretical lenses offered by the extended institutional theory (DiMaggio & Powell, 1983; Haunschild & Miner, 1997; Meyer & Rowan, 1977), the authors investigated economic organizations' isomorphism in adopting digital supports to translate CE principles into feasible circular products and processes. This research built on previous scientific contributions that outlined the association of circular businesses with digital transformation and Industry 4.0 (e.g., Chauhan, Parida, & Dhir, 2022; Dantas et al., 2021; Gebhardt et al., 2022; Hina et al., 2022; Liu et al., 2022; Pizzi, Corbo, & Caputo, 2021; Ranta, Aarikka-Stenroos, & Väisänen, 2021). Although numerous authors have contributed to designing an interesting picture of digital technologies' implementation in CBMs (e.g., Franzò et al., 2021; Ghobakhloo, 2020; Kristoffersen et al., 2020; Pizzi, Leopizzi, & Caputo, 2021), the present study responds to the compelling lack of guidance on the implementation of digital technologies according to their function in granting a higher degree of circularity to sustainability-sensitive businesses (Chauhan, Parida, & Dhir, 2022; Kristoffersen et al., 2020). Based on empirical cases described in the CE literature or policymakers' publications (e.g., European Commission, 2023), it is clear how digitization is profoundly affecting traditional business models and, increasingly, how this is coupled with the transition to renewable production systems. In this context, we believe our attempt to outline a more detailed perspective of circular business evolution according to the adoption of digital technologies offers solid support for scientists and practitioners. Notably, the contribution of this article is based on SMEs and thus winks at economic realities characterized by organizational agility and flexibility, as well as dynamism, in response to external conditions (Chaudhuri, Subramanian, & Dora, 2022; De Angelis, Howard, & Miemczyk, 2018; Dey et al., 2022; Pizzi, Corbo, & Caputo, 2021;

Troise et al., 2022). Drawing on the discussion of our findings, some inferences can be delivered for building theory in the CE domain. Hence, the authors advance the conceptualization of five original propositions supported in this section.

As a result of our multiple case study, we deliver an original *going circular path* expressed through our model represented in Fig. 2. The case researchers observed how digital technologies intervene in four specific circumstances in the establishment of a circular business: (a) during the idea generation phase, where circular practices are shaped according to available digital supports; (b) when the circular business is taking its first steps facing markets or stakeholders, where they act as an enabling factor for the initiation of a CE practice; (c) through the circular climbing phase, where they represent a critical factor for enhancing the sharp growth of organizations' degree of circularity; and (d) during the circular maturity stage, when they help refine a circular practice or product development. These enlightening findings allow us to participate in the literary debate around circular businesses by bringing together several studies and offering new insight into the subject. More specifically, we build on the work of Franzò et al. (2021), which outlined an early phase of idea generation based on circular product development. Coherent with our findings, the path toward the establishment of a circular business goes through the assessment of resources and support that the company owns or can acquire, along with technological possibilities, stakeholder participation, and market appreciation (Lilien, Morrison, Searls, Sonnack & Hippel, 2002; Panizzolo, Biazzo & Garengo, 2010; Pinheiro et al., 2018). The present research emphasized the role of digital technologies in shaping circular businesses' idea generation wherever they can effectively support the translation of CE principles into feasible practices. As suggested by previous studies, companies can take advantage of digital platforms and communication systems to allow stakeholder interaction and collaboration (e.g., Gebhardt et al., 2022; Pizzi, Leopizzi, & Caputo, 2021), IoT systems to monitor or collect data in smart factories (Rejeb et al., 2022; Rusch, Schöggl, & Baumgartner, 2022), and big data analytics and AI forecasting to assist in decision-making (e.g., Gupta et al., 2019; Jabbour et al., 2019; Liu et al., 2022; Ranta, Aarikka-Stenroos, & Väisänen, 2021) or developing lean production and additive manufacturing systems (Dahmani et al., 2021; Sanchez, Boudaoud, Camargo & Pearce, 2020). As such, new cutting-edge technologies offer more and more opportunities for slowing, narrowing, and closing resource and energy flows (Bocken et al., 2016; Dantas et al., 2021; Geissdoerfer et al., 2018; Kristoffersen et al., 2020). In this regard, the perspectives offered by digital tools available to businesses (or not) inexorably condition and shape the exploitation of sustainable opportunities through the adoption of CE principles (Averina, Frishammar, & Parida, 2022; European Commission, 2023; Khan et al., 2020). We can thus advance the following proposition:

P1: Available or acquirable digital technologies shape the design of circular practices in terms of process planning and product designing, so as to orient circular business establishment.

In considering the first steps phase of the *going circular path*, our results suggest that digital technologies represent an essential means without which it would not be possible to achieve certain circular practices. Thus, we outlined their enabling role in the realization of circular processes or product development. These findings are supported by the CE literature, where previous studies have recognized the magnitude of business digitalization in achieving circular practices (e.g., Chaudhuri, Subramanian, & Dora, 2022; Chauhan, Parida, & Dhir, 2022; Kristoffersen et al., 2020). In agreement with Ranta, Aarikka-Stenroos, & Väisänen (2021), Rusch, Schöggl, & Baumgartner (2022), and Wilts et al. (2021), our empirical investigation confirmed the enabling role of big data management in conjunction with AI and machine learning systems for streamlining waste, recovery, and recycling processes. Also, digital platforms and IoT technologies were shown to enable data collection and inter-firm communication, localization, and resources exchange or collection based on circular initiatives (Gebhardt et al., 2022; Kerin & Pham, 2019; Rejeb et al., 2022). Therefore, this study contributes to enriching the literary segment straddling CE and digital transformation by contextualizing when companies are required to rely on digital technology to substantiate a circular practice (Huynh, 2021). It furthers academics' and practitioners' knowledge by highlighting the distinction between the enabling function of digital technologies and the enhancing function found during the circular climbing phase. Initially, digital technologies can be used to introduce and implement a circular practice, ensuring a modest increase in the degree of circularity. At a later stage, circular businesses may then perceive the need to further employ digital tools to support the scalability of circular practices. We theorize on the basis of previous studies, where either this difference has not been clearly unfolded or findings have not been embedded in a well-defined evolutionary pattern. For instance, Chauhan, Parida, and Dhir (2022) and Kristoffersen et al. (2020) advanced two reviews based on literature and practice evidence in which digital technologies have been blurrily considered as circular strategies enablers and enhancers in newly developed frameworks to support companies' CE transition. In line with the enhancing function of digital supports, Bag et al. (2021) outlined how big data analytics can be leveraged to enlarge sustainable manufacturing and CE capabilities to achieve a higher degree of circularity. Similarly, Khan et al. (2021) concluded that blockchain technologies can act in favoring CE practices (i.e., circular purchasing, circular design, recycling, and manufacturing), which in turn can represent higher environmental and financial performance. Liu et al. (2022) also back up our findings by outlining some digital functions aimed at specifically enhancing CE strategies while focusing on data collection and integration, data analysis, and automation in improving CE performance. As such, this study builds on the previously recognized role of digital technologies to advance an original perspective that emphasizes the enabling and enhancing roles of digital technologies against two distinct needs recognized in circular businesses: initiating a circular process or developing a circular product versus widening the range of a circular practice. According to these roles attributed to digital technologies during businesses' *going circular path*, the following propositions can be posited:

P2. Digital technologies enable circular principles translation and integration in businesses for implementing circular processes and realizing circular products and services.

P3. Digital technologies enhance circular processes enlargement and circular products adoption by leveraging stakeholders' engagement, accentuating the scope of circular practices.

Last but not least, our conceptual model advances the ultimate stage of the *going circular path*: circular maturity. Drawing on the empirical cases we had the opportunity to closely observe, it is possible to conclude how circular businesses' major needs at this stage are process efficiency optimization and cost reduction. The circular maturity stage is ascribable to companies characterized by an advanced degree of circularity, where digital technologies are employed as circular strategy refiners. For instance, data collection and analysis systems were shown to be used to monitor emissions and externalities of circular products and processes. Here, big data, AI, and automated systems come into play to optimize energy and resource input, as well as to reduce waste in production processes and enable recycling practices. Also, IoT can be leveraged to further improve supply chain coordination and communication. In agreement with our findings, Liu et al. (2022, p. 331) highlighted the "optimize" function of digital technologies as an attempt to "improve performances and reduce negative impacts, such as increasing efficiency and reliability in the production system while reducing emissions and energy consumption." In previous studies, process circularity has been shown to be related to production cost reduction, alongside the implementation of innovative circular practices (Darmandieu, Garcés-Ayerbe, Renucci & Rivera-Torres, 2022; Jabbour, Jabbour, Godinho Filho & Roubaud, 2018; Yang, Fu & Zhang, 2021). Therefore, our research effort complements these earlier studies by identifying a specific phase in which circular businesses capitalize on digital technologies as a refining tool in circular strategies. The following proposition is thus put forward:

P4. Digital technologies can be implemented to further refine a circular business in terms of process optimization and communication to stakeholders, aiming toward an entirely renewable business.

In addition, the case researchers managed to observe on various occasions how digital technologies can effectively foster circular practices implementation in companies. Consistent with prior studies (e.g., Chauhan, Parida, & Dhir, 2022; Dantas et al., 2021; Kristoffersen et al., 2020; Liu et al., 2022; Pizzi, Leopizzi, & Caputo, 2021; Ranta, Aarikka-Stenroos, & Väisänen, 2021), we reinforce the link between digitization and sustainability in business. In different circumstances, digital transformation provides companies with the means to exploit sustainable opportunities through process adaptation or innovative circular product development. This study highlights how the proper exploitation of digital tools in establishing circular practices also depends on the specific function they can play according to the degree of circularity of the business. Therefore, we can advance the following last proposition:

P5. Overall, digital transformation (and Industry 4.0) effectively supports the development and thriving of circular businesses as long as digital technologies are properly exploited according to their job to be done.

Theoretical contributions

In summary, it is possible to identify some major contributions to theory as a result of the abductive abstraction of the information grounded in our case studies. First, the present study enriches the CE literature by advancing a *going circular path* that outlines four evolutionally stages of circular businesses according to their degree of circularity. Based on the origin of resources employed, the externalities deriving from production and auxiliary activities, and the properties of circular products and services, a common path has been outlined that systematizes the adoption of CE principles in agile organizations (Bocken et al., 2016; Franzò et al., 2021; Hopkinson et al., 2018; Lüdeke-Freund, Gold, & Bocken, 2019; Santa-Maria, Vermeulen, & Baumgartner, 2022). As a second contribution, this research unveils four functions fulfilled by digital technologies in undertaking a CE transition to achieve a higher degree of circularity. Building on assimilable circular strategies involving digital tools identified in previous studies (e.g., Bag et al., 2021; Jabbour et al., 2018; Khan et al., 2021; Liu et al., 2022; Pizzi, Leopizzi, & Caputo, 2021; Ranta, Aarikka-Stenroos, & Väisänen, 2021), the authors improved digital technologies adoption awareness in circular businesses through the association of a specific role with each step of the *going circular path* (Chauhan, Parida, & Dhir, 2022; Kristoffersen et al., 2020; Liu et al., 2022; Pizzi, Leopizzi, & Caputo, 2021). Third, we deliver some important considerations regarding how SMEs transition toward a renewable production and consumption paradigm (Centobelli et al., 2021; Darmandieu et al., 2022; Dey et al., 2022; Mura, Longo, & Zanni, 2020; Zhu et al., 2022). More precisely, this article unveils SMEs strategies for translating CE principles into circular processes and products thanks to the support of digital technologies and Industry 4.0 structures (Chaudhuri, Subramanian, & Dora, 2022; Pizzi, Corbo, & Caputo, 2021; Troise et al., 2022). Although this study took into consideration SMEs due to their agile and flexible condition in approaching CE, we believe our findings can also be applied to ambidextrous organizations due to their similar traits (Bresciani, Ferraris, & Del Giudice, 2018; Chaudhuri, Subramanian, & Dora, 2022; Jain et al., 2020; Marrucci, Rialti, & Balzano, 2023; Scuotto et al., 2017). In conclusion, the fourth contribution of the study is addressed toward the enrichment of the extended institutional theory in the CE domain (DiMaggio & Powell, 1983; Haunschild & Miner, 1997; Meyer & Rowan, 1977). We contribute to earlier studies in depicting circular businesses isomorphism (e.g., Do et al., 2022; Jain et al., 2020; Meherishi, Narayana, & Ranjani, 2019; Ranta, Aarikka-Stenroos, & Mäkinen, 2018) by advancing the perspective of CBMs' legitimation of business digitalization. More specifically, the present research succeeds in furthering circular businesses isomorphism's appreciation of implementing digital technologies by offering four different perspectives of the basis of digital tools integration.

Managerial implications

Furthermore, our results generate remarkable implications for chief executive officers, chief sustainability officers, and sustainability specialists who are attempting to translate their businesses according to CE principles. In the form of best practices and guidelines, this study provides a *going circular path* for organizations yearning to embrace CE and suggests how the application of digital technologies can improve their circularity degree. Thus, practitioners can rely on an evolutionary roadmap to plan a circular business transition or to improve the circularity degree of their organization. Accordingly, managerial figures committed to sustainability may take advantage of the advanced conceptual model while considering which digital tool or support best fits their business' available resources and technological facilities. In the long run, we hope to inspire the implementation of CE practices among sustainability-sensitive companies to increase the widespread adoption of circularity in the world and close the Circularity Gap.

Future research avenues

The present research highly encourages future studies to expand the awareness of each step of the *going circular path* and focus on the advanced roles of digital technologies in supporting the circular transition. From now on, in fact, it might be worthwhile to unpack the circularity transition of sustainability-sensitive organizations. Doing so would offer a better conceptualization and support to the chief sustainability officers and sustainability specialists, providing a compass capable of navigating these managers through the circular business transition. Furthermore, this research is also intended to highlight the need for further quantitative studies on the subject, particularly ones aimed at assessing the relationship between the adoption of digital technologies and the success of circular businesses. Other aspects, such as agility or the presence of organizational flexibility, could in turn improve the starting conditions of businesses and facilitate their approach to a renewable system (Dey et al., 2022; Jain et al., 2020; Troise et al., 2022). In addition, future studies could consider the difference between circular businesses that operate according to a B2B or B2C approach, as well as considering the approach of native circular companies versus adopters that approached a circular transition from the linear economy (Rovanto & Bask, 2021).

Such a fascinating research stream can also find new research opportunities in the incorporation of the serendipitous dimension in the advanced model (Balzano, 2022; Dew, 2009). Since luck has often been acknowledged as a relevant factor in explaining organizational phenomena, some types of luck, such as serendipity, can be included as an external factor in the strategic formulation and managerial processes of circular businesses. Due to the rapid approach to business model innovation required while dealing with sustainability and digitization, the serendipitous dimension could yield interesting insights offering an agile and flexible strategy exploiting sustainable opportunities (Averina, Frishammar, & Parida, 2022; Mirvahedi & Morrish, 2017). In this vein, future scholars could implement the *going circular path* with a serendipitous dimension, for instance by exploring the serendipitous effects related to the adoption of digital technologies in effectively fostering business circularity in SMEs.

On the other hand, the CE and digital transformation fall into the naturalized constructs belonging to the management field, which has been typically framed as positive in nature (Adler, Forbes, & Willmott, 2007, p. 126). Thus, the majority of the authors dealing with these topics are nearly always concerned with the positive behavior, conditions, and outcomes of digitalization and sustainability in businesses. Future studies could investigate the counter side of the coin by challenging such normalized assumptions to uncover conditions under which digital technologies and circularity in businesses lead to a series of undesired outcomes. For instance, we encourage exploring the potential challenges and risks associated with the adoption of digital technologies in circular businesses, such as data security, privacy concerns, technological complexity and skills gaps, change management and organizational culture issues, the digital divide among SMEs, and so on.

Conclusions and limitations

In conclusion, this qualitative paper has explored the adoption of digital technologies in SMEs within the context of the CE. Through a multiple case study analysis conducted wearing positivist philosophical lenses, the research provides valuable insights into the ways in which SMEs leverage digital transformation to embrace CE principles. Our findings led to the development of a *going circular path*, where digital technologies assume different functions – shaper, enabler, enhancer, and refiner – according to a company's circularity degree. By adopting digital technologies according to the advanced conceptual model, SMEs can seize opportunities related to the CE and overcome different barriers in establishing circular processes or developing circular products. Thus, the present study has recognized and confirmed several benefits arising from the integration of digital technologies in circular businesses, including increased resource efficiency, improved supply chain management, enhanced stakeholder engagement, and the development of innovative circular products and services.

It is important to acknowledge the limitations of this research, however. Firstly, the study focused solely on SMEs, and the findings may not be applicable to larger entities characterized by a less agile and flexible organizational structure. In addition, this research does not take into consideration the distinction between B2B and B2C circular organizations, or the possibility of examining separately born circular businesses (i.e., natives) and entities transitioning from a linear model to a CE (i.e., adopters) (Rovanto & Bask, 2021). Finally, even though the research is based on a qualitative in-depth analysis of several multiple case studies, the generalizability of the findings is still limited by the number of firms observed. Further research using quantitative methods, besides having a larger sample size, could provide a complementary understanding of the effectiveness of digital technologies in establishing sustainability-sensitive organizations.

Conflicts of Interest. None declared.

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