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Small Steps to Big Change: The Role of Digitalization, Social Interaction, and Competitive Advantage for Circular Economy Implementation in Small and Medium-Sized Enterprises

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Abstract

Circular economy (CE) is one of the most promising approaches for sustainable business development and achieving climate targets. Small and medium-sized enterprises (SMEs) play a significant role in this context due to their predominance in many countries and their associated ecological and economic impact. Although studies indicate that CE offers various environmental and economic benefits, its implementation within SMEs remains relatively low. While SMEs face multiple challenges and barriers, there is still a lack of insights into the factors that can accelerate CE practices. A promising approach to overcoming these challenges involves digitalization, social interaction, and innovation capability. Essay I focuses on the influence of digitalization on the implementation of CE practices in German SMEs, focusing on specific digital technologies. We find that the breadth of digitalization drives CE implementation, with certain digital technologies like the digitalization of operational and manufacturing processes and the use of e-commerce showing significant positive correlations. However, combining digitalization with sustainability commitment does not significantly impact CE implementation in SMEs. Essay II examines the correlation between social capital and CE implementation in German SMEs. We identify a positive link between social capital and CE implementation, with dynamic capabilities playing a mediating role. Essay III investigates the relationship between innovation capability and CE implementation in German SMEs and their impact on competitive advantage. The results reveal a positive association between innovation capability and CE implementation, as well as between CE implementation and competitive advantage. However, CE practices do not mediate the relationship between innovation capability and competitive advantage. Overall, this dissertation relies on primary data and provides new empirical insights into the factors that can facilitate the implementation of CE in SMEs. These insights could help companies, institutions, and policy makers to target the mechanisms that inhibit and accelerate the implementation of CE practices and further facilitate the path toward a circular business environment.

Summary in German

Die Circular Economy (CE) ist eine der vielversprechendsten Modelle für eine nachhaltige Unternehmensentwicklung und die Erreichung der Klimaziele. Kleine und mittlere Unternehmen (KMU) spielen in diesem Zusammenhang eine wichtige Rolle, da sie in vielen Ländern einen hohen ökologischen und ökonomischen Stellenwert inne haben. Obwohl Studien darauf hinweisen, dass CE verschiedene Vorteile bietet, ist die Umsetzung in KMU gering. Während KMU mit zahlreichen Herausforderungen und Hindernissen konfrontiert sind, fehlt es an Erkenntnissen über die Faktoren, die die Umsetzung von CE beschleunigen können. Ansätze zur Überwindung dieser Herausforderungen sind die Digitalisierung, soziale Interaktion und Innovationsfähigkeit. Essay I konzentriert sich auf den Einfluss der Digitalisierung auf die Umsetzung von CE-Praktiken in deutschen KMU, wobei der Schwerpunkt auf spezifischen digitalen Technologien liegt. Die Ergebnisse zeigen, dass die Breite der Digitalisierung die Umsetzung von CE vorantreibt, jedoch die Kombination von Digitalisierung und Nachhaltigkeitsengagement keinen signifikanten Einfluss hat. Essay II untersucht die Korrelation von Sozialkapital und CE-Implementierung in deutschen KMU. Hierbei zeigt sich ein positiver Zusammenhang zwischen Sozialkapital und CE-Implementierung, wobei dynamische Fähigkeiten eine vermittelnde Rolle spielen. Essay III untersucht den Zusammenhang zwischen Innovationsfähigkeit und CE-Implementierung in deutschen KMU und deren Auswirkungen auf den Wettbewerbsvorteil. Es wird ein positiver Zusammenhang zwischen Innovationsfähigkeit und CE-Implementierung sowie dem Wettbewerbsvorteil festgestellt. Insgesamt stützt sich diese Dissertation auf Primärdaten und liefert neue empirische Erkenntnisse über die Faktoren, die die Umsetzung der CE in KMU erleichtern können. Diese Erkenntnisse helfen Unternehmen, Institutionen und politischen Entscheidungsträgern dabei, die Mechanismen, die die Umsetzung von CE-Praktiken hemmen oder beschleunigen, gezielt anzugehen und den Weg zu einem kreislauforientierten Geschäftsumfeld weiter zu erleichtern.

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Nomenclature

Abbreviations

AVE	Average variance extracted
CE	Circular economy
CEAP	Circular economy action plan
CR	Composite reliability
CtS	Commitment to sustainability
C2C	Cradle-to-Cradle
DC	Dynamic capabilities
DT	Digital technologies
EMF	Ellen MacArthur Foundation
EU	European Union
LLCI	Lower limit confidence interval
MSME	Micro, small and medium-sized enterprises
N	Number of observations
RBV	Resource-based view
SC	Social capital
SE	Standard error
SME	Small and medium-sized enterprises
ULCI	Upper limit confidence interval
VIF	Variance inflation factor

Symbols

%	Percent
€	Euro

1 | Introduction

In this dissertation, I explore the implementation of the circular economy (CE) in German small and medium-sized enterprises (SMEs) through three independent essays. Essay I examines digital technologies and commitment to sustainability, Essay II investigates social capital and dynamic capabilities, and Essay III delves into innovation capability and competitive advantage. The following introduction underscores the significance of the CE and the relevance of SMEs in this transition. Section 1.2 focuses on the explanation of the CE concept while discussing definitions and frameworks. In section 1.3, I outline the current state of research and elaborate the research gap for each essay. Section 1.4 highlights the research overview, emphasizing theoretical and practical contributions, while section 1.5 provides an overview of the dissertation structure.

1.1 Motivation

"SMEs can play a key role in broadening the range of circular products and services available and making circular options convenient for customers."

Ellen MacArthur Foundation (2021)

For most of Earth's existence, the planet has functioned as a typical circular system. The Sun's energy nourishes trees, and once they fall, microorganisms break them down into soil and nutrients that fuel the next generation's growth. The concept of waste did not exist; everything had a purpose. This cycle has only been broken by humans in the last few hundred years. The emergence of the "Industrial Age" came with a linear economic model centered on the consumption of natural resources, where energy was transformed into goods and products to be used and subsequently discarded. The "Industrial Age" improved the lives of billions of people, but it also came at enormous cost to the planet's future. Under current conditions, humanity needs 1.7 Earths to maintain its consumption of natural resources. This is reflected

in Earth Overshoot Day, which shows the date from which humanity has used up the available resources and is living at the Earth's expense. While it was on August 2, 2023, it will be on July 25, 2024, according to forecasts (Diep, 2024). In the past 50 years, global raw material consumption has nearly quadrupled, exceeding 100 billion tons (Circle Economy, 2023). The Global Footprint Network has recorded resource deficits since the 1970s which accelerates every year. By 2050, humanity is expected to generate 3.5 gigatons of solid waste annually (Chen et al., 2020).

Today's socioeconomic systems are based on a linear economic principle in which materials and products are produced, consumed, and finally disposed of when they no longer serve their purpose. The linear economy depletes the earth's limited materials and contributes significantly to global greenhouse gas emissions and waste (Circle Economy, 2023). Therefore, it is crucial to protect the planet while simultaneously enhancing the quality of people's lives. To achieve this, we need to dissociate economic growth from the consumption and the disposal of waste. Based on the above fact, transitioning to a CE is a pivotal approach to solving these pressing environmental and societal challenges. The fundamental goal of the CE is to minimize waste generation and maximize the efficient reuse of materials (Ellen MacArthur Foundation, 2019). This transformative approach seeks to close the loop of resource utilization, creating a regenerative system that promotes sustainability across industries (Sharma et al., 2021). Bocken et al. (2016) position the CE as a shift towards a systems-building orientation characterized by innovative business model configurations, emphasizing the transition from conventional linear systems, known as "Take – Make – Use – Waste" to strategies that focus on narrowing, slowing, as well as closing resource loops. Bocken et al. (2016) point out that a circular business model necessitates innovative approaches to business thinking and operations. Hence, a CE offers a fundamentally new paradigm of industrial organization that is needed to decouple rising prosperity from growth in resource consumption (Geissdoerfer et al., 2017).

Beyond environmental considerations, CE could serve as a catalyst for economic growth. With a restorative and regenerative frame, a CE aims to increase production and consumption efficiency and redefine growth as a methodology that benefits businesses, society, and the environment. Horbach and Rammer (2020) show that firms with circular innovations have a significantly better financial standing. Furthermore, CE has the potential to generate economic growth and competitiveness (Chen & Pao, 2022). CE practices and strategies pertaining to human resources (equality, well-being, and rewards) improve an organization's capacity for

creativity, intellectually stimulate employees' task performance, and encourage change (Dey et al., 2020).

Despite the numerous benefits that a CE is purported to offer, its implementation remains relatively low (De Pascale et al., 2023). The EU's circularity rate, which represents the proportion of used materials sourced from recycled waste, reached 11.5 percent across Europe and 13.0 percent in Germany in 2022 (Eurostat, 2023). Although an 11.5 percent circularity rate may seem like a worthy starting point, this figure represents a mere 0.8 percentage point increase since 2010. De Pascale et al. (2023) further argue that within the EU, the most widespread CE strategy within their framework is recycling, accounting for 24.2 percent while, for instance, designing more sustainable, repairable and durable products is at a mere 2.8 percent, and the utilization of by-products from other process steps is at 4.1 percent. Moreover, CE practices are particularly applied in the food and beverage industries with 17.9 percent, with construction materials and products trailing at 11.0 percent (De Pascale et al., 2023). All this indicates that despite the outlined benefits and commitment from various governments, CE has not yet arrived in practice.

Although the CE approach has attracted the attention of large multinational organizations (Horbach & Rammer, 2020), SMEs tend to be less engaged (Johnson & Schaltegger, 2016; Kondala et al., 2023; Madrid-Guijarro & Duréndez, 2024). Hence, it is crucial to investigate the role of a CE in SMEs, since SMEs are regarded as one of the most promising contexts for the application of CE practices (Al-Awlaqi & Aamer, 2022). Nevertheless, SMEs are lacking behind in the development of sustainable measures (Álvarez Jaramillo et al., 2019). They tend to act more passively in their sustainable development efforts, as they do not normally assess the impact of their activities on the environment (Loucks et al., 2010). Furthermore, the literature indicates various challenges and barriers in implementing CE in SMEs (Dey et al., 2020; Ormazabal et al., 2018; Vermunt et al., 2019). One of the primary barriers identified is the lack of capital, which affects implementation due to high upfront costs, the transition of production processes, and the time commitment required from employees (Rizos et al., 2016). Additionally, SMEs tend to exhibit a deficiency in knowledge about sustainability (Ferreira & Ferreira, 2023), inadequate technology capabilities (Rizos et al., 2016) and a lack of management commitment (Ormazabal et al., 2018). However, given that existing research on SMEs in the CE is predominantly qualitative (Kanda et al., 2024), it is crucial to examine research areas quantitatively through primary data analysis. Therefore, it is crucial to investigate factors that facilitate the implementation of CE practices in SMEs.

1.2 The concept of the circular economy

1.2.1 Definition

The contemporary understanding of a CE as an economic concept can be traced back to Pearce and Turner (1989) and shares several ideas with other concepts, such as the idea of an "economy in loops" by Stahel and Reday-Mulvey (1981) or the later 'Cradle-to-Cradle'-principle (C2C) by Braungart et al. (2007). Focusing more on the economic perspective of a CE, Stahel and Reday-Mulvey (1981) first demonstrated the theoretical economic and ecologic potentials of an "economy in loops" in 1976, after first mentioning the idea of an economy partially working in loops within a study for the Commission of the European Communities in Brussels in 1928. Being published as a book entitled "Jobs for Tomorrow, The Potential for Substituting Energy for Labor," their study indicated that positive potentials could be harnessed through regional loops and the promising impact this has on job creation, competitiveness, resource consumption, and waste reduction (Stahel & Reday-Mulvey, 1981). Picking up the idea of an "economy in loops", the German chemist Braungart and the American architect McDonough developed the principle of C2C towards the end of the 1990s, focusing more on the ecological perspective of a CE. By bringing together the biological cycle for the consumption of products as well as the technical cycle for service products, C2C aims at designing products that continually circulate in both closed cycles (Braungart et al., 2007). Products that follow this principle could then be disassembled or biodegraded at the end of their life cycle and transformed into new products, depending on which cycle they are in – without generating waste (Braungart et al., 2007).

Since Pearce and Turner first introduced the concept of a CE, there have been numerous different definitions of a CE. Due to the increasing economic and ecological importance in practice, a CE became more prominent in academia with a sharp rise in research over the last decade (Kirchherr et al., 2023). Among the first modern researchers dealing with the concept, Preston defined CE as "an approach that would transform the function of resources in the economy – waste from factories would become a valuable input to another process, and products could be repaired, reused or upgraded instead of thrown away" (Preston, 2012, p. 1). Carrying forward the idea of this new transformational economic model, the Ellen MacArthur Foundation (EMF) has developed into today's best-known and most important CE advocacy organization. Since its founding in 2010, the EMF has become the leading global organization

in building networks and cooperating with various institutions regarding CE. In collaboration with a wide range of companies, the EMF published a study in 2013 in which it made a vision of the practical potential of CE visible to the public for the first time (Ellen MacArthur Foundation, 2013).

Kirchherr et al. (2017, p. 226) systematically analyzed 114 definitions in the current scholarly and practitioner CE discourse and found in line with Geissdoerfer et al. (2017, p. 759) that the most employed definition has been provided by Ellen MacArthur Foundation (2013, p. 7): "[CE] is an industrial system that is restorative or regenerative by intention and design. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models." Therefore, the CE is a system solution framework that is based on three principles: elimination of waste and pollution, circulation of products and materials, and regeneration of nature (Ellen MacArthur Foundation, 2019). To drive forward these three principles, in 2020, the European Union (EU) introduced an industrial policy focusing on circularity as part of its Green Deal, accelerating the momentum of the topic of a CE. With the publication of the 'Circular Economy Action Plan' (CEAP) in the same year, the European Commission provided a framework for a CE by focusing on sustainable products, coordinated value chains, and waste prevention to achieve its goal of climate neutrality by 2050 (European Commission, 2020b). According to the CEAP the goal of CE is to "maintain the value of products, materials, and resources for as long as possible by returning them into the product cycle at the end of their use while minimizing the generation of waste" (European Commission, 2020b).

Kirchherr et al. (2023, p. 7) analyzed 221 CE definitions and concluded with the following meta-definition: "The circular economy is a regenerative economic system which necessitates a paradigm shift to replace the 'end of life' concept with reducing, alternatively reusing, recycling, and recovering materials throughout the supply chain, with the aim to promote value maintenance and sustainable development, creating environmental quality, economic development, and social equity, to the benefit of current and future generations. It is enabled by an alliance of stakeholders (industry, consumers, policymakers, academia) and their technological innovations and capabilities." This dissertation assumes this definition as the underlying understanding. CE can thus be summarized as a new economic paradigm that aims

to address global problems such as climate change, biodiversity loss, pollution, and resource scarcity.

1.2.2 Circular economy frameworks

Based on its principles and goals, research has brought up different frameworks for the concept of CE. In this chapter, three selected CE frameworks are introduced, providing theoretical guidance on how to design, implement, and measure the impact of circular initiatives.

Circular strategies

Building on the work of Stahel and Reday-Mulvey (1981) and Braungart et al. (2007), Bocken et al. (2016) introduced three different mechanisms of resource flow. In contrast to a linear economy having a linear flow of resources, these three mechanisms are introduced by the terminologies of narrow, slow, and close resource flow. In the context of a CE, "narrow," "slow", and "close" are principles or strategies that guide the design and operation of economic systems to minimize waste, optimize resource use, and promote sustainability. According to Bocken et al. (2016), the three mechanisms of resource flow fostering circularity within an economy:

1. *Narrowing resource loops*: The "narrow" principle involves narrowing material and energy loops within the economy, essentially reducing the diversity of materials and energy sources used in production and consumption processes. By narrowing loops, businesses and consumers can simplify recycling and recovery processes, making it easier to capture and reintroduce materials back into the economy. This principle emphasizes the importance of designing products and packaging using materials that are easy to recycle or biodegrade, reducing the need for complex sorting and processing infrastructure.
2. *Slowing resource loops*: The "slow" principle emphasizes slowing down the rate of consumption, production, and resource extraction to align with the Earth's regenerative capacity. This involves embracing practices that prioritize durability, longevity, and resource conservation. Slow consumption encourages consumers to invest in high-quality, long-lasting products, repair and maintain items instead of replacing them frequently, and consume less overall. Similarly, slow production focuses on reducing the speed and scale of manufacturing processes, implementing lean production methods, and minimizing waste generation.

3. *Closing resource loops*: The "close" principle focuses on closing the loop of material flows by creating closed-loop or circular systems where materials are continuously reused, recycled, or regenerated. This involves designing products, processes, and business models that minimize waste and maximize resource recovery. Closed-loop systems aim to eliminate the concept of waste by ensuring that all materials are either biodegradable and returned to the natural environment or recyclable and re-enter the production cycle. This principle encourages businesses to adopt strategies such as product design for disassembly, material recovery, recycling programs, and the development of circular supply chains.

Konietzko et al. (2020) added a fourth mechanism, namely, regenerate.

4. *Regenerating resource loops*: The "regenerate" principle goes beyond minimizing negative environmental impacts to actively restoring and regenerating natural ecosystems and resources. This involves adopting regenerative practices that enhance soil health, biodiversity, and ecosystem resilience while providing social and economic benefits to communities. In a CE context, regeneration encompasses strategies such as using non-toxic or biodegradable material and renewable energy. By prioritizing regeneration, businesses and societies can move beyond sustainability towards actively contributing to the regeneration of the planet's natural capital.

Overall, the principles of narrow, slow, close, and regenerate provide a framework for transitioning towards a more sustainable and regenerative economic system. By embracing these principles, businesses, governments, and individuals can work together to create a CE that benefits both people and the planet.

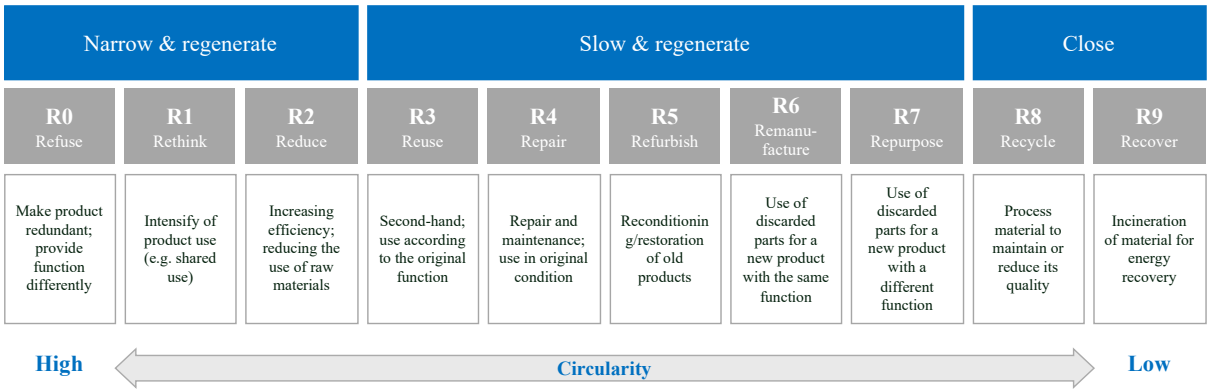
The 10R framework

Research has introduced further frameworks involving imperatives and strategies for individuals and institutions to put CE into action. In this regard, the oldest framework regarding CE imperatives is the 3R framework involving the three strategies "reduce", "reuse", and "recycle" (Blomsma & Brennan, 2017; Ghisellini et al., 2016). Following these imperatives, the EU introduced a framework in 2008 providing concrete strategies for implementing CE with its waste framework directive (European Commission, 2008). As part of this directive, a fourth strategy, called "recover", was introduced, which expanded the old framework into a new 4R framework. Over the last few years, different scholars have proposed adapted and extended frameworks such as the 6R framework (Sihvonen & Ritola, 2015). However, the most

recent and advanced framework is the 9R framework introduced by Potting et al. (2017), which was also adopted by the EU in 2020 (European Commission, 2020a). Although the framework introduced by Potting et al. (2017) is referred to as the 9R framework, some scholars such as Bag et al. (2021) refer to it as the 10R framework since it contains ten different R-strategies, as shown in Figure 1.

Figure 1

The 10R framework



Note. Own illustration (based on (Kirchherr et al., 2017; Potting et al., 2017)

According to Potting et al. (2017) the different R-strategies can be ranked according to their level of circularity and therefore presented in descending order from high to low. Providing the highest level of circularity, the first three strategies can be defined as strategies to facilitate smarter product use and manufacture. These strategies, therefore, relate to the stages before and during the manufacture of products. Especially the circular strategies "narrow and regenerate" cover these stages. R-strategies such as "refuse", "rethink", and "reduce" offer the highest potential to decrease resource consumption. Moreover, they also offer great potential for reducing waste by leading to reduced product manufacturing, optimized product use, and increased material efficiency through more sustainable product design from the very beginning. Following on from these, strategies "R3" to "R7" address the use phase during a product's lifecycle and can be summarized as life-extending strategies and hence slowing and regenerating resource loops. Of these strategies, the "reuse" and "repair" strategies still drive circularity at a medium-high level, as an entire product is reused second-hand or its condition is maintained. In contrast, the hierarchically following R-strategies "refurbish", "remanufacture", and "repurpose" intend to replace significant amounts of parts of an old product with new parts. For this reason, the degree of circularity is significantly lower than in the previous strategies and can thus be considered medium-low. Finally, the R-strategies "recycling" and "recovery" can be grouped as strategies for the useful application of materials,

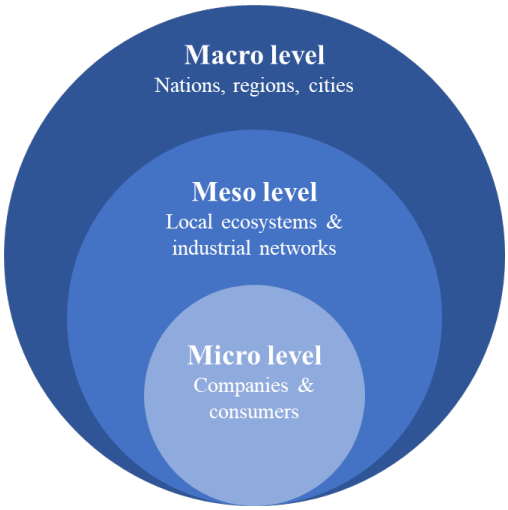
as they focus on the end of the life cycle of a product, closing resource loops, and thus on the future use of the materials. Because these strategies only involve the recycling or incineration of materials for energy recovery, both strategies “R8” and “R9” are considered to provide only a limited level of circularity.

In conclusion, the 10R framework offers a great set of strategies to further integrate circularity into manufacturing processes and product life cycles. Based on their level of circularity, strategies to facilitate smarter product use and manufacture are generally to be favored over life-extending strategies. Due to their low level of circularity, “recycle” and “recover” are given the lowest priority and are seen as the last possible resort within a CE to achieve circularity. The 10R framework is an effective guide for gaining an understanding of the different ways to achieve circularity in an enterprise and understanding the different impacts and potentials of each strategy.

The macro-meso-micro framework

Although CE has primarily gained momentum in the last decade, the concept first appeared politically in parts as early as 1996, when Germany introduced a law focused on waste treatment and recycling. China began incorporating the concept of CE into its policy agenda as early as 2002, and it has been prioritized in three successive five-year plans of the Chinese government from 2006 to today following the 3R framework of CE (Liu et al., 2017; Yuan et al., 2006). Since then, China has been observed to be actively implementing R-strategies at three levels: at a national level, at local and community levels, and at company and individual levels (Yong, 2007). Derived from this, as shown in Figure 2, research has found that CE can generally be considered applicable to three levels of strategy implementation and that strategies focus on a macro level, a meso level, or a micro level (Yuan et al., 2006).

Figure 2
The macro-meso-micro framework



Note. Own illustration (based on (Ghisellini et al., 2016; Kirchherr et al., 2018; Yuan et al., 2006)

At the highest level, R-strategies for implementing CE can be deployed on a macro level, generating circularity focused on nations, regions, and cities. In addition, van Bueren et al. (2021) propose that the macro level can be further subdivided, ranging from a global scale to a national scale to a large/small provincial scale to a neighborhood scale. According to Ghisellini et al. (2016), CE development at the macro level involves influencing economic, social, infrastructural, and legal systems through regulations and policies at a national or regional level.

At the second level, the meso level, CE strategies are focused more locally and thus on industrial networks and local ecosystems. As proposed by van Bueren et al. (2021), the meso level can be split into three scales: ecosystems, supply chain, and eco-parks. In this regard, the eco-park scale refers to companies close to each other forming symbiotic relationships, whereas the supply chain scale refers to the symbiotic process within one sector, and the ecosystem scale refers to symbiotic relationships between several sectors of a region. Therefore, R-strategies implemented at a meso level aim at creating an "industrial symbiosis" to achieve economic and environmental benefits (Ghisellini et al., 2016). The term "industrial symbiosis" "is usually applied to a network of independent companies that exchange byproducts and possibly share other common resources" (Zhu et al., 2007, p. 33). This is accomplished by the creation of industrial networks as well as ecosystems "that become engaged in complex interplays of resource exchange" (Ghisellini et al., 2016, p. 20). Hence, strategies implemented at a meso level typically focus on building networks along the value chain by promoting the

exchange of e.g., information, commodities, and infrastructure to benefit both regional production systems and environmental protection (Yuan et al., 2006).

Finally, at a micro level, CE actions are focused on individual entities such as companies and consumers. Again, as introduced by van Bueren et al. (2021), R-strategies focusing on this level can be further subdivided into four scales: businesses, single processes, objects, and consumers. They propose that the business scale represents the economic and environmental impact of an entire company, while the object, process, and consumer scale represent the impacts of an individual product, a manufacturing process, or an individual's or group's contribution to a CE (van Bueren et al., 2021). The impact of micro-level strategies is particularly dependent on the areas of production, consumer responsibility, green procurement, and waste management (Ghisellini et al., 2016). Therefore, R-strategies implemented at this level focus on improving business processes, such as production and waste management processes. Moreover, they aim to improve the environmental impact of individual entities, such as businesses, products, and consumers, by reducing resource consumption, increasing energy efficiency, and promoting sustainably designed products (Barreiro-Gen & Lozano, 2020).

In conclusion, the research by Yong (2007) and Yuan et al. (2006) offers a comprehensive theoretical framework to categorize CE strategies and initiatives based on their impact and focus level. In practice, most CE actions and efforts are focused on the macro and meso levels while, in contrast, strategies on a micro level are still limited (Barreiro-Gen & Lozano, 2020). In general, today's CE initiatives are thus primarily focused on larger companies, and the implications for SMEs are still lacking (Ormazabal et al., 2018).

1.2.3 Relevance of small and medium-sized enterprises

SMEs are recognized as the main contributors to economic growth and the primary job creators (Tian et al., 2021). SMEs account for approximately 90 percent of worldwide and 99 percent of European companies. They provide 70 percent of jobs and produce 60 percent of the total turnover. Their product spectrum ranges from manufacturing to services (Ormazabal et al., 2018). Their operational agility positions SMEs to rapidly find new market possibilities, adapt to new opportunities, and exploit new market prospects, especially during crises (Syriopoulos, 2020). The European Commission classifies SMEs as companies with less than 250 employees and an annual turnover not exceeding 50 million € or an annual balance sheet total not exceeding 43 million € (European Commission, 2003). SMEs are further categorized into micro which have fewer than ten employees and an annual turnover or balance sheet total of

less than 2 million €; small businesses with fewer than 50 employees and annual turnover or annual balance sheet total of less than 10 million €; and medium-sized enterprises, which have between 50 and 250 and an annual turnover between 10 and 50 million € or an annual balance sheet total between 10 and 43 million € (IfM Bonn, 2024) (see Table 1).

Table 1

Classification of SMEs

Size class	Number of employees	Annual turnover
Micro enterprises	up to 9	and up to 2 million €
Small enterprises	up to 49	and up to 10 million €
Medium enterprises	up to 250	and up to 50 million €
Large enterprises	more than 250	And more than 50 million €

Note. Own illustration (derived from (IfM Bonn, 2024))

The significance of providing a conducive environment for SMEs is emphasized by these figures, highlighting their crucial role in driving the economic development of Europe. SMEs possess unique characteristics that set them apart as a distinct research focus in comparison to larger corporations (Glasl et al., 2008; Pfohl, 2006). Focusing on (1) *legal forms*, SMEs typically have sole proprietorships, while some common legal forms of large and industrial enterprises are either stock corporations or limited liability companies. Also affected by differences in legal forms, SMEs and large companies vary in terms of their (2) *leadership and ownership structure*. While SMEs typically are managed by owners and their families who thus hold both management and ownership (manager owners), management and ownership are usually separate in large companies due to a different ownership structure. When it comes to (3) *funding*, the majority of SMEs are family-owned and do not have entry to capital markets. This results in constrained financial capabilities and inadequate risk management strategies. Additionally, the expertise of a small workforce, particularly in terms of academic qualifications, is a notable aspect of SMEs' (4) *human resources*. Furthermore, SMEs and large companies strongly differ in terms of their (5) *production*. Large companies are known for large sales volumes and great product complexity which is why there is a high level of automation and the use of special tools to facilitate mass production. In contrast, SMEs are known for single- and small-batch production with a low degree of automation and work division. Furthermore, (6) *research and development (R&D) activities* typically lack a formalized departmental structure and are conducted on a short-term basis, involving a significant element of intuition. Frequently, new products and services are created in response

to market needs rather than driven by a substantiated research agenda, given the constraints of time from innovation to commercialization. Moreover, there is a great discrepancy regarding (7) *procurement and sales* between SMEs and large industrial companies. While SMEs usually have limited market power due to their small size, large industrial enterprises typically tend to have great market power. Likewise, both company types strongly differ concerning their sales. While SMEs normally sell their products on local/regional markets having strong personal relationships with their suppliers and customers, industrial companies typically sell their products on national/international markets with rather anonymous relationships with customers and suppliers.

The role of SMEs for a circular economy

It is important to consider resource availability when implementing CE practices. While large enterprises typically have more resources and capabilities to invest in new production methods and can carry out activities (Garcés-Ayerbe et al., 2019), SMEs should continually be motivated to shift from circular practices to circular strategies to speed up the sustainable transition at multiple levels (Prieto-Sandoval et al., 2018). While SMEs make a significant contribution to the economy, their impact on environmental degradation is also concerning (Dey et al., 2020). The implementation of CE can be an effective strategy to simultaneously address environmental concerns and foster economic benefits, further sustaining competitive advantages for businesses. In the transition towards a more sustainable world, SMEs play an essential role, as emphasized by the EU's goal to lead the world to CE. This goal is underlined by the EU's strategies to support and enhance its capabilities (European Commission, 2020c).

Courrent et al. (2018) characterized SMEs in the following ways: Firstly, SMEs always have less complex financial structures, which may enable managers to vest in environmentally friendly initiatives without extensive justification. Secondly, SMEs may be more adaptable in meeting the changing demands of stakeholders. Thirdly, SMEs have less complicated and less hierarchical management structures resulting in "relatively low coordination costs", which facilitates internal collaboration when implementing environment-focused practices. Lately, due to SMEs limited resources, they may be more likely to have a better propensity to collaborate with external partners. These characteristics may be enablers that facilitate the implementation of CE practices in SMEs. Prieto-Sandoval et al. (2018) indicate that SMEs can achieve several benefits and opportunities by embracing CE practices, such as enhancing brand reputation, reducing operation costs, business expansion, increasing productivity, environmental recovery through lower CO2 emissions, and gaining a competitive edge. But

the researchers also reveal that the primary motivation of SMEs to adopt CE is the potential to save costs, rather than build brand reputation or respond to regulatory pressure. However, effective implementation of CE replies on various internal and external organizational elements. External factors contain public policy, market conditions, technological development, and stakeholder actions, while internal factors involve the companies' resources, capabilities, and competencies (Prieto-Sandoval et al., 2018).

Some characteristic features of SMEs, such as cultural barriers, limited client interest and awareness, and a cautious corporate culture, are viewed as the main challenges to implementing CE (Dey et al., 2022). Garcés-Ayerbe et al. (2019) distinguish the barriers to CE implementation are administrative processes, regulations, and a shortage of trained human resources; in the contracts, companies that have not adopted CE principles see financing, investment, and cost-benefit barriers as the most significant barriers. Additionally, management attitudes to CE principles are some of the major barriers to industries transitioning to CE (Chowdhury et al., 2022). Moreover, because SMEs often have limited technical and financial resources, they may not prioritize CE due to a lack of awareness of its benefits (Prieto-Sandoval et al., 2019). In addition, governments and policymakers provide limited support (Prieto-Sandoval et al., 2019).

In summary, this dissertation focusses on German SMEs because SMEs are the backbone for the German economy and Germany has a long historical background in developing environmental laws and the implementation of closed-loop recycling systems. As a result, German stakeholders have greater expectations of a company's environmental standards compared to stakeholders in other countries (Schmidt et al., 2021). In order to adhere to environmental legislations and fulfill stakeholder requirements, German SMEs demonstrate a high level of innovation, contributing to Germany as one of the leading innovation-based economies in Europe (Schmidt et al., 2021). Horbach and Rammer (2020) examine empirical evidence of the high level of CE innovations within Germany compared to other European countries. German SMEs are at the forefront of environmental awareness and adoption of CE practices, with the goal of maintaining their competitive advantages (Schaltenbrand et al., 2015). Investigating the strategic antecedents and outcomes of CE practices in German SMEs is advantageous due to CE plays a relevant role within the German business landscape, which mitigates the possibility of short-term effects (Schmidt et al., 2021). This dissertation targets different strategies in the context of digitalization (Essay I), social interaction (Essay II), and competitive advantage (Essay III) to enhance CE in SMEs.

1.3 Current state of research and research gap

Research on CE implementation in companies has steadily increased in recent years (Ahmad et al., 2023; Kirchherr et al., 2023; Schöggl et al., 2020). These studies often focus on large corporations, while research in the context of SMEs is scarce (Álvarez Jaramillo et al., 2019; Madrid-Guijarro & Duréndez, 2024). In particular, the theoretical and conceptual side is researched, while there is a lack of qualitative and quantitative research (Cullen & De Angelis, 2021; Kondala et al., 2023), especially in SMEs (Gennari, 2023). Regarding CE implementation, research is even less represented at the micro and meso levels compared to the macro level (Kirchherr et al., 2023). The company-internal (micro) and cross-company (meso) perspective on CE processes can therefore be expanded. To the fact, that SMEs suffer from their liability of smallness, as they only have limited monetary, time, personnel, and technical resources at their disposal (Kondala et al., 2023), this dissertation aims to shed light on three CE-related topics in SMEs: digitalization, social interaction, and competitive advantage through innovation capability. In order to further develop research in the context of CE in SMEs and to close the existing gap between theory and practice (Barreiro-Gen & Lozano, 2020), quantitative methods are applied in this dissertation.

Digitalization is a far-reaching trend that is the subject of a controversial debate with regard to sustainable development (Isensee et al., 2020). Digitalization is recognized as pivotal for advancing CE due to its capacity to enhance visibility and intelligence across products and assets (Antikainen et al., 2018). It encompasses the adoption and utilization of digital technologies (Legner et al., 2017). Digitalization leverages advanced digital technologies to revolutionize various aspects of the business model, including value proposition, creation, and delivery (Broekhuizen et al., 2021). Consequently, many firms are adopting digital technologies to reshape their business models (Nambisan et al., 2019). These technologies encompass a wide array of tools, such as sensor technologies (RFID, QR codes) for data storage, process digitalization, digital tools (3D printing, robotics, AI), smart devices (tablets, smartphones), social media, and e-commerce. They play a crucial role in addressing several prerequisites of the CE, including enhancing transparency in supply chains and products, facilitating new business models, and improving production processes (Alcayaga et al., 2019). Notably, the absence of digital technologies has been identified as a barrier to CE implementation for companies (Chauhan et al., 2022). While there is substantial knowledge about how digital technologies contribute to CE implementation within large corporations

(Neligan et al., 2023), the understanding of this relationship in the context of SMEs remains limited (Eller et al., 2020; Kristoffersen et al., 2020). An important challenge lies in the inherent limitations of SMEs, which often lack the resources necessary to adopt and implement digital technologies (Verhoef et al., 2021). Hence, **social interaction**, reflected in social capital, plays a critical role in SMEs and often shapes their culture, operations, and overall success. Social capital is a cornerstone of small business success, shaping its culture, relationships and resilience (Castilla-Polo & Sánchez-Hernández, 2022). By cultivating strong internal and external social networks, small businesses can leverage social capital to drive growth, innovation and long-term sustainability (Ince et al., 2023). Social capital acts as a social integration mechanism, enabling access to external resources and information that might otherwise be difficult to obtain (Zahra & George, 2002). Herewith, dynamic capabilities play a key role in leveraging social capital, allowing firms to effectively utilize the knowledge gained and develop complementary capabilities (Jantunen, 2005). Companies with high levels of dynamic capabilities can capitalize on social capital to enhance performance and gain a competitive edge, particularly in the context of implementing a CE (Hernández-Linares et al., 2021). SMEs, in particular, need to see value in their investments in order to apply new ones. For SMEs, the question of whether they gain a **competitive advantage** through new practices is, therefore, essential. The innovative capacity of companies is also related, as more innovative companies are often associated with a competitive advantage (Anwar, 2018; Jakhar et al., 2019). However, previous research has shown that SMEs pay less attention to innovation than large companies (Park et al., 2013). Especially in the rapidly changing economy, the prosperity of SMEs depends heavily on their ability to innovate (Denicolai et al., 2021; Hock-Doepgen et al., 2021; Saunila, 2020).

In this dissertation, I discuss the different variables of digital technologies, commitment to sustainability, social capital, dynamic capabilities, innovation capability, and competitive advantage that can simplify the implementation of circular economy measures and make them more attractive. Each of the three essays is based on its own research model, builds on a different existing strand of literature, and contributes to different academic discussions. These existing strands of literature are presented in the following three chapters.

1.3.1 Digital technologies for a circular economy

Current state of research

Digitalization is about the adoption and usage of digital technologies in manifold contexts (Legner et al., 2017). Digital technologies act as an enabler to improve or change business processes and thereby allowing new business opportunities (Verhoef et al., 2021). With regard to CE, the researchers agree that digitalization and the intensified use of digital technologies facilitate the implementation of CE. For example, Antikainen et al. (2018) describe that digitalization simplifies all forms of lending models through increased transparency and simplified data collection, thus promoting and facilitating the implementation of CE. In addition, they see a positive influence on all three forms of material flow influence - narrowing, slowing and closing. Other authors note that digitalization leads to more automation, product and process improvements, comprehensive information exchange and increased resource efficiency (Hojnik et al., 2023; Neligan et al., 2023). However, some authors also criticize the fact that there are too few empirical studies on the positive effects of digitalization on CE that have been derived in theory (Bag et al., 2021; Chaudhuri et al., 2022; Rosa et al., 2020). Antikainen et al. (2018) therefore deal with the opportunities and challenges that digitalization currently presents in the context of CE and the associated solutions. Neligan et al. (2023) conducted an empirical study among German companies on the question of whether digitalization is a driving force for CE business models. They also find indicators for the positive influence of digitalization on CE activities.

Research gap

Although firms' adoption of digital technologies is discussed as an enabler of CE in large companies (Antikainen et al., 2018), there is only limited research about the adoption of digital technologies in SMEs. While the literature on digitalization is growing, implementing digital technologies in SMEs is rare (Bag & Pretorius, 2022). Especially literature about what kind of digital technologies can support the implementation of CE in SMEs to focus on relevant digital technologies is scarce (Chauhan et al., 2022; Rosa et al., 2020). Only a few qualitative studies concentrate on the role of digital technologies regarding CE implementation in SMEs. For example, Chaudhuri et al. (2022), who conducted in-depth interviews, stated, that SMEs focusing on CE practices create more value for customers by adopting digital technologies. Hence, with the introduction of digital technologies, the implementation and value of CE

practices can be increased. However, they consider digital technologies as a whole and do not distinguish between different digital technologies. To my knowledge, no previous study has empirically tested whether and how SMEs adopting different digital technologies are more likely to implement CE practices. Particularly in the context of SMEs, this represents a significant knowledge gap, as owners, who have a large influence on the strategic decisions of the business (Jansen et al., 2013), are increasingly willing to adopt digital technologies if they see them as beneficial (Simmons et al., 2008).

1.3.2 Social capital and dynamic capabilities for a circular economy

Current state of research

Social capital plays a vital role in the success and resilience of SMEs (Russo & Perrini, 2010; Wulandhari et al., 2022). It fosters strong internal relationships, facilitates external networks and partnerships, promotes shared values and mission, enables adaptability and flexibility, enhances customer relationships, and supports effective communication and collaboration (Adler & Kwon, 2002; Wulandhari et al., 2022). By leveraging social capital effectively, SMEs can build competitive advantages, foster innovation, and sustain long-term growth in dynamic and challenging business environments (Ince et al., 2023). Social capital is a form of capital that every company possesses as soon as it interacts with social structures (Molina-Morales & Martínez-Fernández, 2010). Social structures and networks are generally used to exchange information with each other and therefore serve as a source of information for a company. The degree of a company's social capital then determines the extent to which the company uses this source of information to build up its own knowledge. Social capital in SMEs refers to the networks of relationships, trust, and shared norms that exist among employees, management, customers, suppliers, and other stakeholders within these organizations to achieve goals (Molina-Morales & Martínez-Fernández, 2010). In the context of this work, social capital is divided into three sub dimensions: Structural, relational, and cognitive social capital. Structural capital describes the relationships between different actors (Nahapiet & Ghoshal, 1998). The decisive factor here, for example, is where connections exist. The relational capital dimension focuses more strongly on individual relationships. Here, the focus is on the type of relationship between two actors, such as mutual respect or friendship, and their history. The relational capital itself then refers to the assets that have been built up through relationships with other

actors. The third dimension, cognitive capital, refers to the ideas and value systems that two parties share (Nahapiet & Ghoshal, 1998).

Research gap

Despite the growing individual contributions in both social capital and CE, the relationship between them remains relatively unexplored. Scholars have emphasized the significance of social capital in the context of CE (Perey et al., 2018; Skawińska & Zalewski, 2018). While some single case studies have investigated how companies utilize SC to implement CE practices (Germundsson & Gernandt, 2019; Istiyani & Wijayanto, 2022), quantitative studies analyzing the nuanced mechanisms focusing on social capital and CE are lacking. Our study aims to address this research gap. Given that studies exploring social capital have produced varied results depending on the dimensions of social capital (Nahapiet & Ghoshal, 1998), we approach social capital as a three-dimensional variable, recognizing that each dimension may have distinct impacts on CE implementation. Consequently, we can identify the most critical conditions within this three-dimensional model associated with implementing CE practices. Furthermore, the dynamic capabilities approach offers insight into this relationship, as dynamic capabilities enable companies to effectively leverage the knowledge acquired from their social capital (Jantunen, 2005), and may foster CE implementation in SMEs by facilitating access to stakeholders' information and enhancing the business model (Elf et al., 2022; Prieto-Sandoval et al., 2019).

1.3.3 Innovation capability in the context of a circular economy and a competitive advantage

Current state of research

Current practices of CE within SMEs primarily concentrate on waste reduction, minimizing energy consumption, and advocating for renewable energy usage (Dey et al., 2020; Katz-Gerro & López Sintas, 2019). Beyond the environmental advantages, embracing CE provides SMEs with additional incentives such as enhanced corporate image, cost reductions, and heightened productivity (Dey et al., 2020). Nevertheless, SMEs encounter escalating challenges in adhering to environmental and social standards outlined in local and global regulations, potentially impacting their competitiveness. Additionally, environmental and social initiatives are often linked with substantial costs (Dey et al., 2020). Prieto-Sandoval et al. (2019) observe that SMEs are faced with limited technical and financial resources, thus potentially

deprioritizing CE, particularly if they lack full awareness of its benefits. Scholars and industry experts commonly underscore that CE can give companies a competitive edge. Nonetheless, transitioning to a CE is not a straightforward endeavor; rather, it involves a complex process necessitating organizational change and innovation (Sehnem et al., 2022; Suchek et al., 2021).

Research gap

As competitive advantage in SMEs relies not solely on implementing CE practices but also on the broader capacity for innovation, it is imperative to delve deeper into SMEs' innovation capabilities. The ability to innovate is a critical factor that fosters a competitive edge for SMEs and enhances business performance (Chen et al., 2018; Tamayo-Torres et al., 2016). Businesses must innovate their processes, products, and services to align with sustainable concepts like CE. Consequently, innovation capabilities can aid companies in enhancing their environmental, economic, and social efficiency while creating market value. Suchek et al. (2021) advocate for expanding research in the intersection of innovation and CE and supporting it empirically with primary data. Sehnem et al. (2022) particularly stress the necessity for comparative studies and empirical validation of innovation capabilities within the CE context.

1.4 Research overview and contribution

To provide a holistic view of CE implementation in SMEs, this dissertation examines both the determinants and outcomes of a CE in three different research models. Each research model was addressed in a separate and independent research project. Therefore, this dissertation comprises three different essays. All three essays use quantitative research designs. While Essay II and III use a mediator analysis, the analysis in Essay I is based on a moderator analysis. In the following, I provide an overview of the research objectives, approaches, main findings and contributions of the essays.

Essay I In the first essay, we deal with the micro level of the CE. More specifically, the focus is on the operational perspective of different digital technologies promoting the implementation of CE practices in SMEs. The effect that digitalization has on the implementation of CE in large companies has already been researched (Agrawal et al., 2022; Antikainen et al., 2018). With regard to SMEs, digitalization facilitates the implementation of new business models (Bouwman et al., 2019; Isensee et al., 2020). However, none of the previous studies have investigated which digital technologies have a positive correlation with the implementation of

CE practices and whether the simultaneous use of several technologies, i.e. the breadth of digitalization, has a positive relationship. The digital orientation of a company often takes place without considering sustainability aspects (Isensee et al., 2020). However, due to the limited availability of resources, it is important for SMEs to combine strategies to achieve common goals (Heikkilä et al., 2018). Hence, we further investigate whether digital companies are more likely to implement CE activities if the companies are committed to sustainability. For this reason, we raise the following research questions: *Do different digital technologies facilitate the implementation of CE practices in SMEs? Does commitment to sustainability moderate the relationship between digital technologies and the implementation of CE practices in SMEs?*

Based on the resource-based view (Barney, 1991), we developed several hypotheses regarding the association of digital technologies with the implementation of CE activities and the moderating role of sustainability commitment. We consider six different digital technologies, namely (1) sensor technologies (RFID, QR codes) for data storage (Antikainen et al., 2018), (2) digitalization in processes (Neri et al., 2023), (3) digital tools (3D- printing, robotics, AI) (Neri et al., 2023), (4) smart devices (tablets, smartphones) (Ormazabal et al., 2018), (5) social media (Amoah et al., 2023), and (6) e-commerce (Romagnoli et al., 2020). We further analyze the role of commitment to sustainability as a possible moderator.

To answer the research questions, we conducted a large-scale survey of 754 SMEs. All variables considered were derived from the literature and use established scales. To explore the relationship between the variables and to test the hypotheses, we use multiple linear regression models. In the models, CE implementation is the dependent variable, while digital technologies are aggregated and considered individually as independent variables. Commitment to sustainability is analyzed as independent and moderating variable. As control variables, we used firm age, industry, segment and firm size counted as number of employees, in line with previous research (Ardito et al., 2021; Eller et al., 2020; Schmidt et al., 2021).

The empirical results show that the breadth of digitalization, i.e., the digital technologies in aggregated form, positively correlates with CE implementation (hypothesis 1). Investigating the six different digital technologies separately shows significant positive effects of all digital technologies on CE implementation. However, when focusing on the coexistence, we found that not all digital technologies simultaneously influence CE implementation. Process digitalization and the adoption of e-commerce mainly encourage the implementation of CE practices. However, sensor technologies (RFID, QR codes), digital tools (3D- printing,

robotics, AI), smart devices (tablets, smartphones), and social media do not have a significant association with CE implementation when investigated together. Furthermore, our results show that commitment to sustainability favors greener behaviors that lead to implementing CE practices in business processes (hypothesis 2). Third, while we test the complementarity of digital technologies and commitment to sustainability, we found no significant support for the assumption that the simultaneous pursuit of digital and environmental orientations is conducive to implementing CE practices (hypothesis 3). Based on the resource-based view, the complexity of managing the different types of resources underlying the adoption of digital technologies and the commitment to sustainability creates problems in allocating limited resources. Also, tying these resources to unrelated goals is more likely to lead to problems in attention allocation, especially among SME managers and employees (Ocasio, 1997, 2010).

With this study, we are making the following theoretical and practical contributions. Firstly, our research not only expands the understanding of digitalization within the context of CE implementation but also contributes to knowledge regarding the adoption of digital technologies in smaller firm settings, thereby providing a theoretical contribution to the CE perspective (Chauhan et al., 2022; Rosa et al., 2020). While several theoretical papers have illustrated how digital technologies facilitate CE (Antikainen et al., 2018), empirical studies validating this literature are lacking (Chauhan et al., 2022; Rosa et al., 2020). Secondly, this study enhances comprehension of the relationship between sustainability and CE implementation, revealing that environmental considerations, in addition to economic factors, play a crucial role in transitioning from a linear to a circular model. Building upon prior research (Ardito, 2023; Ardito et al., 2021; Neligan et al., 2023), our study extends this understanding to include the synergy between digitalization and sustainable practices in the context of CE implementation within SMEs, an area that remains underexplored. Hence, we address recent calls to bridge sustainability and digitalization (Broccardo et al., 2023; Isensee et al., 2020) and to broaden research horizons beyond the conventional scope of CE studies (Sehnem et al., 2022). Thirdly, while not all digital technologies are equally effective, certain ones serve as valuable tools for implementing CE practices. Specifically, the digitalization of service, operational, and production processes, as well as the utilization of e-commerce, positively influence CE practice implementation, particularly in narrowing, slowing, and closing material loops. This paper offers guidance to managers in selecting relevant digital technologies to align with circular activities. Although individual digital technologies may not fully support CE implementation on their own, integrating multiple digital technologies, where

feasible, represents the optimal approach. Consequently, practitioners are encouraged to intensify their digitalization efforts to support and facilitate CE practices effectively.

Essay II The second essay deals with the micro and meso levels of the circular economy. The focus here is particularly on the inter-company level. Many SMEs face difficulties implementing CE measures because they lack awareness, knowledge, access to sustainable materials, financial resources, or a vision (Ormazabal et al., 2018; Sharma et al., 2021). Collaborations and partnerships can provide essential support to SMEs in overcoming these challenges (Vihma & Moora, 2020). Since it is known that collaboration might facilitate CE implementation, scholars demand empirical research to better understand the network-related factors that facilitate or hinder CE transitions (Ferasso et al., 2020). Highlighting the benefits of a company's position in a social network, social capital theory becomes important (Nahapiet & Ghoshal, 1998), which is less explored in the CE context. Social capital comprises a social element that captures the essence of various sociological concepts, norms, and values, and a capital element that represents the added monetary value of the transformation undertaken (Lin, 2002). Focusing on these elements, social capital concentrates on cooperative social relationships and the resources they contain. Social capital is known as "the sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by individuals or social units" (Nahapiet & Ghoshal, 1998, p. 243). Despite the increasing contributions separately made in both fields, social capital and CE, less is known about the relationship between social capital and CE.

Since dynamic capabilities can leverage the knowledge gained through social capital (Jantunen, 2005), dynamic capabilities can explain the relationship between social capital and CE. We define dynamic capabilities as "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environment" (Teece et al., 1997, p. 516). Regarding social capital and dynamic capabilities, it is stated that companies are able to find new perspectives, opportunities and the most suitable alternatives with the help of social capital and in turn identify, interpret and utilize these through their dynamic capabilities (Atuahene-Gima & Murray, 2007). Regarding dynamic capabilities and CE, Khan et al. (2021) established that a firm's implementation of CE practices in medium and larger firms is driven by its dynamic capabilities. Moreover, qualitative studies such as Elf et al. (2022) specify that dynamic capabilities enable small enterprises to advance CE practices. Hence, social capital developed by companies from interaction with other stakeholders provide information, knowledge, and resources that can be anticipated and integrated using dynamic capabilities and

thus be used in new services, products, or processes (Zahra & George, 2002) or specifically in CE practices. We therefore ask: *Does social capital facilitate implementing CE practices in small firms? Do dynamic capabilities mediate this relationship?*

As there is already a great deal of theoretical and qualitative research on the individual constructs, particularly in large companies, our research is based on quantitative primary data collection. For this purpose, we collected data from 1,022 SMEs. The social capital, dynamic capabilities and CE implementation variables were derived from the literature and use established scales. We apply multiple linear regression models to explore the relationship between the variables and test the hypotheses. In the models, circular economy implementation is the dependent variable, while social capital is analyzed both in aggregate form and broken down into the three sub-dimensions - structural, relational, cognitive. In addition, the dynamic capabilities are included in the analyses as an independent variable and as a mediator variable. Because the integration of the CE into a firm's strategy can be influenced by several organizational characteristics, we control for the following including firm size, firm sales, firm age, and firm segment (product and services) (Eikelenboom & de Jong, 2022; Hernández-Linares et al., 2021; Ormazabal et al., 2018; Rizos et al., 2016).

The findings of this study provide empirical support for the proposed association between social capital and the implementation of CE practices in SMEs. Specifically, our hypothesis posited that all three dimensions of social capital would positively influence CE implementation. However, the analysis reveals that not all dimensions of social capital equally contribute to CE activities. Structural capital emerges as the sole dimension demonstrating a significant positive impact. Consequently, we conclude that while relational (trust) and cognitive (shared values) capital may not be indispensable for CE implementation in SMEs, establishing stable, consistent, and reciprocal exchanges among various stakeholders is pivotal. These findings corroborate the theoretical assertions of previous researchers (Germundsson & Gernandt, 2019; Skawińska & Zalewski, 2018) regarding the enabling role of structural capital in CE implementation.

Additionally, we investigated the mediating role of dynamic capabilities in the relationship between social capital and CE implementation in SMEs. Consistent with prior research (Khan et al., 2021), our study demonstrates that dynamic capabilities exert a positive and significant influence on CE implementation. Regarding the mediating effect of dynamic capabilities on the relationship between social capital and CE implementation, the findings suggest that

dynamic capabilities strengthen this positive relationship. Building on existing literature (Helfat & Martin, 2015; Rodrigo-Alarcón et al., 2018; von den Driesch et al., 2015), we highlight the critical role of dynamic capabilities in leveraging social capital, thereby facilitating the flow of knowledge and resources within SMEs. This enables SMEs to anticipate and respond effectively to environmental changes, ultimately facilitating the adoption of CE practices.

The research contributes significantly to both theoretical advancement and practical application. In terms of theoretical contributions, this study delves into the intersection of social capital and CE, a topic that remains relatively unexplored, particularly regarding the influence of individual dimensions of social capital on CE implementation. By integrating the context of CE into existing research on the relationship between social capital and dynamic capabilities, with a specific focus on SMEs (Pinho, 2011; Wang, 2016), we address the call from Sehnem et al. (2022) to bridge diverse theoretical approaches beyond the traditional core of CE studies. Furthermore, our study responds to the call for quantitative research by Kristoffersen et al. (2020), aiming to examine and advance the implementation of CE.

Regarding practical implications, the findings offer valuable insights for managers and institutions. Firstly, managers are advised to actively engage their organizations in networks and cultivate new relationships to facilitate the acquisition and generation of new knowledge. Particularly for SMEs, networking provides access to materials, resources, and knowledge, as well as opportunities to exchange surplus resources. Secondly, while social capital is crucial, effectively utilizing knowledge within social capital is equally important for CE implementation. Social capital, enriched through sharing and interaction, can be leveraged and refined with the assistance of dynamic capabilities. Companies should proactively employ dynamic capabilities to sense and transform their networks and social capital, enabling them to anticipate and implement CE practices effectively. Thirdly, institutions should simplify access to events and networks to facilitate and enhance knowledge transfer.

Essay III In the third essay, I revisit the micro and meso levels to broaden the perspective from examining the determinants to exploring potential outcomes of implementing CE practices in SMEs. For companies to adopt new strategies, implementing CE activities must confer an advantage, typically manifesting as a competitive edge. Competitive advantage entails identifying strategies that offer superiority over competitors (Reuter et al., 2010). Although the primary objectives of a CE are not purely economic, understanding whether CE practices can

be financially rewarding and whether they confer a competitive advantage is essential for policymakers, managers, and entrepreneurs. Prior research has indicated a positive correlation between CE implementation and firm performance in larger corporations (Kwarteng et al., 2022). However, it is crucial to differentiate between larger enterprises and SMEs when considering competitiveness, as they possess distinct characteristics (Man et al., 2002).

Scholars and practitioners often highlight the potential for CE to provide companies with a competitive advantage. However, transitioning to a CE entails a complex process requiring organizational change and innovation (Sehnem et al., 2022; Suchek et al., 2021). Particularly, innovation capability can significantly influence a firm's competitive advantage (Chen et al., 2018; Tamayo-Torres et al., 2016). Hence, innovation capabilities can assist companies in enhancing their environmental, economic, and social efficiency, ultimately generating market value.

Several studies have independently explored innovation capability, CE implementation, and competitive advantage in SMEs (Jakhar et al., 2019; Lieder & Rashid, 2016). However, existing research predominantly relies on theoretical and conceptual frameworks, necessitating a linkage between these variables. Suchek et al. (2021) advocate for expanding and empirically substantiating research on innovation and CE using primary data. Similarly, Sehnem et al. (2022) emphasize the importance of comparative studies and empirical validation of innovation capabilities within the CE context. Given the significant potential of CE implementation in SMEs alongside numerous barriers, it is imperative to investigate the extent to which CE implementation correlates positively with competitive advantage. Therefore, I ask the following research questions: *Does innovation capability help SMEs to implement the CE? Are innovation capability and CE implementation positively related to a competitive advantage in SMEs and what competitive advantage(s) may be derived? Does CE implementation mediate the relationship between innovation capability and a competitive advantage?*

This study utilized a quantitative research approach, employing a questionnaire survey conducted among German SMEs. A total of 15,000 SMEs were contacted, and data collection took place over a six-week period from September to October 2023. The survey, administered online via Qualtrics, was self-administered and distributed through email. Of the responses received, 186 surveys were fully completed and devoid of missing answers, meeting the criteria for inclusion in the analysis. All participating firms met the European Commission's definition of an SME, with fewer than 251 employees. The achieved response rate of 1.24 percent aligns

with typical rates observed in similar research areas (Kristoffersen et al., 2021a). The questionnaire design was informed by validated constructs established in existing literature. To explore the relationships between variables and test hypotheses, multiple linear regression models were employed. These models varied in terms of dependent and independent variables under consideration. Initially, the influence of innovation capability on circular economy practices was examined. Subsequently, another model investigated the relationship between innovation capability, circular economy implementation, and competitive advantage. Circular economy implementation was assessed both as a dependent variable and as an independent and mediator variable. Several organizational factors known to influence the integration of circular economy practices into a firm's strategy and its resulting competitive advantage were controlled for. Specifically, firm age, firm size, and industry (products and services) were considered, as recommended by previous studies in the SME context (Anwar, 2018; Khan et al., 2019; Schmidt et al., 2021; Su et al., 2017).

The findings of this study unveil several key insights. Firstly, a direct correlation was observed between innovation capability and CE implementation among German SMEs. Consequently, SMEs possessing stronger innovation capabilities are more inclined to adopt CE practices. Secondly, the study indicates a significant relationship between innovation capability and competitive advantage. Organizations fostering a culture of innovation tend to cultivate a diverse array of ideas, facilitating the transformation of these ideas into profitable business concepts. Thirdly, the hypothesized link between CE implementation and competitive advantage is substantiated by the findings. These results corroborate previous research demonstrating the positive impact of CE implementation on firm performance, particularly in large corporations (Kristoffersen et al., 2021a; Kwarteng et al., 2022). For example, through advancements in material and process innovation, companies can repurpose waste materials into recycled products, effectively closing the production loop. This transition not only reduces waste generation but also enhances resource efficiency, leading to economic benefits. Lastly, while innovation capability positively influences CE implementation and CE implementation is associated with a competitive advantage, no evidence was found to suggest that CE implementation acts as a mediator in this relationship.

These findings offer evidence that the association between implementing CE practices and gaining a competitive advantage hinges on innovation capability, which itself serves as a key driver of competitive advantage. Consequently, innovative SMEs that implement CE practices may not necessarily hold a competitive edge over their innovative counterparts that do not

engage in CE practices. This study holds significant theoretical and managerial implications, serving as a guiding framework for SMEs seeking to leverage innovation capability and CE practices to enhance their competitive position. Firstly, this study expands the scope of CE research by examining the relationship between CE implementation and competitive advantage, particularly through differentiation and cost leadership strategies. Despite initial cost barriers encountered by early adopters of CE (Mura et al., 2020), companies embracing CE practices view them as opportunities for value creation rather than mere expenses. Aligning with (Anwar, 2018), who empirically demonstrated the positive relationship between business model innovation and competitive advantage, my findings underscore the substantial association of CE implementation with both differentiation and cost leadership strategies. Secondly, the study underlines the imperative for innovation capability in facilitating CE implementation. The results indicate that companies adopting CE practices demonstrate a greater propensity for innovation and agility in adapting their processes, products, and services, thereby exhibiting a greater openness to change. To effectively implement CE practices, SMEs must cultivate an organizational culture that encourages innovative behavior and fosters internal resource coordination to support an innovation-oriented mindset. This, in turn, enables SMEs to cultivate innovation capability and empower individuals within the organization to foster innovation. Thirdly, policymakers are urged to incentivize SMEs towards environmental orientation and environmental responsiveness. Given the significant economic leverage in embedding sustainable activities within small businesses, this study underscores the potential for CE practices to confer a competitive advantage across various organizational levels. Government agencies can play a pivotal role in providing economic incentives, such as tax credits and subsidies, to SMEs adopting proactive environmental practices and initiatives, thereby further enhancing the competitive advantage of circular businesses. Such incentives must be accessible to all companies, not just the pioneering and already innovative firms that occupy the upper echelons of the market.

1.5 Structure of this dissertation

This dissertation consists of a general introduction, three individual research essays, and a summarizing conclusion. While all three essays are dedicated to the topic of the circular economy in small and medium-sized enterprises, each essay sheds light on different aspects of the circular economy as part of its own research project. Each of these three essays is therefore

self-contained and can be read and understood independently of the other essays. Each essay consists of an introduction, theoretical background, methodology, results, theoretical and practical relevance, and a conclusion. Table 2 provides a summarized overview of the essays included in this dissertation.

The following chapters of this dissertation are structured as follows. Chapter 2 contains an essay I entitled “The influence of digital technologies on circular economy implementation in German SMEs: The moderating role of commitment to sustainability”. This examines the relationship between the use of digital technologies, both overall and specifically, and the implementation of circular economy practices. It also analyzes the moderating role of commitment to sustainability. Chapter 3 consists of Essay II, which is entitled “Social capital and circular economy in German small enterprises - The mediating role of dynamic capabilities”. Based on a primary data analysis, this article examines the relationship between social capital, dynamic capabilities, and the implementation of circular economy measures. Chapter 4 then provides essay III, which is entitled “Turning old into new as a competitive advantage? The relationship between innovation capability and the implementation of circular economy practices in German SMEs”. It examines whether innovation capability and the implementation of circular economy practices have a positive correlation and to what extent this has an impact on competitive advantage. Chapter 5 rounds off the dissertation with a summary discussion in which the results, implications, and limitations, as well as future research needs in the field of circular economy implementation in small and medium-sized enterprises, are explained. The appendix provides additional information and material for each essay, such as the survey material.

Table 2
Overview of the three essays

Essay	Essay I (cf. Chapter 2)	Essay II (cf. Chapter 3)	Essay III (cf. Chapter 4)
Title	The influence of digital technologies on circular economy implementation in German SMEs: The moderating role of commitment to sustainability	Social capital and circular economy in German small enterprises – The mediating role of dynamic capabilities	Turning old into new as a competitive advantage? The relationship between innovation capability and the implementation of circular economy practices in German SMEs
Research question	Do different digital technologies facilitate the implementation of CE practices in SMEs? Does CtS moderate the relationship between digital technologies and the implementation of CE practices in SMEs?	Does social capital facilitate implementing CE practices in small firms? Do dynamic capabilities mediate this relationship?	Does innovation capability help SMEs to implement the CE? Are innovation capability and CE implementation positively related to a competitive advantage in SMEs?
Related call for research	Isensee et al. (2020); Liu et al. (2022); Rosa et al. (2020); Rusch et al. (2023)	Gamage et al. (2020); Kristoffersen et al. (2020); Sehnem et al. (2022)	Sehnem et al. (2022); Seles et al. (2022); Suchek et al. (2021)
Research approach and data	Quantitative: 754 German small and medium enterprises	Quantitative: 1.022 German small and medium enterprises	Quantitative: 186 German small and medium enterprises
Methodology	Survey, multiple linear regressions, moderator analysis	Survey, multiple linear regressions, mediator analysis	Survey, multiple linear regressions, mediator analysis
Results	Digital technologies are positively associated with CE practices, while the complementary effect of digitalization and sustainability is not significant.	SC positively correlates with CE implementation and DCs partially mediate this relationship.	Innovation capability is positively associated with CE implementation and CE implementation is positively related to competitive advantage.
Theoretical contributions	Research at the intersection of digitalization, sustainability orientation, and the implementation of CE practices in SMEs.	Exploration of the network forms of SC and extension of the CE literature by suggesting that DCs help organizations leverage SC.	Examination of innovation capability in the context of a CE and a competitive advantage.
Practical implications	Practitioners should build an environment and network that focuses not only on sustainable innovation but also on digital innovation.	Through networks, small firms can access materials, resources, knowledge, and can pass on by-products or resources.	Managers need to invest in innovation capabilities to support innovative and efforts to increase CE and competitive advantage.

2 | The influence of digital technologies on circular economy implementation in German SMEs: The moderating role of commitment to sustainability

Abstract

Little is known about the factors that facilitate the implementation of circular economy (CE) practices in SMEs. We first investigate the influence of digitalization on CE implementation by focusing on the specific impact of particular digital technologies (DT) – sensor technologies for data storage, process digitalization, digital tools, smart devices, social media, and e-commerce – and the impact of the simultaneous adoption of multiple DTs (breadth of digitalization). Second, we investigate whether the impact of digitalization is moderated by the commitment to sustainability (CtS) in the context of CE. The results of a self-developed survey of 754 German SMEs show that DTs, i.e., the breadth of digitalization, drive the implementation of CE practices. However, each DT has a different impact on implementing CE practices. In particular, we highlight that the digitalization of operational and manufacturing processes and the use of e-commerce correlate positively and significantly with CE implementation. Interestingly, the complementary effect of pursuing a dual strategy toward digitalization and sustainability is not significant for CE implementation. Our study contributes to SMEs, which are inherently more resource-limited, by providing insights into which DTs are helpful in implementing CE practices.

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Status: Submitted[1]

[1] At the time of handing in this dissertation, this essay has the option to revise and resubmit at International Small Business Journal. A short version published in ECIE 2023 18th European Conference on Innovation and

2.1 Introduction

Circular economy (CE) practices are important in reducing resource consumption and providing economic potential (Bressanelli et al., 2018). The concept of CE is being used in a wide range of contexts. Kirchherr et al. (2017) analyzed 114 different definitions concerning the core principles of the CE concept and summarized these into one definition: "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes […] to accomplish sustainable development, which implies creating environmental quality, economic prosperity, and social equity, to the benefit of current and future generations" (Kirchherr et al., 2017, pp. pp. 224-225). However, the world was only 7.2 percent circular in 2022 (Circle Economy, 2023). For this reason, great efforts are needed from various parties. Small and medium-sized enterprises (SMEs) are one of these parties.

SMEs play an important role in the world's economy (European Commission, 2020d). Their economic but also their environmental, and social impact is significant (Revell et al., 2010). However, research indicates that SMEs fall behind in sustainability in general (Brammer et al., 2012; Cassells & Lewis, 2011; Revell et al., 2010). One reason might be that most SMEs struggle to include CE practices in their operations due to a lack of financial, personal, and technological resources (Ormazabal et al., 2018). Therefore, it should be interesting to investigate how CE practices can be accelerated in SMEs since they have a particular organizational structure, strategies, and capabilities that differentiate them from larger enterprises (Aragón-Correa et al., 2008).

Digitalization has been identified as a key enabler of CE "due to its building visibility and intelligence into products and assets" (Antikainen et al., 2018, p. p. 45). Digitalization is about adopting and using digital technologies (DT) (Legner et al., 2017). In line with several researchers, we define digitalization as the organizational application and adoption of DTs and how they support the company's business (Gradillas & Thomas, 2023). Hence, we focus on the digitalization breadth. Digitalization addresses several prerequisites of the CE, such as enabling new business models (Alcayaga et al., 2019), improving production (Chauhan et al., 2022), and

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Entrepreneurship (Vol. 18, No. 1, pp. 392-401) and is available under DOI: https://doi.org/10.34190/ecie.18.1.1742. My contributions are as follow: development of the research idea and design, literature review, joint data collection, empirical analysis, creation of the visualizations, writing, editing.

monitoring and optimizing product performance (Rosa et al., 2020). Liu et al. (2022, p. p. 2185) have analyzed 174 papers and revealed the "intensity of the impact which DT can have on the transition towards CE" (Liu et al., 2022, p. p. 2185). Nevertheless, there is a gap between the potential shown in theory and practical implementation (Ingemarsdotter et al., 2020). Especially empirical studies that support the existing literature in the context of DT and CE are missing (Alcayaga et al., 2019; Rosa et al., 2020). According to previous research, "a clear move needs to be made to raise understanding of the issues involved and to stimulate faster translation from theory to practice" (Rusch et al., 2023, p. p. 1170). Hence, there is a call for research to advance the understanding of DTs in empirical studies in the context of CE implementation. Research specifically calls for investigating specific DTs for enhancing the implementation of CE practices (Liu et al., 2022).

Although firms' adoption of DTs is discussed as an enabler of CE in large companies (Antikainen et al., 2018), there is only limited research about the adoption of DTs in SMEs. While the literature on digitalization is growing, implementing DTs in SMEs is rare (Bag & Pretorius, 2022). Especially literature about what kind of DTs can support the implementation of CE in SMEs to focus on relevant DTs is scarce (Chauhan et al., 2022; Rosa et al., 2020). Only a few qualitative studies concentrate on the role of DTs regarding CE implementation in SMEs. For example, Chaudhuri et al. (2022), who conducted in-depth interviews, stated, that SMEs focusing on CE practices create more value for customers by adopting DTs. Hence, with the introduction of DTs, the implementation and value of CE practices can be increased. However, they consider DTs as a whole and do not distinguish between different DTs. In addition, Neri et al. (2023) conducted semi-structured interviews with SMEs and emphasized the supportive role of DTs in the implementation of CE practices. The authors provide some preliminary insights into the circular transition support offered by the integrated and synergistic application of different DTs, especially the Internet of Things, big data analysis, and robots. Other studies, that dealt with the role of digitalization for sustainable development in SMEs, have focused on innovation performance (Ardito et al., 2021) and the development of sustainable innovations (Ardito, 2023). However, they did not concentrate on CE practices in SMEs, although more is needed to know about the implementation of DTs in the context of SMEs (Neri et al., 2023). To our knowledge, no previous study has empirically tested whether and how SMEs adopting different DTs are more likely to implement CE practices. Particularly in the context of SMEs, this represents a significant knowledge gap, as owners, who have a

large influence on the strategic decisions of the business (Jansen et al., 2013), are increasingly willing to adopt technology if they see them as beneficial (Simmons et al., 2008).

Research has theoretically and qualitatively identified several DTs in paving the way for CE in large companies (Rajput & Singh, 2021; Rusch et al., 2023) and SMEs (Neri et al., 2023). Specifically, the integration of the Internet of Things, big data analysis, system integration, cloud technologies, and autonomous robots are of great interest to fostering CE implementation in SMEs (Neri et al., 2023). Furthermore, sensor technologies such as RFID help to collect information about products and processes (Antikainen et al., 2018). E-commerce can improve the information flows of any trade by making information more available, market access to online aftermarkets easier and the overview of the product portfolio more transparent (Romagnoli et al., 2020). Moreover, social media might foster the implementation of CE as large companies publish CE information via their official social media accounts, such as Twitter (L'Abate et al., 2024). This may inspire smaller companies that also use social media to adopt CE practices, as the use of social media has an impact on the sustainability (Amoah et al., 2023) and the knowledge about CE (Ormazabal et al., 2018) in SMEs. To make the mentioned areas tangible for managers of small companies, we focus on the following six DTs that might positively influence the implementation of CE practices, namely (1) sensor technologies (RFID, QR codes) for data storage, (2) digitalization in processes, (3) digital tools (3D- printing, robotics, AI), (4) smart devices (tablets, smartphones), (5) social media, and (6) e-commerce.

Since a partial connection between CE and sustainable development is indicated (Geissdoerfer et al., 2017), the question arises as to what extent digital strategies are already linked to sustainability in SMEs or whether digital strategies in SMEs have only been integrated due to the digitalization of the company without thinking about other goals. In other words, is digitalization seen as a separate goal or a precursor to sustainable development in the circular economy? As the megatrend of digitalization has emerged and grown independently from the megatrend of sustainability (Brenner & Hartl, 2021) it should be emphasized that the digitalization of companies does not necessarily target sustainability goals (Beier et al., 2018; Beier et al., 2020) and that digitalized companies do not necessarily pursue sustainability practices. As small companies, in particular, will initially only be indirectly affected by formal sustainability obligations, implementing CE practices in digitalized companies can be achieved due to the new value creation opportunities that DTs open up (Broekhuizen et al., 2021). Some studies provided the first empirical evidence and questioned the complementarity between

corporate digitalization and the adoption of sustainability practices (Ardito, 2023; Ardito et al., 2021; Isensee et al., 2020). Ardito et al. (2021) have found that digital and environmental orientations positively relate to innovation performance in SMEs. However, a better understanding of the role of digitalization and commitment to sustainability (CtS) concerning CE implementation is needed to elaborate on the motivation to apply DTs in CE implementation (Chauhan et al., 2022; de Sousa Jabbour et al., 2018; Kristoffersen et al., 2020).

We aim to address the mentioned gaps by conducting a large-scale, cross-sectional survey that unveils the relationship between the adoption of DTs and the implementation of CE practices in SMEs. Specifically, we examine the individual impacts of specific DTs and the impact of the degree of digitalization, i.e., the degree to which companies use several DTs simultaneously. This is reminiscent of research findings showing that DTs can be implemented individually or in combination with different effects on business performance (Büchi et al., 2020), sustainable development (Bag et al., 2021) as well as the implementation of sustainable innovations (Ardito, 2023), as the phenomenon of digitalization is very complex (Lanzolla et al., 2020). Furthermore, considering the topic's novelty, we will investigate whether DTs complement a company's sustainable orientation in the form of CtS when implementing CE practices. Thus, the moderating role of CtS on the relationship between the company's level of digitalization and the likelihood of adopting CE practices will be investigated. Overall, there appears to be a research gap regarding the complex and multi-layered relationship between strategies for sustainability and digitalization. A better understanding gives SMEs additional tools to manage this complex relationship and make profound business model changes (Isensee et al., 2020). Hence, this paper contributes to the literature on CE, DTs, and CtS in SMEs by answering the following research questions: *Do different DTs facilitate the implementation of CE practices in SMEs? Does CtS moderate the relationship between DTs and the implementation of CE practices in SMEs?*

In line with previous research (Ardito et al., 2021; Eller et al., 2020; Schmidt et al., 2021), we rely on the resource-based view (RBV) of the firm (Barney, 1991) and consider the adoption of DTs and CtS as strategic orientations that can influence the likelihood of implementing new products and processes by affecting the availability, accumulation, and use of firm resources (Gatignon & Xuereb, 1997). From this multidisciplinary angle, the RBV provides a useful framework for looking at SME digitalization that has been used in sustainability research (Ardito et al., 2021) as well as in the CE context (Schmidt et al., 2021) to uncover relationships and capabilities in SMEs. To investigate the role of CtS and digitalization in implementing CE

practices in SMEs, we surveyed a self-developed sample of 754 German SMEs, represented by their managing directors. The hypotheses are tested using multiple linear regression. Unlike previous studies that investigate the role of digitalization and CE in larger firms (Bag et al., 2021), our sample mainly focuses on small firms. Our results confirm that DTs are positively related to implementing CE practices. Specifically, the digitalization of service, operational, and production processes and the use of e-commerce positively and significantly affect the implementation of CE practices. In addition, the simultaneous implementation of DTs and CtS adversely does not significantly explain the implementation of CE practices.

The contribution of the paper is threefold. First, we complement the limited research in the CE field by empirically examining the different impacts of the adoption of DTs on CE implementation in SMEs (Liu et al., 2022; Neri et al., 2023). Specifically, the digitalization of service, operational, and production processes and the use of e-commerce positively influence the implementation of CE practices. Second, we not only extend research on digitalization in the context of CE implementation but also add knowledge on adopting DTs in the smaller firm setting, representing a theoretical contribution to the CE perspective (Chauhan et al., 2022; Rosa et al., 2020). Third, we add to the existing literature by exploring the moderating effect of CtS on the relationship between DTs and CE implementation (Ardito, 2023). The lack of complementarity between DTs and sustainability practices suggests that digitalization and sustainability practices are currently managed in a way that does not connect them. Hence, we answer recent calls on the need to build bridges between sustainability and digitalization (Isensee et al., 2020) and encompass research topics that are outside the traditional core of CE studies (Sehnem et al., 2022).

2.2 Theoretical background and hypotheses

2.2.1 The resource-based view and the relevance of SMEs

The recognition that the competitive advantage of firms can be attributed not only to external forces but particularly to the internal resources of a firm led to the development of the RBV (Barney, 1991). The RBV focuses on sustained competitive advantage and how this can be achieved under the assumption that strategic resources are not homogenously distributed across firms and that these differences persist. RBV focuses on the link between strategy and firms' internal resources. These strategic alignments specifically aim to create an internal

environment at the firm level in which desired actions are encouraged, supported, and implemented and in which strategic alignment decisions are meaningfully linked to company resources (Gatignon & Xuereb, 1997; Terziovski, 2010).

Since small companies have fewer resources than larger companies, they suffer from what is known as the "liability of smallness". The unique characteristics such as the lack of resources or the problems with the implementation and the environment of SMEs are identified as reasons for falling behind in sustainability (Jansson et al., 2017). Therefore, effective resource deployment and strategic alignment are critical for SME growth and survival (Grimmer et al., 2017). For this reason, it is particularly important for SMEs to use their scarce resources sustainably and to identify success factors for establishing sustainable practices such as CE activities. Consequently, SMEs are suited to study how CtS and digitalization influence the implementation of CE practices. First studies focused on the relationship between strategic orientation and CE implementation in SMEs through the RBV framework (Schmidt et al., 2021) and the relationship between CE and digitalization (Antikainen et al., 2018; Chauhan et al., 2022; Kristoffersen et al., 2020; Neri et al., 2023). However, there is a lack of empirical research quantitatively investigating the association between different DTs and CE implementation and the duality of digitalization and CtS in the context of CE implementation in SMEs. To advance the burgeoning stream of qualitative (Neri et al., 2023) and conceptual (Rusch et al., 2023) research, we focus on SMEs as an appropriate empirical context for our study.

2.2.2 Digitalization and circular economy

Digitalization can boost CE implementation by helping to close, slow, and narrow material loops (Antikainen et al., 2018; Chauhan et al., 2022; Kristoffersen et al., 2020). Digitalization empowers companies to use advanced DTs to transform the value proposition, value creation, and value delivery components of their business model (Broekhuizen et al., 2021). Hence, many companies have begun to use DTs to alter their business model (Nambisan et al., 2019). DTs include, among other things, sensor technologies (RFID, CR codes) for data storage, process digitalization, digital tools (3D-printing, robotics, AI), smart devices (tablets, smartphones), social media, and e-commerce. DTs can address several prerequisites of the CE. Specifically, DTs bring transparency to supply chains and products (Agrawal et al., 2022), enable new business models (Alcayaga et al., 2019), and improve production (Chauhan et al., 2022). It has been argued that the non-existence of DTs hinders companies in CE

implementation (Chauhan et al., 2022). When a product should stay inside the loop throughout its lifetime and even afterward, it is important to know the product's location. Which in turn can be facilitated by DTs (Agrawal et al., 2021). The usage of sensor technology (e.g., RFID), process digitalization, or smart devices is highlighted to foster CE implementation (Rajput & Singh, 2021). Sensor technology allows predictive maintenance, which can extend the lifetime of a product (Sun et al., 2012). Additionally, the data collected and stored can be used to continuously improve a product and process (Bressanelli et al., 2018). Moreover, digital tools such as 3D printing can be fed with waste material and reduce scrap and thus waste (Garmulewicz et al., 2018). Social media can help to disseminate and identify circular market trends and innovations and draw attention to innovations and sustainable products and materials (Bhimani et al., 2019; L'Abate et al., 2024).

A functioning CE requires collaborating with different parties (Holzer et al., 2021). The output of one party becomes the input of the next. Digitalization facilitates cooperation between different companies (Holzer et al., 2021). Data provides the respective company with information about the previous and following stages of the process. This allows companies to optimize the product in terms of, e.g., durability and reusability (Ingemarsdotter et al., 2020). E-commerce can also connect companies. This could allow the exchange and trade of used and recycled materials (Antikainen et al., 2018). Digitalization enables service-oriented business models. This breaks with the unsustainable concept in manufacturing, that profit is driven primarily by higher unit sales and thereby reduces resource consumption (Bocken et al., 2014). Consequently, manufacturers are incentivized to work on the durability and repairability of their products. Additionally, products can be shared by more than one customer (Ingemarsdotter et al., 2020). Various DTs therefore contribute to closing, narrowing, and slowing material loops. Therefore, companies that apply DTs should have a higher degree of CE implementation.

Neligan et al. (2023) and Bag et al. (2021) showed a positive relationship between digitalization and CE implementation in larger organizations. However, the current understanding of the relationship between DTs and CE is shallow in the SME-specific context (Chauhan et al., 2022; Kristoffersen et al., 2020). There is a gap between the potential shown in theory (Alcayaga et al., 2019; Bressanelli et al., 2018) and the practical implementation (Ingemarsdotter et al., 2020). Therefore, scholars emphasize the need for more empirical research in the CE field (Antikainen et al., 2018; Ingemarsdotter et al., 2020) and the SME context (Eller et al., 2020). Especially SMEs lag behind in integrating DTs, as only 17 percent have implemented some

(European Commission, 2020d). One issue is the liability of smallness and, thus, the lack of resources that allow for the implementation of DTs (Verhoef et al., 2021). Furthermore, the unique circumstances in each industry must be considered (Chauhan et al., 2022). The policy challenge identified by OECD (2017b, p. p. 115) is assessed: "SMEs' ability to rapidly adopt new technologies, learn from experience, innovate and optimize their production is constrained by their small size, which limits their ability to reap the benefits of the digital economy." However, when implemented appropriately, DTs oriented to intra- and inter-organizational processes can result in process changes and the generation of new products and/or service lines in SMEs (Ardito et al., 2021; Eller et al., 2020). Due to DTs, SMEs optimize existing business operations by enabling more efficient coordination between processes (Verhoef et al., 2021).

The mentioned aspects point towards a positive relationship between DTs and CE implementation. As the implementation of CE is highly dependent on digitalization in the company (Chauhan et al., 2022) and CE activities can be implemented more easily with the help of DTs, we argue the following:

Hypothesis 1. DTs are positively related to CE implementation of SMEs.

2.2.3 Commitment to sustainability and circular economy

CtS is particularly suitable in the context of this research work, as it is concerned with implementing sustainable practices. Literature has referred to the strategic orientation of a company towards environmental sustainability in different terms: environmental sustainability orientation (Roxas et al., 2017), corporate environmentalism (Banerjee, 2002), or CtS (Jansson et al., 2017). A reason might be that the research on this construct is limited (Roxas et al., 2017). Nonetheless, the different terms address the same underlying notion of a companywide focus on environmental sustainability. The environmental sustainability orientation "reflects the deliberate strategy of the firm to reconfigure its organizational system, structure, processes, and activities to mitigate the negative impact of its practices on the natural environment" (Roxas et al., 2017, p. p. 164).

CtS is a logical derivation of the RBV and is pointed out to be a potential source of sustained competitive advantage (Banerjee, 2002; Hart, 1995; Roxas et al., 2017). CtS builds upon the premise of integrating an environmental focus into the strategic orientation of the firm (Linnenluecke & Griffiths, 2010). It requires a company to recognize that its activities can harm the environment and to strive to limit this impact (Banerjee, 2002). The relationship

between CtS and entrepreneurial orientation has received the most scholarly attention (Jansson et al., 2017; Roxas et al., 2017). However, more research must be conducted on CtS in SMEs, especially in the CE context, to identify whether the implementation of CE practices is motivated by sustainable reasons (Dey et al., 2020).

The traditional linear model poses significant challenges to the environment and resource sustainability. This reality is particularly relevant for SMEs, as they often operate within manufacturing resource-intensive processes and generate substantial waste (Dey et al., 2020). Different barriers to the establishment of CE practices in SMEs have been discussed in the literature, including aspects such as financial barriers, companies' policies and strategies, or lack of resources (Hina et al., 2022). The companies' policies and strategies have been argued to be a key aspect to foster the implementation of CE (Ferasso et al., 2020). Moreover, the values of the management are pointed out to be of importance in SMEs for the implementation of sustainability practices (Jansson et al., 2017). SMEs are characterized by strong and dominant top management. As the top management often owns the company, the decision-making power is far-reaching (Willard et al., 1992). This is supported by flat hierarchies (Matzler et al., 2008). The management beliefs or attitudes strongly influence, for example, proactive environmental management (Banerjee, 2001).

As nature suffers from the prevailing exploitation of resources and air pollution, among other things, more and more laws are being enacted to protect the climate and the environment. As these laws mainly affect large companies and SMEs are only indirectly affected by them, SMEs differ in how and when they apply various sustainability practices and how these practices relate to management values and, thus, CtS. Hence, the implementation of CE practices may vary in nature. It may be that a company experiences institutional or regulatory pressure and therefore feels more or less "forced" to implement CE activities, so there may be little correlation between management values, i.e., CtS, and sustainability practices, i.e., CE practices (Bansal et al., 2018). On the other hand, these decisions and implementation of CE practices may also be based on management's long-term CtS. For example, SMEs may implement CE practices based on environmental motivations (Ormazabal et al., 2018). However, especially when implementing CE practices, the motivation may ultimately be purely financial, as CE practices save resources and thus require less payment (Gusmerotti et al., 2019). In addition, since CE is a very old concept that is gaining momentum through the Ellen MacArthur Foundation (2013) and current climate discussions, it may be that the

implementation of CE practices arose from a traditional rather than sustainable orientation of the company (Geissdoerfer et al., 2017).

Investigating the influence of CtS on CE activities is important to understand the sustainability practices in the SME segment (Cassells & Lewis, 2011). Therefore, a company that has a CtS, in the sense that its management focuses on sustainability in its decisions and strategic planning, should tend to have more CE practices established. Hence, we conclude the following:

Hypothesis 2. CtS is positively related to CE implementation of SMEs.

2.2.4 The complementary effect of digital technology and commitment to sustainability

It has yet to be clarified whether it is advantageous for the implementation of CE practices if companies focus on sustainability and digitalization simultaneously. Existing research calls for a closer look at the interaction between sustainability and digitalization (Neri et al., 2023). If the interactions between sustainability and digitalization are not understood and may be underestimated, SME decision-makers will miss the opportunity to leverage these powerful tools to meet diverse interests (Isensee et al., 2020). Ardito et al. (2021) investigated the relationship between digital orientation, environmental orientation, and innovation performance in SMEs. They found that a focus on the environment and digitalization simultaneously decreases innovation performance. However, regarded separately, both positively influence innovation performance.

We argue that digital and sustainable orientations lead SMEs to develop a mindset that commits the company to implement DTs that protect the natural environment, e.g., by reducing waste, reducing resource consumption, switching to sustainable resources, and extending the product and material life cycle (Burmaoglu et al., 2023). This leads SMEs to acquire new knowledge and skills, build relationships with other organizations, and link the digital world and the natural environment with new products and processes, thereby carrying out CE activities. Therefore, companies with a CtS can use digitalization to unlock the underlying social and/or environmental value-creation potential of DTs for innovation (Isensee et al., 2020) and, hence, the implementation of CE practices.

In considering DTs and sustainability simultaneously, the problem of attention allocation has been raised in research (Ardito, 2023; Ardito et al., 2021): Since attention is limited, managers need to "concentrate their energy, effort and mindfulness on a limited [non-competing] number of issues" to achieve better (innovation) performance (Ocasio, 1997, p. p. 203). Thus, CtS are unlikely to promote digitalization and therefore do not provide the expected benefits in terms of sustainable CE implementation. Moreover, corporate resources are scarce, especially in SMEs, so CtS and DTs compete for the same (scarce) organizational resources. As the knowledge, relationship, and human resources required for the adoption of different DTs and sustainable orientation are inherently different and have different objectives, managers are unlikely to be able to manage resource commitment to both digitalization and sustainability in parallel (De Roeck & Delobbe, 2012; Stevens et al., 2015).

Conversely, DTs can be used for different reasons in SMEs. For example, DTs increase innovation (Ardito et al., 2021) and financial performance (Eller et al., 2020). According to previous findings, a sustainable management orientation can lead to DTs being used for sustainable practices, such as implementing CE, especially if sustainability is thought about and planned for from the outset. Thus, the CtS of the management can reduce the resource allocation problem because DTs are already being adopted to improve sustainable practices. The potential of DTs may be more sustainably exploited if SME managers exhibit more CtS and thus are more likely to have resource-conserving activities on their radar, thus introducing the implementation of CE activities. Accordingly, CtS positively strengthens the relationship between DTs and CE implementation.

While CE implementation of SMEs is correlated with economic performance, only a part of CE is associated with environmental and social performance (Dey et al., 2020). This leads to the conclusion that CE is an intersection of sustainability, but cannot be used as a synonym. In particular, this means that it is important to investigate whether companies that want to act more sustainably implement more CE practices and whether digitalization facilitates this implementation. In summary, digitalization is an important enabler for the implementation of CE (Chauhan et al., 2022), and CE is an important component of sustainability (Bocken et al., 2016). Thus, digitally positioned companies that are committed to sustainability can more easily implement CE activities. Therefore, we hypothesize the following:

Hypothesis 3. The interaction between digitalization and CtS positively affects the CE implementation of SMEs.

Figure 3 shows the research model with the hypotheses.

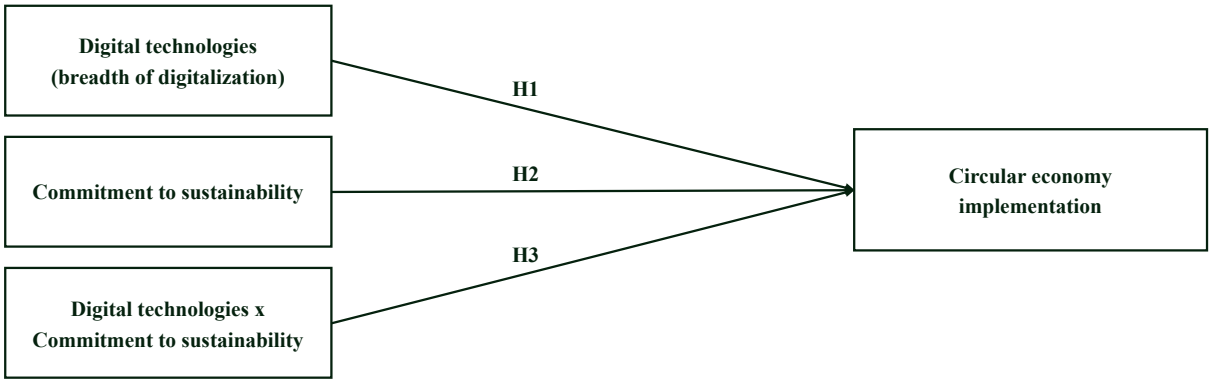

Figure 3

Research model Essay I

2.3 Methodology

2.3.1 Sample and data collection

We focus on managing directors of German SMEs. German SMEs are well suited for the investigation of CE in SMEs, as pointed out by Schmidt et al. (2021). Consumers and other stakeholders in Germany have high expectations of companies regarding sustainable business practices due to a long tradition of sustainability-oriented legislation (Geng et al., 2013; Patel et al., 2000). Therefore, German firms can attain a competitive advantage by addressing those expectations. This is reflected in a high CE innovation rate in Germany (Horbach & Rammer, 2020). In line with the European Commission (2003), we categorize SMEs according to two criteria: staff headcount and balance sheet total. The staff headcount must be smaller than 250, and the balance sheet total has to be smaller than € 43 million for a company to be categorized as an SME. As the strategic orientation of the firms will be assessed and SMEs are characterized by strong and dominant top management with far-reaching decision power, the management should be best suited for the survey. To ensure its clarity, understandability, and face validity, we pre-tested the survey on several experts in the German sector and ten selected SMEs (Dillman, 1978). Thus, developing the questionnaire was a back-and-forth process of interviewing and testing completion with small selected samples.

Overall, 15.034 companies were contacted. Therefore, the publicly available business and contact information from German Chambers of Crafts were used. The self-administered online survey

was distributed via email (see Appendix 1). The data collection, including a reminder, took place over eight weeks from August to September 2022. Overall, 1.058 emails were undeliverable, and 34 companies were permanently closed. A total of 755 questionnaires were filled out completely and correctly, i.e., the questionnaire was completed, and there are no missing answers in the construct items. One questionnaire had to be further excluded as it had more than 250 employees and did not meet the criteria of an SME. Thus, 754 questionnaires were considered. This results in a response rate of 5,43 percent. This represents a comparable response rate for this field of research (Ardito et al., 2021; Eller et al., 2020; Khan et al., 2021). Table 3 contains descriptive statistics of the sample.

Table 3

Chapter 2: Descriptive statistics of the sample.

Firm size	**Frequency**	**%**	**Firm sales**	**Frequency**	**%**
1	126	16.71	< 22.000 €	39	5.17
2-4	208	27.59	22 T. - < 50 T. €	53	7.03
5-9	216	28.65	50 T. - < 125 T. €	95	12.60
10-19	110	14.59	125 T. - < 250 T. €	102	13.53
20-49	53	7.03	250 T. - < 500 T. €	179	23.74
50-250	14	1.86	500 T. - < 2.5 Mio. €	224	29.71
n/a	27	3.58	2.5 Mio. - < 5 Mio. €	32	4.24
			> 5 Mio. €	20	2.65
			n/a	10	1.33
Industry	**Frequency**	**%**	**Firm age**	**Frequency**	**%**
Food	49	6.50	<= 5 years	108	14.32
Electro & metal	104	13.79	6-20	280	37.14
Construction	368	48.81	21-35	324	42.97
Timber	163	21.62	>= 36	41	5.44
Other	70	9.28	n/a	1	0.13

2.3.2 Measurement

The research model builds upon established indicators, which were applied in the context of SMEs. The measures were translated into German and adapted to the specific circumstances of

the sample with the feedback of academics and industry experts. In the following, the variables are introduced. Table 4 presents the study's measures and factor loading.

Table 4

Chapter 2: Factor loadings after varimax rotation

Variable	Item	Factor loading
CE		
	Do you design and develop products that can be easily repaired? (Spare parts and repair possibilities available, economic efficiency of repair given).	0.9062
	Do you design and develop products that are easy to maintain (e.g., easy monitoring and control of functionality)?	0.9082
	Do you design and develop products that are recyclable (e.g. easily separable)?	0.8066
	Do you use products (not packaging) made from recycled material?	0.4432
	Do you design and develop products that are biodegradable (e.g. no hazardous substances, fast decomposition)?	0.7259
	Do you use products (not packaging) that are biodegradable?	0.8332
	Do you use packaging that is biodegradable and/or reusable?	0.6087
	Are there closed loops in production (e.g. return/recycling of product residues into production, waste as raw material)?	0.6416
	Do you increase the material and energy efficiency of your business by achieving the same result with less material and energy input?	0.5526
	Do you reduce your waste by passing on by-products (e.g. products resulting from a manufacturing process whose main purpose is to produce another product; production residues)?	0.6451
	Do you procure by-products from other companies/organizations?	0.6125
	Do you provide repair services for customers?	0.7766
	Do you provide maintenance services for customers? (e.g. monitoring and control of product functionality)	0.7373
	Do you use materials that have been used before (e.g. old products)?	0.4679
	Do you rent and share tools, machines, or facilities/rooms?	0.5538
Digital technologies		
Sensor & storage	How pronounced is the use of sensor technology (e.g. RFID or QR codes) for measurement and control in your operation?	0.5926
Sensor & storage	How pronounced is the collection and analysis of data in your operation?	0.5370
Process digitalization	How pronounced is the digitalization and automation of service/operating processes in your company (e.g. ordering processes)?	0.6230
Process digitalization	How pronounced is the digitalization and automation of production processes in your company (e.g. computer-aided manufacturing processes)?	0.8423

Digital tools	How pronounced is the use of (innovative) digital tools in product design and manufacturing (e.g. 3D printing, robotics, AI) in your company?	0.7898
Smart devices	How pronounced is the use of "smart" devices in your operation (e.g. smartphones, tablets, etc.)?	0.7504
Social media	How pronounced is the use of social media and technologies that support collaboration in your business?	0.6256
E-Commerce	How pronounced is the use of e-commerce (e.g. an online store) for buying and selling goods on the Internet?	0.8354
E-Commerce	How pronounced is the use of digital trading platforms for the marketing of (quality-assured) secondary materials (e.g. recyclates, already used materials) in your company?	0.7784
Commitment to sustainability		
	In strategic decisions involving a product/service, the environmental friendliness of the product/service is an important factor.	0.8255
	Environmental friendliness is an important aspect in planning the competitive focus for our key products, services and markets.	0.8350
	Environmental friendliness and social compatibility are important in the purchase and manufacture of products and services.	0.8220
	Sustainability is an important part of our company's values and philosophy.	0.8381
	Sustainability is a prioritized area for the management in the firm	0.8346
	Sustainability considerations have an impact on the strategic planning in the firm.	0.8370

Note. After Varimax Rotation

Dependent variable – Circular Economy. We assess the dependent variable CE implementation with the scale established by Khan et al. (2021). The scale covers various CE practices in different implementation phases since different firms might have adopted different CE practices: design, production, consumption, collection, recycling, and resourcing. To address the specific circumstances of German small businesses, we adopted the established scale according to our population. The items are measured on a 5-point Likert scale (1= currently not planned, 5 = successfully implemented). We added the option "not possible in my company" as some CE practices are not feasible due to resource constraints or the nature of the respective business model in SMEs.

Independent variable – Digital Technologies. To measure DTs, we used items addressing specific technologies identified by Rajput and Singh (2021) that might be relevant for CE implementation: sensor technologies for data storage, process digitalization, digital tools, smart devices, social media, and e-commerce. The items are measured on a 4-point Likert scale (1 =

very low, 4 = very high). For the items assessing the use of a particular technology, we added the option “not possible in my company”. To assess the relationship between the degree of digitalization and the likelihood of launching CE practices, the six DTs described above were summed up. This approach is similar to existing research (Ardito, 2023).

Independent & moderating variable – Commitment to Sustainability. The independent variable CtS is assessed with the scale by Jansson et al. (2017), which is partly based on Kärnä et al. (2003). The scale consists of 6 items. The items address respondents’ perceptions of whether sustainability is important in the company in terms of management philosophy, strategic product decisions, competitiveness, and strategic planning. The items are measured on a 4-point Likert scale (1 = completely disagree, 4 = completely agree). The original scale used a 7-point Likert scale. However, feedback from practitioners indicated that too many points are more burdensome and complex and could therefore reduce the response rate. As it was shown that Likert scales with 7, 5, or 4 points do not show different results with regards to mean, SD, correlations, or factor analysis, the scale was reduced accordingly (Leung, 2011).

Control variables. The companies in our sample are all SMEs according to the definition of the European Commission (2003). Nevertheless, there are characteristics in this category that distinguish these companies from each other and can influence the dependent variable CE. Therefore, following earlier research in the field of SMEs, we control for firm age, industry, segment, and the firm size counted as number of employees (Ardito et al., 2021; Eller et al., 2020; Schmidt et al., 2021). Larger firms, i.e., companies with more employees, might have more resources at their disposal and therefore implement more CE practices (Longoni et al., 2018; Schmidt et al., 2021). Additionally, older firms have been shown to innovate less (Gopalakrishnan & Bierly, 2006). Different CE practices can be implemented depending on the industry and whether a firm produces products or provides services.

2.4 Analysis and results

2.4.1 Construct validity and reliability

In line with other researchers (Ganguly et al., 2019; Schmidt et al., 2021), we confirmed measurement reliability and validity before estimating the hypotheses. To build the constructs, we calculated the mean of the items for every scale. We computed Cronbach’s alpha (Cronbach,

1951) and composite reliability (CR) to assess the inter-item reliability of the scales (see Table 5).

Table 5

Chapter 2: Validity and reliability indicators

Variable	Number of items	Cronbach's alpha	CR
1 CE	15	0.79	0.75
2 DT	9	0.81	0.82
4 CtS	6	0.91	0.91

Note. CR = Composite reliability.

A Cronbach's alpha above 0.70 is commonly assumed to be acceptable (Cortina, 1993; Taber, 2018). Furthermore, a threshold of 0.60 (Fornell & Larcker, 1981) for CR is applied. All constructs fulfill the threshold for CR. Hence, internal reliability can be assumed (Lam, 2012). Therefore, it can be concluded that all items of the respective scale measure the same construct.

Appendix 2 shows descriptive statistics and pairwise correlations. Since the six DTs together build the variable "DT", it is not surprising that therefore higher correlations arise between the individual DTs and the main variable. For the regression analysis, the individual DTs were considered separately from the main variable. All correlation values are sensibly below 0.70, thus suggesting multicollinearity is not a relevant issue (Cohen et al., 2013).

2.4.2 Common method bias

The data in the sample might be subject to common method bias (CMB), as the indicators for dependent and independent variables were collected simultaneously from one participant in the same survey (Podsakoff et al., 2012). This could falsely increase the relationship between the variables. We applied Harman's one-factor test, using exploratory factor analysis for all variables, to assess whether CMB was an issue (Podsakoff et al., 2003). CMB can be assumed if one factor emerges or the largest factor explains the majority (> 50 percent) of the total variance. The analysis yielded 8 factors with an eigenvalue larger than 1, accounting for 63.5 percent of the variance. The largest factor explained only 20.9 percent of the variance. In this respect, it can be inferred that CMB is not a major problem. Although CMB can still exist, it is unlikely to affect the results.

2.4.3 Regression analysis

To test hypotheses 1-3, we use multiple linear regression analysis. Therefore, we tested the Gauss-Markov assumptions, which must be fulfilled to ensure that the respective results are unbiased and reliable (Hallin, 2014). For all variables, these assumptions are fulfilled. Furthermore, variance inflation factor (VIF) statistics were run to deal with concerns about multicollinearity. None of the VIF score of each variable, when connected to the remaining all other variables, has been found to be above the threshold score of 3.3 (Hair et al., 2011; Johnston et al., 2018). Hence, multicollinearity is not a problem in our study.

Model 1 includes control variables only and reveals that company age (β = -0.00, p = 0.77) and the number of employees (β = -0.00, p = 0.81) have no effect on CE implementation. The control variable segment shows statistically significant effects on CE implementation. While companies that offer only services have on average a lower level of CE practices (β = -0.66, p = 0.00), being a company that offers both services and products increases the level of CE (β = 0.30, p = 0.00) compared to being a company that produces only products. Moreover, the different industries influence CE implementation significantly.

For hypothesis 1, we did a linear regression with DTs as the independent variable and CE as the dependent variable (Model 2a). DTs have a positive statistically significant effect on CE implementation among SMEs (β = 0.18, p = 0.00). Hence, hypothesis 1 is supported. To gain more detailed insight, we examined the simultaneous effects of each DT on the implementation of CE practices. According to Model 2b, process digitalization (β = 0.12, p = 0.02) and e-commerce (β = 0.17, p = 0.00) positively and significantly affect CE implementation. The other DTs, sensor technologies (β = 0.01, p = 0.87), digital tools (β = 0.05, p = 0.29), smart devices (β = -0.05, p = 0.25), and social media (β = 0.05, p = 0.23) do not have a significant association with CE implementation. Since the DTs can also be implemented separately, we carried out six linear regressions, each with only one DT as an independent variable. According to Model 2c-h, sensor technologies (β = 0.19, p = 0.00), process digitalization (β = 0.21, p = 0.00), digital tools (β = 0.17, p = 0.00), smart devices (β = 0.08, p = 0.03), social media (β = 0.12, p = 0.00), and e-commerce (β = 0.23, p = 0.00) have an individual significant association with CE implementation. Since the control variables do not differ markedly from those in Model 2b and for the sake of clarity, we have omitted the coefficients in Model 2c-h (see Table 6).

Table 6

Chapter 2: Results of regression analysis (I)

CE as dependent variable	Model 1	Model 2a	Model 2b (simultaneous DT analysis)	Model 2c-h (separate DT analysis)
Controls	β	β	β	β
Firm age	-0.00	-0.00	-0.00	
Firm size (employees)	-0.00	-0.00**	-0.00	
Segment (production as base)				
Services	-0.66***	-0.63***	-0.60***	
Both	0.30***	0.32***	0.32***	
Industry (food as base)				
Electro & metal	0.87***	0.73***	0.76***	
Construction	0.77***	0.63***	0.66***	
Timber	1.17***	1.01***	1.02***	
Other	0.97***	0.80***	0.84***	
Independent Variables				
DT		0.36***		
Sensor & storage			0.01	0.19***
Process digitalization			0.12**	0.21***
Tools			0.05	0.17***
SmaDev			-0.05	0.08**
SocMed			0.05	0.13***
Ecom			0.16***	0.23***
R^2	0.26	0.31	0.32	
F	35.23***	40.70***	26.95***	

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 749.

Model 3 consists of a linear regression with CtS as the independent variable and CE implementation as the dependent variable. CtS has a positive statistically significant effect on CE implementation in SMEs (β = 0.47, p = 0.00). Thus, hypothesis 2 is supported. Model 4 includes DT and CtS and their simultaneous effect on CE implementation. DT (β = 0.26, p =

0.00) and CtS (β = 0.43, p = 0.00) have a positive statistically significant effect on CE. The highest effect judging by the betas has CtS. Model 5 includes DT and CtS as well as the interaction effect of DT and CtS. While DT (β = 0.36, p = 0.10) becomes insignificant, CtS (β = 0.50, p = 0.00) remains positive and statistically significantly associated with CE. The interaction effect is slightly negative but insignificant (β = -0.03, p = 0.64). Hence, hypothesis 3 is not supported. All models are statistically significant (see Table 7).

Table 7

Chapter 2: Results of regression analysis (II)

CE as dependent variable	**Model 3**	**Model 4**	**Model 5**
Controls	β	β	β
Firm age	0.00	0.00	0.00
Firm size (employees)	-0.00	-0.00**	-0.00**
Segment (production as base)			
Services	-0.61***	-0.60***	-0.60***
Both	0.23***	0.25***	0.25***
Industry (food as base)			
Electro & metal	1.01***	0.90***	0.90***
Construction	0.86***	0.75***	0.75***
Timber	1.26***	1.13***	1.13***
Other	1.05***	0.92***	0.91***
Independent Variables			
DT		0.26***	0.36
CtS	0.47***	0.43***	0.50***
DT x CtS			-0.03
R^2	0.37	0.40	0.40
F	53.58***	50.86***	45.78***

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 749.

2.5 Discussion

2.5.1 Interpretation of results

The goal of this paper was to shed light on the mechanisms by which small firms can increase their CE implementation. Building upon the RBV (Hart, 1995), we illuminate whether and how different DTs and CtS contribute to implementing CE practices and how they interplay in German SMEs. Based on a self-developed sample of 754 German SMEs, we reveal that DTs are positively related to CE practices in SMEs (hypothesis 1). Investigating the six different DTs separately shows significant positive effects of all DTs on CE implementation. However, when focusing on the coexistence, we found that not all DTs simultaneously influence CE implementation. Process digitalization and the adoption of e-commerce mainly encourage the implementation of CE practices. However, sensor technologies (RFID, QR codes), digital tools (3D- printing, robotics, AI), smart devices (tablets, smartphones), and social media do not have a significant association with CE implementation when investigated together.

Antikainen et al. (2018) argue that CE can be sustained by applying open data to analyze and track products, establishing virtual platforms to engage customers, and networking with stakeholders to co-design or redesign products and services in large companies. Our findings can only partially support these statements. In particular, the establishment of virtual platforms, for example, e-commerce, promotes the implementation of a CE, while the use of open data to analyze products that can be captured by sensor technologies is insignificant in our results. Furthermore, our findings partially support the results of Rajput and Singh (2021), who examine the challenges of Industry 4.0 in implementing CE and find that process digitalization and sensor technology have a driving power for CE in large companies. We have significant positive results for process digitalization in our data, but not for the application of sensor technologies when investigated simultaneously. It can be assumed that adopting sensor technologies in small companies is not as widespread as in large companies, as large companies already have common sensor technologies to keep track of their inventory compared to small companies (Atnafu & Balda, 2018).

Second, our results show that CtS favors greener behaviors that lead to implementing CE practices in business processes (hypothesis 2). Third, while we test the complementarity of DTs and CtS, we found no significant support for the assumption that the simultaneous pursuit of digital and environmental orientations is conducive to the implementation of CE practices

(hypothesis 3). Based on the RBV, the complexity of managing the different types of resources underlying the adoption of DTs and CtS creates problems in allocating limited resources. Also, tying these resources to unrelated goals is more likely to lead to problems in attention allocation, especially among SME managers and employees (Ocasio, 1997, 2010). A summarized overview of the hypotheses and their results is given in Table 8.

Table 8

Chapter 2: Summary of results

Hypothesis	Content	Result
H1	Digital technologies positively relate to CE implementation of SMEs.	Significant effect
H2	CtS positively relates to CE implementation of SMEs.	Significant effect
H3	The interaction between digitalization and CtS has a positive effect on CE implementation of SMEs.	No significant effect

2.5.2 Theoretical implications

With this study, we contribute to a cross-sectional illumination of current topics on digitalization and sustainability at the firm level. The research provides a theoretical contribution at the intersection of digitalization (Eller et al., 2020), sustainability orientation (Dey et al., 2020), and the implementation of CE practices (Schmidt et al., 2021) in SMEs. Although some studies theoretically investigated digitalization and CE implementation, empirical studies supporting the existing literature are missing (Rosa et al., 2020). With this study, we respond to the call not only to investigate the relationship between digitalization and CE implementation but also to extend existing studies in large companies to the SME context.

Specifically, we theoretically contribute to research in the following ways. First, we complement the limited research in the CE context by empirically investigating the different effects of DT adoption on CE implementation in SMEs (Liu et al., 2022). As far as we know, previous studies have looked at digitalization in the context of CE implementation (Chauhan et al., 2022), but less specifically in SMEs and involving a dataset. In particular, we are the first to investigate the role of digitalization in terms of the relevance of each DT concerning the implementation of CE practices in SMEs. We hereby focus on the separate adoption of six different DTs and the simultaneous implementation of different DTs. Furthermore, we not only extend research on digitalization in the context of CE implementation but also add knowledge on adopting DTs in the smaller firm setting representing a theoretical contribution to the CE

perspective (Chauhan et al., 2022; Rosa et al., 2020). Various theoretical papers have shown how DTs enable the CE (Antikainen et al., 2018) and how their absence hinders it (Chauhan et al., 2022). However, empirical studies that support the existing literature are needed (Rosa et al., 2020).

The results of this paper support the hypothesized relationship between DTs and CE implementation in SMEs. Companies with a high degree of DTs can implement CE practices in different phases of the product lifecycle. Our results reveal that all six DTs investigated separately show a positive and significant association with CE implementation. However, Battistoni et al. (2023) note that even if DTs can be used individually, the full use of their functions can only be achieved through an appropriate combination, as the systematic implementation of these technologies only enables the full development of CE in the company, since CE targets all product lifecycle phases. By analyzing the DTs simultaneously, our results reveal that the digitalization and automation of production, service, and operating processes enable increased CE implementation and hence, material and energy efficiency (Rajput & Singh, 2021). Furthermore, digital trading platforms and e-commerce facilitate adopting CE practices, such as reusing by-products or recycled materials from other organizations (Antikainen et al., 2018). In contrast, we could not find significant results for the remaining DTs, such as the use of sensor technology and storage, digital tools, smart devices, or social media, concerning the implementation of CE practices. The reasons for this can be manifold. Following Ardito (2023), we argue that a partial explanation for the lack of importance of the other DTs could be that they need to be integrated into a comprehensive entity to get the benefit for a CE implementation, as shown by the positive correlation between the company's level of digitalization and CE implementation. Although the DTs individually are positively associated with CE implementation, there is a lack of holistic adoption

Second, the results of this paper support the hypothesized relationship between CtS and CE in SMEs. The higher the CtS is in a company, the higher the CE implementation. CtS measures the extent to which companies prioritize sustainability, for example, whether sustainability plays a role in planning, strategic decision-making, or procurement. CE is a very effective way of increasing the sustainability of a company. If, for example, a company decides to increase the environmental friendliness of its products in its strategic product decisions, the implemented CE practices, such as narrowing, slowing, and closing resource loops, can contribute to achieving that goal (Lüdeke-Freund et al., 2019). Moreover, when environmental friendliness plays a role in purchasing decisions, used or recycled materials could be preferred,

or their products could be remanufactured, increasing the degree of CE. Therefore, CE is one of several potential manifestations of CtS. Hence, this paper empirically supports the connection between an emphasis on sustainability and implementing CE practices.

Third, we add to the existing literature by exploring the moderating effect of CtS on the relationship between DTs and CE implementation. While Ardito (2023) found negative significant results for the interaction effect of sustainability practices and digitalization in large companies, our data reveal that CtS and digitalization simultaneously decrease CE implementation when considering the full model. However, this effect is insignificant and small. The results do not support the assumption that pursuing digital and sustainable orientations simultaneously does improve CE implementation. The differences in the results could be explained by the fact that large companies have more resources at their disposal than small companies, and small companies, therefore, must consider which strategies they pursue more carefully. Accordingly, large companies are more likely to invest resources in different strategies, even if they pursue divergent goals as a result. However, since our data reveal a slightly negative interaction effect, according to Ardito et al. (2021), the reasons for this could additionally be due to the complexity of managing the different types of resources underlying digital and sustainable orientation, as well as the commitment of these resources to unrelated goals. As a result of the liability of smallness that SMEs often face, SMEs are not able to meet resource-intensive strategic commitments. Managers and employees of SMEs are thus more likely to have attention allocation problems (Ocasio, 1997, 2010).

Our study contributes to a better understanding of the relationship between sustainability and CE implementation and shows that, in addition to economic considerations, environmental aspects are important contributors to a move from linear to CE. This study thus builds on previous work (Ardito et al., 2021; Neligan et al., 2023) and extends it to include the complementarity of digital and sustainable orientation concerning CE implementation in an SME context, an area that remains under-researched. Hence, we answer recent calls on the need to build bridges between sustainability and digitalization (Isensee et al., 2020) and to encompass research topics that are outside the traditional core of CE studies (Sehnem et al., 2022).

2.5.3 Managerial and practical implications

The results of this paper contribute to the understanding of the interrelationship of digitalization, CtS, and CE in the context of small firms. For practitioners, several implications can be derived. First, certain, not all, DTs are indeed effective tools to implement CE practices. Specifically, the digitalization of service, operational, and production processes and the use of e-commerce positively influence the implementation of CE practices. These DTs are particularly helpful in narrowing, slowing, and closing material loops. This paper can therefore guide managers in selecting the most relevant DTs for aligning circular activities. Although some DTs alone do not support implementing CE, integrating multiple DTs, if feasible for a company, is the best option. Therefore, practitioners should increase their digitalization efforts when increasing and facilitating CE practices.

Second, a general focus on sustainability fosters the implementation of CE practices as well. Therefore, practitioners should increase awareness throughout the company for sustainability. This could lead to employees incorporating sustainability aspects into their daily activities and decision-making, thus increasing the circularity of the whole business. Our findings are very interesting, as we see that CE activities are implemented because of the company's sustainable attitude and CtS and not just because external factors move companies in that direction. This is an important contribution, as it may make it easier to achieve sustainability goals In the future, as the intrinsic motivation of the companies can be addressed.

Third, the combined focus on CtS and digitalization must be carefully considered. The lack of complementarity of DTs with sustainability practices indicates that current digitalization and sustainability practices are still far apart or managed in ways that do not connect them. Therefore, small business managers should carefully examine current strategic directions and seek to understand where and when issues arise so that limited resources can be used in a targeted manner. As the transition to CE can only be mastered if strategic orientation can be linked, SMEs must be shown how to connect their digital and sustainable strategies without inhibiting CE implementation. Awareness must be created in SMEs that resources for digitalization and sustainability engagement are not only available within the company but also outside its boundaries (Ardito et al., 2021). Therefore, SMEs need to consider not only their own commitment to digitalization and sustainability but also that of their stakeholders, as they can be a source of relevant resources, and their interests and knowledge about digitalization and sustainability are related to the implementation of CE in SMEs.

The exchange of tangible and Intangible resources will become Increasingly Important regarding CE to close material loops with the help of digitalization and sustainable orientation. Therefore, practitioners should build an environment and network that focuses not only on sustainable innovation but also on digital innovation. SMEs should adopt green digitalization tools to improve their environmental performance (Isensee et al., 2020) and integrate digitalization into their sustainability strategy (de Sousa Jabbour et al., 2018).

2.5.4 Limitations and future research

Some limitations must be considered to properly assess the results of this study. First, this paper focused on SMEs. These companies are particularly suitable for CE implementation as they have a high intensity of processing and treatment of materials and have the potential for efficiency increases and material savings. In this respect, other companies may benefit less from implementing CE practices, and the observed relationships may be less distinctive. Nevertheless, the results of this study concerning contexts and prerequisites for successful CE implementation should also be generalizable to other contexts. Further research could apply the research model in other SMEs and regions outside Germany to assess whether the results are reproducible and generalizable to other contexts.

Second, we used self-assessment by the top management of the firms as a single source in data collection. Although we could rule out CMB being a problem for the results, self-assessments are often biased and might not adequately reflect the real circumstances in the companies. Future research could use objective measures to complement subjective measures to assess the constructs. Moreover, we used one survey to assess all constructs. However, the mutual influence of the different constructs often happens over time. In this respect, a longitudinal study could provide further insights.

Third, digitalization provides a high potential to increase CE implementation by synergizing resources. Therefore, future research could address why digitalization is rather low in SMEs and specialize in the interdependencies between CtS and digitalization. Future research that applies case studies in SMEs might extend the understanding of our findings. Research could thereby focus on the two digital technologies, namely the digitalization of processes and the usage of e-commerce, which were shown in this paper to be correlated with CE implementation.

2.6 Conclusion

The main objective of the study was to answer the two research questions: *Do different DTs facilitate the implementation of CE practices in SMEs? Does CtS moderate the relationship between DTs and the implementation of CE practices in SMEs?* By answering the first research question, we empirically assess what role different DTs have for CE implementation in SMEs and to what extent the breadth of digitalization as a sum of DTs has an impact in this regard. As one of the first studies, we have empirically shown that DTs, i.e., the breadth of digitalization, drive the implementation of CE practices in SMEs. However, not all DTs lead to the implementation of CE practices to the same extent. In particular, we highlight that the digitalization of operational and manufacturing processes and the use of e-commerce correlate positively and significantly with CE implementation. Hence, we contribute to the knowledge of SME digitalization in the context of CE. By answering the second research question, we found that the sustainable orientations of the company have a positive and significant impact on the implementation of CE practices. However, we have shown that a simultaneous focus on digitalization and sustainability is insignificant for CE implementation and no moderating effect can be assumed. Accordingly, the integration of the strategies in SMEs must take place to make meaningful use of the limited resources.

3 | Social capital and circular economy implementation in German small enterprises: The mediating role of dynamic capabilities

Abstract

Small firms face challenges in implementing a circular economy (CE) due to their limited resource base. Through social interaction between different actors, social capital (SC) can help to overcome these obstacles. Using a self-generated sample of 1.022 German micro, small, and medium-sized enterprises (MSMEs), we apply regression analyses to investigate the influence of SC and its three dimensions - structural, relational, and cognitive capital - on the implementation of CE. Additionally, we consider the role of dynamic capabilities (DCs) as a mediator. We find that SC positively correlates with CE implementation and DCs partially mediate this relationship. Interestingly, the different SC dimensions vary in importance for CE implementation. We empirically explore the network forms of SC and extend the CE literature by suggesting that DCs help organizations leverage SC to drive CE implementation. From a practical perspective, our study fosters circular production and service capabilities in MSMEs.

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Status: Submitted[2]

[2] At the time of handing in this dissertation, this essay has the option to revise and resubmit at International Small Business Journal. My contributions are as follow: development of the research idea and design, literature review, data collection, empirical analysis, creation of the visualizations, writing, editing. The paper was presented at the R&D Management Conference in Seville, Spain.

3.1 Introduction

The circular economy (CE) concept is currently gaining traction in industry, government, and academia as a way to increase economic output decoupled from resource consumption (European Commission, 2020b, 2020c). According to this concept, resources can be consumed at a rate without exceeding the capacity of the earth. In terms of CE practices, the improved and more efficient use of resources and their extended useful life are the central elements (Blomsma & Brennan, 2017; Lüdeke-Freund et al., 2019). We define CE according to Geissdoerfer et al. (2017) as a restorative system in which energy and resource losses are minimized by narrowing, slowing, and closing material cycles. The realization of the different strategies along the entire product life cycle can be attained through, e.g., sustainable eco-design, modular construction, biodegradable resources, maintenance, repair, reuse, and recycling (Ellen MacArthur Foundation, 2013; Mignacca et al., 2020). The latter are also referred to as components of the R-strategies, which aim to replace the 'end-of-life' concept in production/distribution and consumption processes (Kirchherr et al., 2017). Although, there are studies tackling CE implementation in medium and large organizations (Khan et al., 2021; Kumar et al., 2019; Zhu et al., 2010), only few focus on the adoption of CE in small enterprises. These studies mainly explore barriers and potentials in small and medium-sized enterprises (SMEs) (e.g., García-Quevedo et al., 2020; Ormazabal et al., 2018; Sharma et al., 2021) and only few have investigated the antecedents of CE implementation in SMEs (e.g., Schmidt et al., 2021). Particularly micro firms are under-researched in this regard.

This generates a need for further research: micro, small, and medium-sized enterprises (MSMEs) react differently from large firms and play a vital role in achieving most countries' sustainable development goals (Smith et al., 2022). MSMEs have a small and limited sustainable impact as individual businesses, but their potential impact on society is large when considered together (Smith et al., 2022). It therefore puts major political strategies such as the European green deal at risk if MSMEs fail in capitalizing on CE (Dey et al., 2020). Due to this high status, a successful shift towards the CE depends on MSMEs and their overall contribution to the economies of different countries (Ghisetti & Montresor, 2020).

Scholars have found that CE practices are advantageous for SMEs. The implementation of a CE not only has financial advantages, as material and energy consumption can be reduced (Ormazabal et al., 2016; Ormazabal et al., 2018) but also generated safety in the provision of materials due to value extraction from used products or reuse-opportunities (Sharma et al., 2021). Furthermore, the company's corporate image can be advanced by attaining sustainability (Ormazabal et al., 2018). However, most SMEs fail to implement the CE concept in their company due to various problems, such as lack of awareness, lack of knowledge, problems with the availability of sustainable materials, financial issues, and weak vision of management for implementing CE (Ormazabal et al., 2018; Sharma et al., 2021). Especially in eco-innovation, SMEs are more financially constrained than large firms (e.g., Cecere et al., 2020; Ghisetti et al., 2017).

To overcome the mentioned barriers, Bressanelli et al. (2019) stated that partnership and collaboration are levers in facilitating CE implementation as they can procure external knowledge and skills for SMEs (Vihma & Moora, 2020). Especially tackling environmental challenges needs collaborations in SMEs (Hofmann et al., 2012). Since it is known that collaboration might facilitate CE implementation, scholars demand empirical research to better understand the network-related factors that facilitate or hinder CE transitions (Ferasso et al., 2020). Highlighting the benefits of a company's position in a social network, social capital (SC) theory becomes important (Nahapiet & Ghoshal, 1998), which is less explored in the CE context. SC comprises a social element that captures the essence of various sociological concepts, norms, and values, and a capital element that represents the added monetary value of the transformation undertaken (Lin, 2002). Focusing on these elements, SC focuses on cooperative social relationships and the resources they contain. SC is known as "the sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by individuals or social units" (Nahapiet & Ghoshal, 1998, p. 243).

Previous literature has investigated how the SC of a firm can improve interfirm learning, strengthen cooperation with stakeholders (Ramström, 2008), foster new opportunities identification and supplementary resources acquisition (Gulati et al., 2000), influencing firm innovation (Ince et al., 2023; Molina-Morales & Martínez-Fernández, 2010) and entrepreneurial orientation (Rodrigo-Alarcón et al., 2018). Despite the increasing contributions separately made in both fields, SC and CE, less is known about the relationship between SC and CE. Scholars have highlighted the importance of SC when it comes to CE (Perey et al.,

2018; Skawińska & Zalewski, 2018). Single case studies investigated how companies use SC to implement CE practices (Germundsson & Gernandt, 2019; Istiyani & Wijayanto, 2022). However, quantitative studies to analyze the fine-grained mechanisms focusing on SC and CE are missing. Our study seeks to close this research gap. Since studies investigating SC found different results depending on the SC dimensions, we analyze SC as a three-dimensional variable (Nahapiet & Ghoshal, 1998), with each dimension potentially having a different impact on CE implementation. Consequently, the most critical conditions within the three-dimensional model can be associated with implementing CE practices.

The dynamic capabilities (DCs) approach helps explain the relationship because DCs help companies effectively leverage the knowledge acquired from their SCs (Jantunen, 2005). We define DCs as "the firm's ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environment" (Teece et al., 1997, p. 516). While the concept was developed with a focus on large companies, research has shown that DCs provide equally important insights for micro and SMEs (Elf et al., 2022; Filser et al., 2021; Hernández-Linares et al., 2021; Wu et al., 2013). Especially in the context of CE implementation, qualitative research has shown that DCs might foster CE implementation in MSMEs by facilitating access to stakeholders' information and improving the business model (Elf et al., 2022; Prieto-Sandoval et al., 2019). Regarding SC and DC, it is found that with the help of SC, companies are able to find new prospects, possibilities and the most suitable set of alternatives and in turn identify, interpret and use them through their DCs (Atuahene-Gima & Murray, 2007). Regarding DCs and CE, Khan et al. (2021) established that a firm's implementation of CE practices in medium and larger firms is driven by its DCs. Moreover, qualitative studies such as Elf et al. (2022) specify that DCs enable small enterprises to advance CE practices. Hence, SCs developed by companies from interaction with other stakeholders provide information, knowledge, and resources that can be anticipated and integrated using DCs and thus be used in new services, products, or processes (Zahra & George, 2002) or specifically in CE practices.

We therefore ask: *Does social capital facilitate implementing CE practices in small firms? Do dynamic capabilities mediate this relationship?* Our paper thereby answers the demand for more research on SC and DCs for the implementation of CE (Chowdhury et al., 2022; Prieto-Sandoval et al., 2019; Suchek et al., 2021). To answer this research question, we collect and assess survey data from 1,022 German MSMEs. Unlike previous studies that investigate CE in larger firms (Erdiaw-Kwasie et al., 2023; Khan et al., 2021) and medium-sized enterprises

(Ormazabal et al., 2018; Schmidt et al., 2021), our sample mainly comprises micro and small firms. Our findings confirm that SC significantly impacts the implementation of CE activities. Specifically, structural capital positively and significantly correlates with CE implementation, while relational and cognitive capital have a positive but insignificant effect. In addition, DCs positively and significantly effect CE implementation and act as a partial mediator between SC and CE. The contribution of the paper is threefold. First, we complement the scarce research in CE by empirically examining the multifaceted character of SC and its impact on the implementation of CE practices, emphasizing that structural capital in particular needs to be strengthened in order to increase the implementation of CE practices. Second, we investigate the mediating role of DCs on the association between a company's SC and CE implementation, answering recent calls on the need to build bridges to encompass research topics that are outside the traditional core of CE studies (Sehnem et al., 2022). Third, we not only extend research on SC theory in the context of CE implementation but also add knowledge on DCs in the small and micro firm setting representing a theoretical contribution to the CE perspective.

3.2 Theoretical background and hypotheses development

In recent years, academic literature has focused on understanding the driving forces and impediments to CE adoption in SMEs, as these companies play an important role in the European economy (Yadav et al., 2018). In 2020, SMEs accounted for 99.8 percent of the total companies located in the European Union (European Commission, 2021). In addition, they generate 53 percent of value added and employ 65 percent of the workforce in the European Union (European Commission, 2021). SMEs are among the most economically vulnerable organizations, as they have limited resources and face financial and market barriers (Prieto Sandoval et al., 2021). SMEs potentially have a greater propensity to partner with stakeholders as their resources are limited (Courrent et al., 2018). Furthermore, SMEs have simpler and flatter structures which might lead to lower coordination costs (Courrent et al., 2018). Only recently scholars have begun to study the implementation of CE in SMEs (Chowdhury et al., 2022; Schmidt et al., 2021). To enhance this burgeoning line of research, we concentrate on small firms as an appropriate context for our empirical research.

3.2.1 Social capital and circular economy

Advancing from a linear economy to a CE entails collaboration (Hazen et al., 2020) which plays an important role throughout the entire value chain (De Angelis, 2020; Köhler et al., 2022). Through social interaction, companies can comprehensively increase mutual knowledge exchange (Lane & Lubatkin, 1998). Furthermore, strategic alliances are important for CE (Suchek et al., 2021) and an ecosystem of different actors is necessary for a CE to thrive (Rajala et al., 2018). An enhancement of this perspective is that companies incorporated in social structures are equipped with SC. The basis of SC lies in the relationships between individuals and their interactions (Putnam, 1995). Companies equipped with SC can more easily identify new opportunities and acquire complementary resources (Gulati et al., 2000). SC theories provide important evidence that trust, networks, and shared goals play key roles in overcoming actions and constraints (Ostrom, 2014; Putnam, 2000). SC facilitates access to resources, knowledge, and information and helps stakeholders to align critical responsibilities and interdependencies (Gargiulo & Benassi, 2000). Thus, when considering the composition and character of existing social relationships, SC has been emphasized as a valuable strategic resource and considered crucial to effective collaborative efforts (Adler & Kwon, 2002; Coleman, 1994; Ince et al., 2023; Subramony et al., 2018; Wulandhari et al., 2022).

Although it is known that SC positively influences innovations (Molina-Morales & Martínez-Fernández, 2010; Rodrigo-Alarcón et al., 2018) and innovation performance (Ince et al., 2023) less is known about the role of SC regarding CE implementation. The correlation between collaborations and CE has attracted increasing attention in the scientific community (Baah et al., 2023; Köhler et al., 2022). However, as related as collaboration is to SC, previous research has failed to highlight the fine-grained and nuanced mechanisms of how companies should use SC to build the capabilities needed for CE implementation. Social interactions, where SC is created, enable companies to learn how to share crucial information effectively and reach a joint agreement on tasks or objectives, as well as to access other resources, knowledge, and ideas regarding CE (Castilla-Polo & Sánchez-Hernández, 2022). Based on the SC theory perspective, we postulate that although SMEs may suffer from their liability of smallness, interaction with and pressure from partners force the implementation of CE practices (Jakhar et al., 2019), leading SMEs to leverage resources to support business activities (Durand et al., 2019). To the fact that SC can facilitate access to information, technologies, markets, knowledge, and resources, CE implementation can be facilitated.

Germundsson and Gernandt (2019) discussed how SC plays an essential role for companies in practicing CE. Nevertheless, they have qualitatively analyzed SC and CE in companies without focusing on a close examination of their interrelationships. Thus, we aim to demonstrate that SC can be a strategic resource for companies to advance the implementation of CE activities, as CE is built, among other things, on the exchange of knowledge and the collaborative use of resources. Hence, we propose:

Hypothesis 1. SC is positively associated with CE implementation.

SC can be broken down into three key dimensions: structural capital, relational capital, and cognitive capital (Nahapiet & Ghoshal, 1998). The structural dimension relates to the company's network of relationships and aims to capture the social exchange and activity in this network (Nahapiet & Ghoshal, 1998). Hence, structural capital addresses the overall relationships and interconnections among social actors (Ganguly et al., 2019; Nahapiet & Ghoshal, 1998). Relational capital focuses on the characteristics of personal exchange developed by actors in the course of their relationships and interactions (Granovetter, 1992). Trust is seen as the main component of this dimension. It is based on the fact that the other stakeholders in the social environment will not behave in an opportunistic manner (Nahapiet & Ghoshal, 1998). Cognitive capital depicts information and resources based on a common representation and interpretation and similar meaning systems between the partners (Nahapiet & Ghoshal, 1998). Accordingly, the main components of the cognitive dimension are shared goals, beliefs, and visions.

In line with previous literature, we investigate SC as a three-dimensional variable that incorporates three subdimensions (Koka & Prescott, 2002). These dimensions can also be considered separately because each SC dimension can have a differential impact on the dependent variable under study. To make the study more robust and informative (Ganguly et al., 2019), we dive deeper and study the relationship of each dimension of SC separately with CE implementation.

Structural capital comes from more social interaction (Molina-Morales & Martínez-Fernández, 2010). Resources are embedded in the social relations of actors, and their access is enabled by social interactions and network formation (Coleman, 1988; Nahapiet & Ghoshal, 1998; Putnam, 2000). These social relationships and interactions might result in greater access to external resources (Powell et al., 1996), especially needed by smaller firms. Companies in dense networks are able to develop new ideas and opportunities because the interaction within

a collaborative network is intense (Fountain & Atkinson, 1998). Due to this, companies could stimulate their implementation of CE activities (Chowdhury et al., 2022). Hence, we propose:

Hypothesis 2a. Structural capital is positively associated with CE implementation.

As the second dimension, relational capital reduces opportunistic behavior between parties through greater trust between actors, resulting in fewer resources being spent on monitoring (Kaasa, 2009; Kwon & Arenius, 2010). This allows the exchange of sensitive information (Akçomak & Ter Weel, 2009) and enhances the opportunities for the development of joint cooperation activities and new CE practices. Furthermore, relational capital improves the success and survival of firms. When companies are affected by unexpected events or disruptions, recovery from such negative events can be facilitated by the existence of relational capital, as trusted stakeholders would act in a benevolent manner to resolve the situation (Jia et al., 2020). Hence, we conclude:

Hypothesis 2b. Relational capital is positively associated with CE implementation.

Cognitive capital, for example, shared goals, language, and understanding, give individuals a common cognitive frame of reference to identify, understand, and then share common knowledge with other actors in a social network (Kang et al., 2007; Nonaka, 1994). With the help of shared visions and goals, a bonding mechanism is created that makes it easier for the various actors in a network to acquire, share and integrate new knowledge (Inkpen & Tsang, 2005). Moreover, a shared culture, which includes shared beliefs, values, and norms, influences the knowledge-sharing and integration process. Cognitive capital enables companies to correctly understand external knowledge and thus avoid misunderstandings (Tang, 2010). Furthermore, cognitive capital facilitates the interpretation of useful information (Doh & Acs, 2010). This enhances the circular practices of a company by encouraging activities that focus on innovativeness and creativity. Hence, we propose:

Hypothesis 2c. Cognitive capital is positively associated with CE implementation

3.2.2 Social capital and dynamic capabilities

DCs are resources that SMEs cannot easily build in comparison to companies with a larger firm size and more extensive capacities (Palmié et al., 2016; Park & Kim, 2013). Due to fewer opportunities regarding capabilities, resources, and power in the market (Drnevich & Kriauciunas, 2011; Sawers et al., 2008), SMEs are more prone to environmental changes (Wade

& Hulland, 2004) and competition (Wang & Shi, 2011). The most relevant factors for SMEs are therefore maintaining agility and adapting to environmental change (Wade & Hulland, 2004; Wang & Shi, 2011). Since it can be difficult for SMEs to periodically reconfigure their resource foundation to react to changes in the environment, DCs are particularly important to SME competition and success (Wang & Shi, 2011). Based on earlier works by Teece (2007) and Teece et al. (1997), we concentrate on four dimensions of DCs that serve as instruments for the regeneration of existing capabilities according to Pavlou and El Sawy (2011): sensing, learning, integration, and coordination capabilities. For a company to become more performant and competitive, all capabilities can be in place when it changes its resource base (Hernández-Linares et al., 2021). Since we have smaller and more direct structures in the SME domain, we follow Pavlou and El Sawy (2011), focusing on a more concrete consideration of DCs at the level of managers' decision-making.

Small companies, in particular, are subject to the problem of smallness, which leads to resource constraints. Thus, it is particularly important to build DCs in SMEs, as small companies that have limited resources can be more successful if they are able to leverage valuable and rare resources through DCs that they can access with the help of SC (Coviello & McAuley, 1999; Pinho, 2011). To build capabilities, therefore, SMEs often need to leverage their social connections to develop SC, which creates the necessary requirements for gaining access to new sources of information and possibilities beyond the company (Grabher, 1993). However, there is a lack of research regarding smaller firms and a call for research linking SC and DCs in the context of SMEs (Gamage et al., 2020).

Literature has shown that SC positively correlates with DCs in medium-sized companies (Rodrigo-Alarcón et al., 2018) and family businesses (Wang, 2016). Through the availability of dense networks, companies gain SC which is relevant for building DCs. Network density allows companies to interact with different actors and therefore be able to share tacit knowledge and sense and absorb information about the market and its product developments and technologies more easily (Hansen, 1999). The constant recurrent exchange, therefore, plays an essential role in ensuring that organizations gain an understanding of where truly relevant knowledge can be found and who possesses it (Kale et al., 2000). With the possession of SC, small companies are able to collaborate with actors to overcome resource constraints and barriers. Furthermore, established trust within a network enables greater knowledge sharing because opportunism is reduced and reciprocity is enhanced (Nahapiet & Ghoshal, 1998). Hence, companies with more SC connect with a wider business community and anticipate and

seize more information (Wang, 2016). Similar cultural backgrounds enable the acquisition of tacit knowledge more easily (Parkhe, 1991). In particular, a shared vision brings together different actors and helps to facilitate access to knowledge and resources (Inkpen & Tsang, 2005). This knowledge and these resources must then be understood, integrated, and coordinated by companies within the framework of DCs.

To build new DCs that provide a competitive advantage, SMEs must utilize their network relationships to access new information sources (Pinho, 2011). DCs thus enable companies to process and pool information to better understand its importance (Blyler & Coff, 2003). The SC serves as an intermediary for acquiring resources by providing access to cohesive and diverse sources of information, which in turn can be processed by DCs. Hence, we conclude:

Hypothesis 3. SC is positively associated with DCs.

3.2.3 Dynamic capabilities and circular economy

The DCs define the company's capability and readiness to implement necessary changes for business sustainability (Mousavi et al., 2018). Hence, research suggests that companies need to focus on identifying and developing DCs to achieve sustainability (Annunziata et al., 2018). Although DCs have already been explored in the context of CE (Khan et al., 2021), there is little quantitative literature on the topic focusing on SMEs. Chowdhury et al. (2022, p. 370) stated that "investigation is required to model the relationship between knowledge and skills-based antecedents [and] CE practice". The logic of CE requires several changes that can lead to improved resource utilization (Stankevičienė et al., 2020). In this, the CE implementation of a firm is driven by its capabilities and resources (Helfat & Martin, 2015). Several researchers have shown that DCs facilitate CE implementation in larger organizations by allocating resources and planning investments (Kabongo & Boiral, 2017; Khan et al., 2020, 2021; Marrucci et al., 2022b). Furthermore, DCs can be seen as drivers of the CE in innovation environments (Sehnem et al., 2022) and play an important role in business model innovation for sustainability (Bocken & Geradts, 2020). Especially for SMEs, DCs are relevant in establishing CE practices (Elf et al., 2022). Herewith, research has shown that the interaction between the individual DC dimensions is often fluid and takes place simultaneously in SMEs while implementing CE practices (Elf et al., 2022). In contrast to large companies, the individual DCs - sensing, learning, integration, and coordination - therefore blur and interlock.

Thus, the dimension of DCs should not be considered separately but rather analyzed as one construct in smaller companies. Hence, DCs are relevant for achieving CE and we propose:

Hypothesis 4. DCs are positively associated with CE implementation.

3.2.4 The mediating effect of dynamic capabilities

To identify the origin of companies' capabilities, previous research highlights the crucial role of SC in creating new assets and strategic skills (Helfat & Martin, 2015). Therefore, capabilities are developed by acquiring external tacit knowledge using SC, which is seen as a key factor (von den Driesch et al., 2015). The knowledge gained from a company's SC can be used effectively with the help of DCs (Jantunen, 2005). In doing so, companies can be enabled to identify and acquire new insights, possibilities, and the best appropriate choices through the company's SC (Atuahene-Gima & Murray, 2007). SC acts as a social integration mechanism that transforms potential exterior expertise into a company's particular capabilities (Zahra & George, 2002). It enables access to extraneous resources and dedicated information that is difficult to acquire in alternative ways. DCs enhance the development of these insights (von den Driesch et al., 2015).

Companies avoid risky activities if they cannot interpret the knowledge of their partners. Thus, the firm's value creation is inhibited (Marrucci et al., 2022a). Based on these arguments, knowledge sharing between companies through higher SC does not warrant CE transformation. It will be the companies that leverage their DCs to use SC by identifying, assimilating, and transforming external knowledge to generate complementary capabilities (Zhang & Wu, 2013). Hence, DCs are important for firms to take advantage of SC. SMEs with high levels of DCs can readily acquire the abilities needed to enhance performance and strengthen their competitive advantage (Hernández-Linares et al., 2021). Thus, DCs lead organizations to identify and interpret new angles, possibilities, and the best options through the organization's SC (Atuahene-Gima & Murray, 2007). This reasoning suggests that DC mediates the association between SC and CE. According to our previous hypotheses, we conclude:

Hypothesis 5. DCs mediate the association between SC and CE implementation.

Figure 4 shows the research model with the hypotheses.

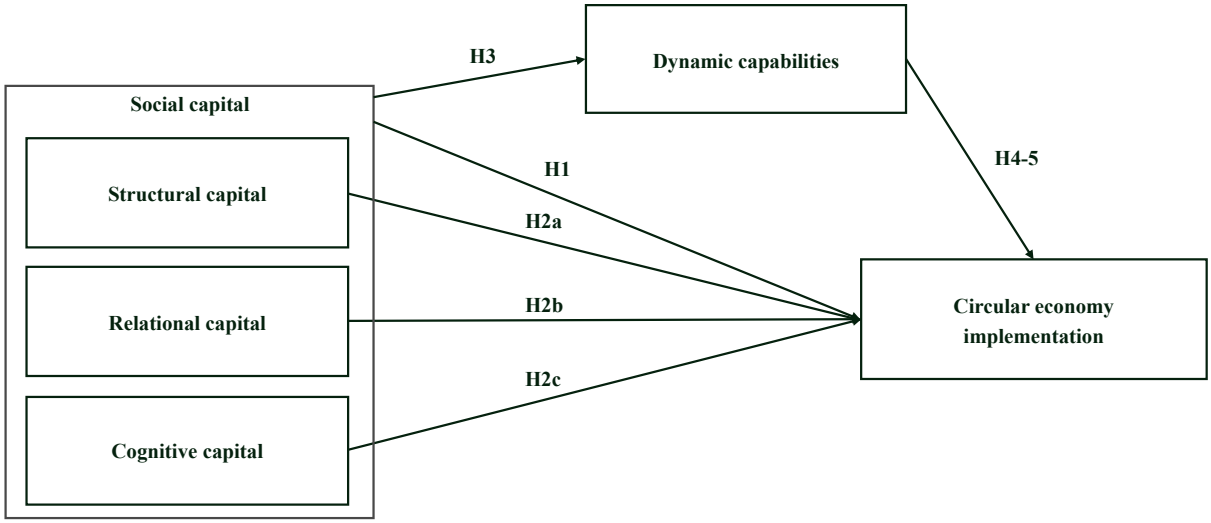

Figure 4

Research model Essay II

3.3 Methodology

3.3.1 Sample and data collection

To investigate the determinants for CE implementation, we focus on German MSMEs. To comply with the definition of MSMEs, we have followed the EU-wide definition (European Commission, 2003). We concentrate on German firms because the empirical assessment of the collaborative determinants of CE implementation is especially effective in this context to the fact that Germany is known for a long tradition of environmental legislation and circularity and is often considered an important pioneer of CE-related politics (Geng et al., 2013).

We applied a stratified sampling approach and collected cross-sectional data over the course of two months from July to August 2022. The publicly available business and contact information of manufacturing as well as service MSMEs provided by different Chambers of Crafts were used. We ensured a comprehensive distribution over Germany and different sectors. 14,488 German MSMEs were contacted by e-mail twice including a reminder e-mail sent two weeks after the initial contact. A total of 1,240 valid responses were received. This corresponds to a response rate of 8.56 percent. Of the 1,240 returns, 217 responses had a missing value in one or more of the variables examined and were consequently excluded. Another company was

additionally excluded as it did not count as an SME because they employed more than 250 people (European Commission, 2003). Finally, our sample contains 1,022 companies, resulting in a response rate of 7.05 percent which is comparable to other studies in this field, such as Khan et al. (2020). Table 9 contains the descriptive statistics of the sample.

Table 9

Chapter 3: Descriptive statistics of the sample

Firm size	Frequency	%	Firm age	Frequency	%
1 (micro)	270	26.42	<= 5 years	145	14.19
2-4 (micro)	361	35.32	6-20	286	27.98
5-9 (micro)	186	18.20	21-35	251	24.56
10-19 (small)	105	10.27	>= 36	339	33.17
20-49 (small)	66	6.46	n/a	1	0.10
50-250 (medium)	29	2.84			
n/a	5	0.49			

Especially in the area of sustainability, social desirability is considered a critical factor (Podsakoff et al., 2003). To reduce this effect, the participating companies were promised absolute confidentiality and anonymous evaluation of the data collected. Appendix 3 shows the questionnaire which was designed based on validated constructs established in the literature (see Appendix 4). Since the existing constructs were in English, the items first had to be translated into German. We carefully translated them into German and then back-translated them into English (Brislin, 1970). Furthermore, items were adapted and expanded in consultation with various experts close to the target group, which led to better comprehensibility of the questions. The revised items were then reviewed in pre-tests with employees from various trades and refined with examples.

3.3.2 Measurement

Dependent variable. To measure the construct of CE implementation, we referred to Khan et al. (2020) who partly developed and adapted indicators from Zhu et al. (2010). This scale has been widely used by prior research (Khan et al., 2021; Marrucci et al., 2022b). To address the specific circumstances of the sample population we adapted the existing scale. We follow the literature and combine the items into one construct (Khan et al., 2021). The survey of CE activities is based on a six-point, fully verbalized Likert scale. The complete verbalization increases both the reliability and the validity of the survey (Menold et al., 2014). Following

previous work in the CE field (Khan et al., 2021; Zhu et al., 2010), the following nomenclature was chosen: not currently planned - thinking about it - already planned - started implementing - successfully implemented. Since the implementation of CE activities can also depend on external factors such as the client or prescribed materials, a sixth answer option “not possible in my company” was added. The scale has a Cronbach’s alpha of 0.82.

Independent variable. We analyzed SC through the three dimensions suggested by Nahapiet and Ghoshal (1998) and measured them by using different scales adapted from Rodrigo-Alarcón et al. (2018). To capture structural capital, we measured social interaction ties with the 3-item scale from Maula et al. (2003). Regarding relational capital, we draw on the five-item scale by Kale et al. (2000). Cognitive capital was measured by a four-item scale developed by Villena et al. (2011). All items were slightly adjusted in wording to fit the underlying subject of our sample. Responses were scored on a four-point Likert scale, ranging from fully disagree to fully agree. We have changed the Likert scale from a five-point to a four-point scale in order to adapt the questionnaire to our target group. Cronbach’s alpha for the scale of structural capital is 0.70, relational capital is 0.78, and cognitive capital is 0.87. We apply Bartlett’s test for sphericity and use the Kaiser-Meyer-Olkin value (KMO) to determine the adequacy of the sample and whether the data were suitable for exploratory factor analysis (Cerny & Kaiser, 1977; Cop et al., 2020; Schmidt et al., 2021). The results indicate the suitability of the data and model with a p-value of less than 0.05 and a KMO value higher than 0.8 (KMO = 0.85, p = 0.00). The analysis of the principal components revealed three factors with eigenvalues above 1.0 (factor 1 = 5.05; factor 2 = 1.56; factor 3 = 1.25). Since not only the Scree-Test shows only the first factor as relevant, but also each item has its main loading on factor 1 (Cattell, 1966), the three constructs - structural, relational, and cognitive capital - were combined into one variable SC. The reliability analysis for SC yielded a Cronbach’s alpha of 0.87.

Mediator. We measured DCs by adapting the 19-item scale developed by Pavlou and El Sawy (2011) that has been applied by others (Hernández-Linares et al., 2021). This scale includes the mentioned four capabilities: sensing (four items), learning (five items), integrating (five items), and coordinating (five items). We measure DCs based on established scales with a four-point response format ranging from fully disagree to fully agree. Again, we adjusted the Likert scale from a five-point to a four-point response scale to measure the variables consistently. Cronbach’s alpha for this scale is 0.90. Appendix 4 shows the different measurement scales.

Control variables. Because several organizational characteristics can influence the integration of the CE into a firm's strategy, we control for the following including firm size, firm sales, firm age, and firm segment (product and services) (Eikelenboom & de Jong, 2022; Hernández-Linares et al., 2021; Ormazabal et al., 2018; Rizos et al., 2016). As suggested by Longoni et al. (2018), we controlled for *firm* size by measuring the number of employees. Since larger companies have more resources and thus more human, time, and financial capacity to invest in CE activities. Research has also shown that larger companies generally show more engagement in sustainability activities (Block & Wagner, 2014). On the other hand, smaller firms may have more flexibility and the ability to develop capabilities more quickly (Drnevich & Kriauciunas, 2011). We included *firm sales* as another control as it also determines the extent to which resources are available (Aragón-Correa et al., 2008). Moreover, the implementation of CE activities may depend on the *firm age*. Older companies have a greater experience with entrepreneurial practices (Kyrgidou & Spyropoulou, 2013), which can promote the implementation of CE activities. However, the age of the company can also be a negative factor, as it leads to greater rigidity and causes less agility in the company (Lee, 2008). Therefore, we used the age of the firm measured as the number of years between the establishment of the firm and the survey date (Hernández-Linares et al., 2021; Rodrigo-Alarcón et al., 2018). We further included the *firm segment*. Here we distinguish between three categories: production, service, and companies that offer both. This is reasonable because CE activities can be implemented differently depending on whether companies offer tangible or intangible goods.

3.4 Empirical results

3.4.1 Preliminary analysis

In line with previous research, we verified the validity and reliability of the measurements before analyzing our hypothesis (Ganguly et al., 2019; Schmidt et al., 2021). We considered four criteria, namely indicator reliability, internal consistency, convergent validity, and discriminant validity to evaluate our research model (Bagozzi & Yi, 1988; Hair et al., 2019). As written above, we assess indicator reliability with Cronbach's alpha above 0.70 for all constructs (Churchill & Gilbert, 1979). Furthermore, we found that composite reliability (CR) values for all constructs ranged above 0.70 (Bacon et al., 1995) from 0.71 to 0.87, meeting the criteria for internal consistency (see Table 10). Hence, we satisfy the validity and reliability

standards. By conducting exploratory factor analysis using a varimax rotation with Stata 17, we verify the convergent validity of the variable constructs (Hair Jr et al., 2010).

Table 10

Chapter 3: Validity and reliability indicators

	Number of items	**Cronbach's alpha**	**CR**
1 CE	15	0.8237	0.7843
2 SC	12	0.8713	0.8696
2a Structural capital	*3*	*0.6583*	*0.7087*
2b Relational capital	*5*	*0.7807*	*0.7798*
2c Cognitive capital	*4*	*0.8738*	*0.8739*
3 DCs	19	0.9004	0.8984

We assess discriminant validity by showing that the square root of the average variance extracted (AVE) is a bigger value than the correlation between each construct pair (Fornell & Larcker, 1981) (see Appendix 5). It should be noted that the variable SC is formed from its subdimensions structural, relational, and cognitive capital and that the correlations between these are therefore higher. For the regression, however, we considered SC and the dimensions separately in different models.

For this study, data is collected from a single source which could be a potential source of CMB. Therefore, Harman's one factor test was performed through explanatory factor analysis by extraction of principal components analysis recommended by Podsakoff et al. (2003). CMB was present when a single factor arose from an unrotated factor solution or when the first factor accounted for more than 50 percent of the calculated variance (Podsakoff et al., 2012). The analysis yielded 10 factors with an eigenvalue greater than one that explained 61.10 percent of the total variance. The first factor declares 17.38 percent of the variance. Hence, no single factor emerged, so CMB was not a major problem.

To confirm non-response bias, we utilized t-tests to compare early and late respondents (Armstrong & Overton, 1977). The concept is founded on the premise that the way late responders answer the questionnaires is similar to the way non-responders answer the questionnaires. This approach was also followed by other research (Weimann et al., 2020). For this purpose, the mean values of the first 25 percent of participants were compared with those of the last 25 percent. To ensure that no systematic bias occurred among the responses, the mean values of selected key figures of the early-responding participants were compared with

those of the late-responding respondents from the sample (see Appendix 6). The mean comparisons performed using t-tests show no significant differences between early and late responses. The findings revealed insignificant differences between the two groups, thus invalidating concerns about non-response bias.

3.4.2 Regression analysis

To analyze the collected data, we employ multiple linear regression analysis to test hypotheses 1, 2, and 3 with control variables firm size (employees), firm sales, firm age, and segment. Therefore, we test the Gauss-Markov assumptions which must be fulfilled to ensure that the respective results are unbiased and reliable (Hallin, 2014). For all variables, these assumptions are fulfilled. Furthermore, variance inflation factor (VIF) statistics were run to deal with concerns about multicollinearity. None of the VIF values of the individual variables were found to be above the threshold of 3.3 when combined with the other variables (Hair et al., 2011; Johnston et al., 2018).

Model 1 includes control variables only and reveals that the size of the company appears to be negatively related to CE implementation (β = -0.01, p = 0.006). Moreover, the highest sales volume has a positive influence on CE implementation (β = 0.61, p = 0.04). The control variable segment shows statistically significant effects on CE implementation: On the one hand, companies that offer only services have on average a lower level of CE practices (β = -0.44, p = 0.00). On the other hand, being a company that offers both services and products increases the level of CE (β = 0.51, p = 0.00). Furthermore, the company age (β = -0.00, p = 0.261) has no effect on CE implementation.

In Model 2 and 3, we assess the direct effect of SC and DCs on CE to account for hypotheses 1 and 4. As predicted by hypothesis 1, SC (β = 0.42, p = 0.00) is a significant predictor for CE implementation (Model 2). Regarding hypothesis 4, the direct association between DCs and CE implementation is significant and positive (β = 0.27, p = 0.00) (Model 3). Thus, hypothesis 4 is supported as well (see Table 11).

Table 11

Chapter 3: Results of regression analysis (I)

CE as dependent variable	Model 1	Model 2 (composite)	Model 3 (composite)
SC		0.4167***	0.3703***
DCs			0.2656***
Controls			
Firm size (employees)	-0.0076***	-0.0067**	-0.0063**
Sales (<22 T. € as base)			
22 T. -<50 T €	0.1726	0.1395	0.1811
50 T. - <125 T. €	0.0201	-0.0149	0.0375
125 T. - <250 T. €	-0.0171	-0.0938	-0.0635
250 T.- <500 T. €	-0.0058	-0.1135	-0.0578
500 T. - <2,5 M. €	-0.0965	-0.1651	-0.1117
> 5 M. €	0.6135**	0.4543	0.4814
Firm age	-0.0010	-0.0007	-0.0007
Segment			
Services	-0.4434***	-0.4120***	-0.4174***
Production & Services	0.5125***	0.5021***	0.4908***
R^2	0.1463	0.1750	0.1829
F	17.29***	20.31***	20.15***

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 968

The individual components of SC – structural, relational, and cognitive capital – were tested on CE implementation in Model 4. Structural capital is a significant predictor for CE implementation ($\beta = 0.28$, $p = 0.00$). Hence, hypothesis 2a is supported. Relational ($\beta = 0.03$, $p = 0.63$) and cognitive capital ($\beta = 0.11$, $p = 0.11$) are insignificantly related to CE implementation. Hence, hypotheses 2b and 2c are not supported. Thus, the results indicate that not all components of SC are equally important in explaining CE implementation. Model 5 underlines these results. All models are statistically significant (see Table 12).

Table 12

Chapter 3: Results of regression analysis (II)

CE as dependent variable	**Model 4 (factor)**	**Model 5 (factor)**
Structural Capital	0.2772***	0.2664***
Relational Capital	0.0325	0.0026
Cognitive Capital	0.1052	0.1049
DCs		0.2699***
Controls		
Firm size (employees)	-0.0064**	-0.0061**
Sales (<22 T. € as base)		
22 T. -<50 T €	0.1268	0.1718
50 T. - <125 T. €	-0.0354	0.0201
125 T. - <250 T. €	-0.1216	-0.0894
250 T.- <500 T. €	-0.1397	-0.0800
500 T. - <2,5 M. €	-0.1953	-0.1385
> 5 M. €	0.3922	0.4256
Firm age	-0.0007	-0.0007
Segment		
Services	-0.4081***	-0.4138***
Production & Services	0.4967***	0.4858***
R^2	0.1805	0.1885
F	18.26***	18.37***

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 968

Table 13 shows the regression with DCs as the dependent variable. We assess the direct effect of SC and DCs on CE to account for hypotheses 3. As predicted by hypothesis 3, SC ($\beta = 0.17$, $p = 0.00$) is significantly associated with DCs (Model 6).

Table 13

Chapter 3: Results of regression analysis (III)

DCs as dependent variable	**Model 6**
SC	0.1749***
Controls	
Firm size (employees)	-0.0014
Sales (<22 T. € as base)	
22 T. -<50 T €	-0.1568
50 T. - <125 T. €	-0.1975
125 T. - <250 T. €	-0.1140
250 T.- <500 T. €	-0.2095
500 T. - <2,5 M. €	-0.2013
> 5 M. €	0.1019
Firm age	-0.0000
Segment	
Services	0.0202
Production & Services	0.0425
R^2	0.0754
F	6.27***

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 968

3.4.3 Mediation analysis

Hypothesis 5 suggests that the association of SC with CE implementation is mediated by DCs. According to Baron and Kenny (1986), a mediation analysis demands three results. In a structural equation modeling (SEM) model that included only SC, CE implementation, and the aforementioned control variables (Model 2), there is a significant relationship (β = 0.42, p = 0.00). Second, in an SEM model that included only SC, DCs, and the control variables, there is a significant relationship (β = 0.17, p = 0.00) (Model 6). Third, if SC is no longer significantly related to CE implementation after the introduction of DCs, then full mediation can be claimed. In an SEM model that included SC, DCs, CE implementation, and the control variables (Model 3), there is a significant SC – CE implementation relationship (β = 0.37, p = 0.00) and a significant DCs – CE implementation relationship (β = 0.27, p = 0.00). To the fact, that the

effect of SC on CE implementation is reduced after introducing DCs, we can thus assume that the effect of SC on CE implementation is partially mediated by DCs.

To validate this assumption, we followed the approach by Iacobucci et al. (2007). This approach builds upon Baron and Kenny (1986), however allows for latent variables, and reduces standard errors (Mehmetoglu, 2018). As the constructs used in this study are all latent variables, the approach is preferable. Additionally, we chose the alternative to bootstrapping proposed by Jose (2013), namely the Monte Carlo approach, which is less computationally intensive. Table 14 displays the findings of the analysis concerning the indirect effect.

Table 14

Chapter 3: Results of mediation analysis (Monte Carlo Approach)

Hypothesis	Indirect Effect (Monte Carlo)	SE	p	LLCI	ULCI	Result
SC → DC → CE	0.110	0.050	0.027	0.027	0.222	Partial mediation (complementary mediation)

Regarding hypothesis 5, the relation between SC and CE implementation is partially mediated by DCs (ind. effect = 0.110 (0.027, 0.222)). Both the direct (p = 0.00) and indirect effect (p = 0.03) as well as Sobel's z (p = 0.02) are statistically significant. Note that after introducing DCs, the relationship between SC and CE remained significant but with a lower coefficient (Model 3). Following Zhao et al. (2010) it can be classified as complementary mediation as the Monte Carlo test is significant (p = 0.03) and both coefficients point in the same direction.

3.5 Discussion

By applying multiple linear regression analysis, we investigated to what extent SC, with its subdimensions of structural, relational, and cognitive capital, facilitates CE implementation in the context of German SMEs. Furthermore, we analyzed the role of DCs in this context and whether DCs mediate the relation between SC and CE implementation in SMEs. Table 15 provides an overview of the different hypotheses tested and the results.

Table 15

Chapter 3: Summary of results

Hypothesis	Content	Result
H1	SC is positively associated with CE implementation.	Significant effect
H2a	Structural capital is positively associated with CE implementation.	Significant effect
H2b	Relational capital is positively associated with CE implementation.	No significant effect
H2c	Cognitive capital is positively associated with CE implementation.	No significant effect
H3	SC is positively associated with DCs.	Significant effect
H4	DCs are positively associated with CE implementation.	Significant effect
H5	DCs mediate the association between SC and CE implementation.	Partial mediation effect

3.5.1 Interpretation of results

Only a few studies empirically investigate how SMEs develop CE practices (Schmidt et al., 2021). We focused on the determinants of CE implementation as previous research emphasized the need for new studies analyzing the determinants of CE implementation (Prieto-Sandoval et al., 2018; Sehnem et al., 2022). The scarce literature focusing on understanding the drivers for CE in SMEs totally ignores the role SC plays. The results of this paper support the hypothesized relationship that SC contributes to the implementation of CE in MSMEs. Specifically, we hypothesized that the three dimensions of SC are positively related to CE implementation. However, our findings reveal that not all SC dimensions support the implementation of CE activities: We found that structural SC is the only dimension that has a significant positive impact. Thus, we conclude that relational (trust) and cognitive (shared values) capital are not necessarily paramount for CE implementation in SMEs, but rather the stable, constant, and regular exchange between different parties. Our results confirm the theoretical proposals of previous researchers (Germundsson & Gernandt, 2019; Skawińska & Zalewski, 2018) that structural capital enables the implementation of CE.

SMEs are characterized by small and stable network structures, which are reflected in structural capital (Wulandhari et al., 2022). With the help of social interactions, the boundaries between organizations can be dissolved, and the formation of a common interest can be stimulated (Molina-Morales & Martínez-Fernández, 2010). Consequently, when a company established a

higher number of social exchanges with other companies, it has more possibilities to share and connect resources in the network, which has a positive impact on the implementation of CE. Specific, valuable and rich knowledge gained through social networks allows CE efforts to be directed in the right direction and carried out effectively both within and between companies. Hence, MSMEs can acquire the inputs through structural capital to develop their CE knowledge and increase CE activities. This implies that actively fostering structural capital, for example through installing business associations, could indeed support CE implementation in MSME.

The relationship between relational capital and CE implementation was not significant. This is surprising as we would have expected companies with relational capital to implement more CE practices. An explanation could be that, given that exchanges between MSMEs and their stakeholders are already characterized by trust (Brunetto & Farr-Wharton, 2007) and that MSMEs generally have a high degree of personal interaction with existing stakeholders (Coviello et al., 2000), relational capital is not a rare or scarce capital, but one that has been present in exchanges between MSMEs for decades and is part of everyday business life. The implementation of CE practices might not be influenced by relational capital. Hence, more implementation of CE activities only occurs when relational capital is accompanied by other elements. Future research could investigate when trust becomes crucial for CE implementation.

Regarding cognitive capital, the results show no significant relationship concerning CE implementation. Common values, ambitions, and goals are core elements of cognitive capital (Nahapiet & Ghoshal, 1998). Researchers found that conflict and loss of trust can be fueled by a lack of shared values, vision, and goals (Inkpen & Tsang, 2005). Cognitive capital thus plays an essential part in transferring knowledge and innovation (Ganguly et al., 2019). However, our findings did not show a significant effect in the context of CE. Since MSMEs tend to be hands-on and therefore do not have an explicitly formulated corporate culture, the corporate culture tends to be implicit. Accordingly, it is difficult for outsiders to recognize and assess the culture and visions of other companies and to reconcile them with their visions. The implicit communication in MSMEs (Morsing & Spence, 2019) contributes to the fact that cognitive capital does not reflect significance. Our results suggest that CE implementation is about interactivity and regular, stable exchange with and proximity to other business partners to access market knowledge (for example, logistics, framework conditions, and structures). Thus, the implementation of CE is about social interactions, exchange, and knowledge sharing.

Furthermore, we examined the mediating role of DCs on the association between SC and CE implementation in MSMEs. Consistent with Khan et al. (2021), we demonstrated that DCs positively and significantly influence CE implementation. Concerning the mediating influence of DCs on the relationship between SC and CE implementation, we proposed that DCs enhance the positive relationship. According to previous research, we show the importance of DCs in taking advantage of SC (Helfat & Martin, 2015; Rodrigo-Alarcón et al., 2018; von den Driesch et al., 2015) and further demonstrate how this leads to implementing CE practices. DCs bring the body of knowledge gained through SC into the knowledge flow by facilitating the sharing of resources and enabling MSMEs to leverage their SC. This allows MSMEs to anticipate environmental changes, respond to those changes, and implement CE practices

3.5.2 Theoretical contribution

We extend the understanding of the mechanisms leading to CE implementation by being, to our knowledge, the first empirically studying the influence of SC on CE implementation. The theoretical contribution of this study is threefold. First, we empirically explore the network forms of SC and show that firms that incorporate SC, especially structural capital, are more likely to implement CE practices. We further examined the three SC dimensions for their influence on CE implementation and found a heterogeneous effect on CE implementation. Based on this, targeted dimension-specific interventions can be recommended to further drive CE implementation in MSMEs. Hence, we complement the scarce research in the CE field by empirically examining the multidimensional nature of SC and its impact on the implementation of CE activities in MSMEs, emphasizing that structural capital in particular needs to be strengthened to increase the implementation of CE practices. Second, we demonstrate how the creation and enhancement of DCs utilize the SC of companies to implement CE activities. In this context, we highlight the importance of DCs as exploiters of SC on the way to higher CE implementation. Third, previous studies have only focused on the importance of DCs for CE implementation in larger companies (Khan et al., 2021; Köhler et al., 2022). We reinforce previous research (Elf et al., 2022) by showing the significance of DCs in the context of CE implementation in small companies. Hence, we extend research on SC theory and add knowledge on DCs in the smaller firm setting in the context of CE implementation.

In summary, our study contributed to the research in the field of SC and CE, where the impact of the individual dimensions of SC on CE implementation has not yet been investigated. With this study, we add the context of CE to the existing research on the relation between SC and

DCs focusing on SMEs (Pinho, 2011; Wang, 2016). We respond to the demands of Sehnem et al. (2022) on the need to build bridges to encompass research topics that are outside the traditional core of CE studies linking three theoretical approaches, namely SC, DCs, and CE implementation. We further answer the call of Kristoffersen et al. (2020) for quantitative research to examine and develop the implementation of the CE.

3.5.3 Managerial and practical implications

The idea of CE is to maximize the value of resources by closing, slowing, and narrowing material cycles. Herewith, a high level of interconnectedness and resource dependency between different stakeholders (i.e., suppliers, customers, etc.) is central. CE practices aim to transform companies and industries into an industrial symbiosis with closed resource loops by eliminating waste and pollution, facilitating several life cycles of products and materials, and maximizing the use of the embedded value of resources (Kennedy & Linnenluecke, 2022). However, since the implementation of CE activities can tie up resources and since MSMEs in particular lack key resources, it is even more important for them to build SC and thus a network that can be used to identify and implement various CE activities. The development of SC, particularly structural capital, is essential for implementing CE activities. This focuses on regular and stable exchanges with other companies, allowing new ideas, activities, and technologies to be captured. SC can enable the sharing and efficient exchange of resources. With the help of DCs, companies can better respond to changes in the environment, leverage SC, and implement CE activities.

Several conclusions for managers and institutions can be drawn from the findings of the present study. First, companies should develop, expand, and improve their structural capital in the form of networks and information sharing. Hence, managers should focus on building social interaction ties. Specifically, we encourage managers to gather new information by exploring new relationships with actors outside their current network to access new knowledge and innovation. This is particularly important because with the innovation of new business models, structures within the value chains change, and new forms of cooperation emerge, leading to new networks (Lüdeke-Freund et al., 2019). Through networks, MSMEs in particular can not only access materials, resources, and knowledge, but also pass on by-products or resources that they no longer need themselves. Since, for example, no overarching platforms have yet been developed to map the availability of (used) materials, those MSMEs that have a broad network of contacts, especially benefit because they have access to new potential buyers and suppliers

as well as sources of knowledge. Small companies, especially in comparison to large enterprises, can use direct contacts and thus direct paths to keep resources in the cycle and thus slow down, reduce, and close circles. Second, the implementation of CE does not depend on SC alone, but also on the extent to which knowledge can be used within SC. SC gained through sharing and interaction can be anticipated and specified with the help of DCs. Companies should proactively sense and transform their networks and the SC gained with the help of DCs to be able to anticipate and implement CE practices. DCs here refer to the ability to sense the environment in order to detect new business prospects, integrate them, and thus adapt one's own offering. It also describes the capacity to assess and further develop new information and knowledge and to integrate them into the company. Third, we propose that institutions should encourage measures to facilitate the flow of knowledge and information between companies. They should increase access to partnerships between companies to increase the volume and transparency of available knowledge that companies can reach. In addition, institutions should explore and develop new ways and possibilities for MSMEs to share material and cognitive resources across sectors.

3.5.4 Limitations and future research

As with any survey, there are several limitations to this study. First, our data collection is a cross-sectional design. Especially in the strategic literature, the cross-sectional design is widely used (Schmidt et al., 2021), but it limits the possibility to draw causal conclusions. As the debate on sustainable business practices continues and legislation continues to drive non-financial reporting and the implementation of CE, MSMEs will increasingly be affected directly or indirectly and will therefore also continuously change their behavior. Hence, a longitudinal research design could shed more light on the development of CE implementation and its antecedents. Second, we focus on German MSMEs and hence one cultural background. The results of this study concerning contexts and prerequisites for successful CE implementation should also be generalizable to other contexts. Further research could apply the research model in other MSMEs and other regions outside Germany to assess whether the results are reproducible and generalizable to other contexts. In addition, the research model could be studied in the context of larger companies to analyze and compare the differences and similarities according to company size. Third, the data do not allow to ask why certain implementations of CE activities are not planned. The reasons for answering the question about CE activities can be manifold and were not queried further. To improve the understanding of

the motives, concepts, and antecedents of CE implementation, especially in relation to SC, a case study design would be appropriate.

3.6 Conclusion

MSMEs play a significant part in the implementation of a CE. Based on a self-generated sample of MSME owners, we help decipher the mechanisms of CE implementation. We extend the understanding of the determinants of CE implementation by empirically focusing on MSMEs in this context. We found that SC and DCs are positively and significantly related to CE implementation and that DCs are a partial mediator between SC and CE implementation. Furthermore, we investigated the influence of the three SC dimensions: While structural capital has a positive, significant influence, we could not prove a significant influence for relational and cognitive capital. We connect two theories, SC and DCs, to explore firms' CE antecedents. Our study provides valuable insights for practice and research at the intersection of sustainability, network, and strategy. It thus gives a foundation for driving the development toward a circular, resource-efficient transformation.

4 | Turning old into new as a competitive advantage? The relationship between innovation capability and the circular economy implementation in German SMEs

Abstract

For small and medium-sized enterprises (SMEs), adopting innovative practices can become a critical driver in achieving the circular economy (CE) and obtaining a competitive advantage by enabling them to optimize resource use, minimize environmental impact, and create sustainable business models. This study aims to empirically investigate the transformative potential of innovation capability for SMEs in achieving CE implementation and further focuses on the extent to which innovation capability and CE implementation are associated with a competitive advantage. Based on a self-generated sample of 186 German SMEs, I used a questionnaire to investigate the influence of innovation capability on implementing a CE. I further analyzed the mediating effect of CE implementation in explaining the relationship between innovation capability and competitive advantage (including differentiation and cost-leadership advantage). Using regression analysis, the results reveal that innovation capability is positively associated with CE implementation and that CE implementation is positively related to competitive advantage. However, CE implementation does not mediate the relationship between innovation capability and competitive advantage. I theoretically and empirically examine innovation capability in the context of a CE and extend the literature by proposing that the CE helps firms achieve a competitive advantage.

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Status: Working paper[3]

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4.1 Introduction

The increase in local and global competition in various industries has led to the need for companies to continuously improve their competitiveness. Competitive advantage is therefore focused on the identification of strategies that create an advantage over other competitors of the company (Reuter et al., 2010). This depends, in particular, on a corporate strategy for the successful management of tangible and intangible resources. Due to the prevailing linear economy, which functions according to the motto “take-make-use-waste”, more and more resources have been exploited. SMEs must reconfigure and combine their resources and capabilities to align with environmental requirements while maintaining competitiveness (Mishra & Yadav, 2021). As economic growth must be decoupled from resource consumption in the future, companies are trying to focus on the benefits of reuse and recycling and, therefore, a circular economy (CE) (Fomina et al., 2018). The optimization of resource consumption is seen as a key lever for curbing the exploitation of resources and promoting economic growth (Blomsma & Brennan, 2017). Companies are optimizing their processes, reducing their resources, and innovating their products and services to slow down, narrow, and close cycles in the sense of the CE. The CE is described as a new economic concept with which this competitive advantage can be achieved. With the help of circular practices, companies are trying to embed sustainability in their business to be competitive (Lin et al., 2016). Although a previous study has shown that sustainable practices can be linked to competitive advantage in SMEs (Mady et al., 2023), research with regard to CE implementation is missing.

The CE is a key concept in the transformation to a sustainable economic paradigm and is defined as a “system that is restorative or regenerative by intention and design” (Ellen MacArthur Foundation, 2013, p. 7). A CE is not necessarily a disruptive concept but rather a step-by-step approach to doing business economically, ecologically, and socially. While the environmental impact of a CE has been studied (Domenech & Bahn-Walkowiak, 2019), relatively little is known about its economic impact. As the main objectives of a CE are not of an economic nature, it is nevertheless important for politicians, managers, and entrepreneurs to know whether a CE can be profitable and whether companies that implement CE practices gain a competitive advantage. Previous research has found a positive relation between CE implementation and firm performance in large companies (Kwarteng et al., 2022). However, when considering competitiveness, it is important to distinguish between larger companies and small and medium-sized enterprises (SMEs), as they have different characteristics (Man et al.,

2002). In addition to internal differences in organizational structure and management style, there are also external differences in terms of regulation and interaction with the environment. Smaller companies in Europe are often critical to economic growth as they drive radical innovation because they often operate outside dominant paradigms and exploit opportunities neglected by larger firms. SMEs are also often more responsive to customer needs (OECD, 2017a). They are particularly well placed to take advantage of greener supply chain opportunities in local clean technology markets that are unattractive or inaccessible to large global companies (OECD, 2017a). As SMEs often act as suppliers to large organizations, the implementation of CE practices also has an impact on their actions (Ghazilla et al., 2015). For this reason, the analysis of large companies is not directly transferable to SMEs.

Current CE practices in SMEs mainly focus on reducing waste production, reducing energy consumption, and promoting the use of renewable energy (Dey et al., 2020; Katz-Gerro & López Sintas, 2019). In addition to environmental benefits, CE offers SMEs additional incentives such as improved corporate image, reduced costs, and increased productivity (Dey et al., 2020). However, SMEs face increasing challenges in complying with environmental and social standards according to local and global guidelines, which can affect their competitiveness. Furthermore, environmental and social initiatives are often associated with significant costs (Dey et al., 2020). Prieto-Sandoval et al. (2019) note that SMEs often have limited technical and financial resources and, therefore, may not prioritize CE, especially if they are not fully aware of its benefits. Academics and practitioners often note that CE can give companies a competitive advantage. However, the transition to a CE is not that simple, but rather a complex process that requires organizational change and innovation (Sehnem et al., 2022; Suchek et al., 2021).

Since the competitive advantage in SMEs does not have to stem exclusively from the implementation of CE practices, but can also derive from the general ability to innovate, it is important to take a closer look at the ability to innovate in SMEs. Competitive advantage can be based on two different types, the differentiation and cost-leadership advantage (Porter, 1985). These strategies can be influenced by innovation capability and have already been highlighted in detail in previous studies with a focus on large companies (Li & Li, 2008; Zott & Amit, 2008). Innovation capability is an important factor that generates a competitive advantage for SMEs and improves business performance (Chen et al., 2018; Tamayo-Torres et al., 2016). However, previous research has found that SMEs pay less attention to innovation than large companies (Park et al., 2013). Especially in the rapidly changing economy, the

prosperity of SMEs depends heavily on their ability to innovate (Denicolai et al., 2021; Hock-Doepgen et al., 2021; Saunila, 2020).

It is reasonable that innovation capability can be a vehicle for triggering sustainable transformation, as innovation has also fueled the development of the industrial, carbon-intensive economy. Since the innovation behavior of small companies is different from that of large companies (Çakar & Ertürk, 2010; Nieto & Santamaría, 2010) it is important to understand which role innovation capability plays in SMEs in the context of CE implementation. Companies are forced to innovate their processes, products, and services to adapt to sustainable concepts such as CE. Thus, innovation capabilities can help companies increase their environmental, economic, and social efficiency and create market value. Suchek et al. (2021) call for research in the field of innovation and CE to be expanded and empirically underpinned in terms of primary data. Sehnem et al. (2022) specifically underline the need for comparative studies and empirical validation of innovation capabilities within the CE context.

There are some studies that have already investigated innovation capability, CE implementation, and competitive advantage in isolation in SMEs (Jakhar et al., 2019; Lieder & Rashid, 2016). However, prior research is predominantly based on theoretical and conceptual work, and a link between these variables is needed. This study, therefore, focuses on competitive advantage with its sub-strategies, differentiation and cost-leadership, and investigates the effects of innovation capability and CE implementation on these strategies. Furthermore, I elaborate on the mediating effect of CE implementation on the linkage between innovation capability and competitive advantage. Thus, this research not only provides a theoretical framework to examine the relationship between the three concepts, innovation capability, CE implementation, and competitiveness but also investigates the relationships using empirical primary data from German SMEs.

German SMEs are targeted for this study since the role of SMEs in the EU and the OECD countries is fundamental to the global economy. In the context of pursuing a sustainable and inclusive growth model, and the transitioning to circular business models, the role of SMEs is key. Technological and organizational innovations that support a CE can increase Europe's resource productivity by up to 3 percent by 2030 (Rizos et al., 2016). The OECD recognizes SMEs as key actors in protecting the environment and promoting inclusive economic growth (Prieto-Sandoval et al., 2019). To adhere to environmental legislations and fulfill stakeholder requirements, German SMEs demonstrate a high level of innovation, contributing to Germany

as one of the leading innovation-based economies in Europe (Schmidt et al., 2021). Investigating the strategic antecedents and outcomes of CE practices in German SMEs is advantageous due to CE plays a relevant role within the German business landscape, mitigating the possibility of short-term effects (Schmidt et al., 2021). However, it is important to note that SMEs are not a homogeneous group but are highly heterogeneous in nature, meaning that these companies are at very different stages of environmental management maturity (Ormazabal et al., 2018).

On the one hand, researchers have already hypothesized that the ability to innovate can have an influence on the implementation of CE activities (Sehnem et al., 2022) and have shown this for larger companies (Saari et al., 2024). On the other hand, it is known that innovative capability has a positive influence on the competitiveness of companies (Ferreira et al., 2020). However, the relationship between CE and competitiveness has only been examined qualitatively (Kahupi et al., 2021; Razminiene, 2019) or with a focus on firm performance in large companies (Kristoffersen et al., 2021a; Kwarteng et al., 2022). Since the implementation of CE in SMEs has great potential but, at the same time, many barriers, the extent to which CE implementation is positively associated with a competitive advantage should be investigated. In particular, the splitting of competitive advantage into the two well-known types, differentiation advantage and cost leadership advantage, is, to my knowledge, empirically unexplored. Furthermore, I investigate whether the implementation of CE activities mediates the relationship between innovation capability and competitive advantage. Since the implementation of a CE in the company can save resources, avoid waste, and offer a competitive advantage through innovative processes and products, I assume that CE implementation can act as a mediator. As there is still a lot of research to be done in this area, further studies involving CE and SMEs should be carried out in the future (Sharma et al., 2021). Hence, I ask the following research questions:

1. *Does innovation capability help SMEs to implement the CE?*
2. *Are innovation capability and CE implementation positively related to a competitive advantage in SMEs and what competitive advantage(s) may be derived?*
3. *Does CE implementation mediate the relationship between innovation capability and a competitive advantage?*

While the majority of studies in the context of SMEs' innovation capability focus on the manufacturing sector (Saunila, 2020), this study focuses on the service and manufacturing

industry to enhance the knowledge in the field. Seles et al. (2022) call for studying more services companies because offering services instead of products can have an important role in the transition to circularity. Especially with regard to competitive advantage, future studies should address both, manufacturing and service companies (Mady et al., 2023). I use multiple linear regressions and structural equation modeling to assess and validate the theoretical model that is created based on previous research and validated measurement models. By analyzing survey data from 186 German SMEs, collected from September to November 2023, this study contributes to the theory and practice in the following ways. First, I contribute to the research on innovation capability in SMEs and complement the existing knowledge by investigating the relationship between innovation capability and different competitive strategies, namely differentiation and cost-leadership, in SMEs. Second, I extend the body of knowledge on CE innovation and capabilities by examining the relationship between innovation capability and CE implementation. Hence, I respond to the call by Sehnem et al. (2022) for further quantitative studies in this context. Third, I extend existing studies in the CE field by focusing on competitive advantage in SMEs and separately analyze the two main competitive strategies, differentiation and cost-leadership, in the area of CE implementation. Fourth, I investigate the mediating role of CE implementation in the relationship between innovation capability and competitive advantage. I hereby combine different areas of research.

The findings reveal that innovation capability and CE implementation are positively and significantly related to competitive advantage. However, CE implementation does not mediate the relationship between innovation capability and competitive advantage. These findings provide evidence that while the implementation of CE practices can be positively associated with competitive advantage, it depends on the ability to innovate, which provides a competitive advantage. For this reason, innovative SMEs that implement CE are currently not necessarily ahead of innovative SMEs that do not implement CE in terms of competitiveness. In addition, the study has strong managerial implications since it can guide SMEs leveraging innovation capability and CE practices to improve competitive advantage.

4.2 Theoretical background

4.2.1 Innovation capability in SMEs

Innovation can only happen if the company has the capability to innovate (Laforet, 2011). Innovation capability is "the ability to continuously transform knowledge and ideas into new products, processes, and systems for the benefit of the firm and its stakeholders" (Lawson & Samson, 2001, p. 384). Hence, it is a valuable asset of a firm (Guan & Ma, 2003) by being the ability to bundle and integrate the main resources of an organization in order to successfully stimulate innovation. According to Adler and Shenhar (1990), innovation capability is defined as (1) the ability to develop new products and services that satisfy the market (product innovation), (2) the ability to apply appropriate processes to produce new products (process innovation), (3) the ability to develop and adapt new products, services, and processes to satisfy future needs, (4) the ability to respond to unexpected opportunities created by competitors. In addition, innovation capability is the ability to combine the knowledge that exists within the organization to generate new knowledge that can lead to product, service, or process innovations (Kogut & Zander, 1992). With the help of innovation capability, internal company methods can be revised to offer increased benefits and identify critical factors to create value. A high level of innovation capability, therefore, means that a company is able to react to change, develop new ideas, and transform them into new products, services, or processes (Sehnem et al., 2022). The capability of innovation facilitates firms to introduce new products quickly and adopt new systems. Rather, it is important to factor in feeding the ongoing competition.

Existing research indicates that innovation capability differs greatly between large and small companies due to different determinants of innovation efforts and different types of innovation (Çakar & Ertürk, 2010; Nieto & Santamaría, 2010). In the small business context, empirical evidence on innovation capability has elaborated into two paths of research: the one studying the antecedents of innovation capability and the one studying the outcomes of innovation capability (Saunila, 2020). In the context of SMEs, innovation capability is most often conceptualized as an outcome studied with its determinants (e.g., leadership, knowledge development, networks) (Saunila, 2020). Regarding innovation capability as a process, previous research has mainly focused on firm performance and uncovered a positive relation between innovation capability and firm performance in small businesses (Zhang & Hartley, 2018). Hence, research in the context of small companies about other innovation capability

outcomes, such as the implementation of CE practice and competitive advantage, is scarce and missing.

4.2.2 Circular economy in SMEs

CE encourages different ways of using and processing materials throughout the product life cycle (Kirchherr et al., 2017). Adhering to a closed-loop system of resources and energy through biological or technical cycles, CE ensures that growth is restricted with minimal emissions during product manufacturing (Prieto-Sandoval et al., 2018). The primary objective of CE can thus be seen as the autonomous regeneration of the economy without affecting natural capital, or as the enhancement of each product's value by improvement of the material quality and minimization of resource and energy consumption (Geissdoerfer et al., 2017; Katz-Gerro & López Sintas, 2019; Mura et al., 2020). According to the Ellen MacArthur Foundation (2013), the optimization of resource yields is achieved by using products, components, and materials in the technical and biological cycle for as long as possible at the highest possible level. Hence, the CE is defined as a regenerative system that focuses on minimizing materials and energy, using products and stocks for longer periods, reusing products, and using non-toxic materials. These strategies are described as 'Narrow', 'Slow', 'Close', and 'Regenerate' strategies (Bocken et al., 2016; Geissdoerfer et al., 2017). On an operational level, CE practices can be implemented by various CE product/service design principles or so-called R's highlighted in the CE literature (e.g., reduce, rethink, reuse, recycle, refurbish, and remanufacture) (Kirchherr et al., 2017). For most of these strategies, some innovation is required (Dey et al., 2022).

Prieto-Sandoval et al. (2018) indicate that SMEs can achieve several benefits and opportunities by embracing CE practices, such as enhancing brand reputation, reducing operation costs, business expansion, increasing productivity, environmental recovery through lower CO2 emissions, and gaining a competitive edge. However, the researchers also reveal that the primary motivation of SMEs to adopt CE is the potential to save costs, rather than build brand reputation or respond to regulatory pressure. Effective implementation of CE relies on a range of internal and external organizational elements. External factors include public policy, market conditions, technological development, and stakeholder actions, while internal factors involve the companies' resources, capabilities, and competencies (Prieto-Sandoval et al., 2018). Nevertheless, some characteristic features of SMEs, such as cultural barriers, limited client interest and awareness, and a cautious corporate culture, are viewed as the main challenges to

implementing CE (Dey et al., 2022). Garcés-Ayerbe et al. (2019) distinguish that the barriers to CE implementation are administrative processes, regulations, and a shortage of trained human resources; in the contracts, companies that have not adopted CE principles see financing, investment, and cost-benefit barriers as the most significant barriers. Additionally, management attitudes to CE principles are some of the major barriers to transitioning to CE (Chowdhury et al., 2022). Moreover, governments and policymakers provide limited support to implement CE (Prieto-Sandoval et al., 2019). It is clear from the various barriers mentioned that CE is only implemented in SMEs if it brings an advantage or a business case can be made for it.

4.2.3 Competitive advantage in SMEs

A competitive advantage is essential for helping organizations to outperform their competitors. The firm's competitive advantage refers to a company's capability to strategize and deliver services and novel products that are superior in quality and cost-leader than those of the competitors (Leskovar-Spacapan & Bastic, 2007). According to the resource-based view (RBV), possessing resources that are scarce, valuable, cannot be easily replaced, and are difficult to imitate gives the company a stronger opportunity to gain a competitive advantage (Barney, 1991). RBV highlights the significance of differentiating companies in the market through resource utilization. Resources that the company holds are important, but the employment and allocation of these resources are equally valuable.

Although a competitive advantage is widely explored together with firm performance, it does not equate to superior performance (Ma, 2000). Porter (1985, p. 3) states: "Competitive advantage grows fundamentally out of the value a firm is able to create for its buyers that exceeds the firm's cost of creating it. Value is what buyers are willing to pay, and superior value stems from offering lower prices than competitors for equivalent benefits or providing unique benefits that more than offset a higher price. There are two basic types of competitive advantage: cost leadership and differentiation." In this sense, Porter defines competitive advantage in rather specific and concrete ways. Hence, competitive advantage is treated as an outcome (of positioning) and should be pursued as an end in itself.

Companies can achieve two different types of competitive advantage: differentiation and cost leadership (Lechner & Gudmundsson, 2014). A differentiation advantage allows firms to achieve competitive advantages by providing distinctive and innovative products to customers

or by modifying the features and design of current products (Khan et al., 2019). The novelty and newness can be merged into the product's features, design, and structure (Porter, 1980). It enables a firm to differentiate itself from competitors, build customer loyalty, and win higher profits (Su et al., 2017). In contrast, a cost-leadership advantage enables companies to gain a cost-based competitive advantage by cutting costs relevant to materials, product development, marketing, operations, suppliers, wages, and management, ultimately leading to improved performance (Porter, 1980). Reducing costs leads to a decrease in the expenses associated with product development and enhances the overall profitability of businesses (Su et al., 2017). The firm can attain a cost-based competitive advantage through a variety of methods, including improved management of manufacturing and materials to capitalize on the experience curve and continually reduce costs, as well as enhancing and updating its expertise within established technological paths and market segments (Li & Li, 2008).

Although competitive advantage in cost or differentiation may increase the likelihood of better performance, competitive advantage per se is not the same as performance (Ma, 2000). At least, cost advantage and differentiation advantage, two generic types identified by Porter (1980), are not necessarily the ultimate determinants of performance. Saunila (2020) notes that many studies in the SME context only focus on testing the direct relationship regarding firm performance, while testing the direct relationship only serves to obscure many influencing factors in this relationship, and the results will be unreliable. Therefore, to obtain reliable results, influencing variables that are omitted and ignored should be considered and empirically examined. For example, previous studies found that competitive advantage and firm performance are positively associated in the context of SMEs (Khan et al., 2019) and that business model innovation and firm performance are partially mediated by competitive advantage (Anwar, 2018). Since competitive advantage and performance are two different constructs (Ma, 2000), competitive advantage is included as an outcome variable in this study to obtain a reliable result.

4.3 Hypotheses development

4.3.1 Innovation capability and circular economy

Innovation is opined to be a valuable policy for managers to follow for the adoption of CE (Berrone et al., 2013). Innovations lead to new processes, products, procedures, and services

in companies, which can result in a CE (Scarpellini et al., 2020). Therefore, business organizations will try to exploit their distinctive, innovation capabilities to adopt sustainable innovations. Innovation capability is associated with the development of the skills needed to implement CE (Jakhar et al., 2019). The prominent role of managers in SMEs with a strong innovation capability in the implementation of the CE is mainly reflected in their openness to innovative concepts and ideas. This attitude is crucial for CE implementation as it requires fundamental changes in both production processes and products themselves. To achieve this, it is important to establish a culture of creativity and interdisciplinary exchange (Sehnem et al., 2022). Innovations in new products and services are key factors in the implementation of CE and in the development and application of CE practices. (Santa-Maria et al., 2021). Managers who embrace innovation tend to possess a forward-looking perspective, which plays a pivotal role in advancing the adoption of CE principles (Konietzko et al., 2020). The transition to CE is fraught with various risks, especially in the early stages. Managers with a strong propensity to innovate are more willing to accept such risks and adopt new, experimental methods to develop innovative solutions (Saari et al., 2024). These aspects underline the crucial importance of innovation capability in management for the successful implementation of CE and the overall success of the company (Gupta et al., 2016).

Horvath et al. (2019) examine the trend for innovation in business models and identify processes in the sector aligned with CE implementation. Furthermore, Jakhar et al. (2019) propose that the implementation of CE practices becomes easier for companies with innovation capabilities because their structures are tailored toward adopting rapid changes. Design-oriented innovations, such as design thinking, service design thinking, and co-creation may support managers to generate ideas and identify opportunities present in the CE (Fleischmann, 2019). Moreover, innovation capability helps to remove the barriers that exist in the implementation of a CE (De Jesus et al., 2018). Saari et al. (2024) posit that innovation capabilities play a key role in guiding firms to adopt CE practices. The acceptance of CE will require organizations to develop innovation capabilities (Jakhar et al., 2019). Therefore, CE is the indicator of a business shift underpinned by the way manufacturer produces, consumers consume, and people behave while responding to ecological and societal needs (Prieto-Sandoval et al., 2018). Companies with innovation capabilities and the willingness to incorporate innovation, in contrast to those that remain conservative, promote CE practices (Kuzma et al., 2022). Due to the fact that research in the field of innovation capability and CE

implementation is scarce, especially in the context of SMEs (Rodríguez-Espíndola et al., 2022), this study focuses on this relationship. Hence, I propose:

Hypothesis 1. Innovation capability is positively associated with CE implementation in SMEs.

4.3.2 Innovation capability and competitive advantage

Innovation capability encompasses the continuous pursuit of new ideas, the introduction of new products or services, and the enhancement of existing offerings. Managers with an innovation capability are often characterized by creativity, willingness to experiment, and openness to change. This orientation is crucial for SMEs as it enables them to navigate rapidly changing market environments and differentiate themselves from competitors. Innovation capability is often seen as the most important factor in the success and competitiveness of SMEs due to the fact that innovation capability enables SMEs to exploit market gaps and grow more successfully (Buonanno et al., 2005). A firm's competitive advantage depends on its ability to innovate in ways that its rivals cannot easily imitate (Jakhar et al., 2019). Specifically, the innovation capability of the manager is a fundamental factor in SMEs' survival and achieving competitive advantage (Hatani, 2022). Innovation capability can drive the development of production processes, quality, technology, new products, and services to meet customers' needs. It is usually crucial for SMEs to focus on innovation as it facilitates the firms' capabilities required to respond competitively to achieve sustainable competitive advantage. Hence, innovation capability should be an integral part of a firm's strategy because higher innovativeness levels lead to improved cooperation and coordination within firm (Antoncic & Prodan, 2008).

The majority of the empirical studies found a positive link between innovation capability and firm performance in the context of SMEs (Agyapong et al., 2017; Saunila, 2020). Innovation capability is connected to new product performance (Zhang & Hartley, 2018), brand performance (Odoom & Mensah, 2019), and overall firm performance (Keskin, 2006). Further, different types of innovation capability, meaning innovation in products, processes, organization, and marketing, contribute to operational performance (Kafetzopoulos & Psomas, 2015), and business return (Maldonado-Guzmán et al., 2018) in the SME context. Moreover, previous researchers have found that a high level of innovation in large companies can contribute significantly to improving firm valuation and revealed that innovation has a positive and significant impact on competitive advantage (Liu et al., 2020; Saari et al., 2024).

Innovation capability is considered a special asset for firms to provide and sustain competitive advantage in the implementation of the entire strategy. While previous research focuses on innovation capability in SMEs and competitive advantage in large companies, studies with a focus on innovation capacity and competitive advantage in the context of SMEs are scarce. Hence, I argue the following:

Hypothesis 2. Innovation capability is positively associated with a competitive advantage in SMEs.

4.3.3 Circular economy and competitive advantage

To gain a sustainable and competitive edge, SMEs can consider implementing CE strategies. CE practices focus on reducing energy, material, and waste and increasing resource efficiency by reusing, repairing, refurbishing, and recycling products and materials (Geissdoerfer et al., 2017). Furthermore, CE strategies substitute fossil energy with renewables. Research in the context of CE has shown that companies that successfully circularize their business model are more likely to have economic benefits and lower production costs by, for example, recycling valuable waste as new resources, lowering input prices, and minimizing environmental impact and waste (Park et al., 2010), resulting in higher firm performance (Kristoffersen et al., 2021a). New products serving a CE (such as energy-saving products or products characterized by a better repairability and recyclability or a longer lifetime) may lead to first-mover advantages that are accompanied by higher competitiveness of the innovating firm (Porter & van der Linde, 1995).

Research in the context of CE has already shown in large companies that CE can lead to many benefits, such as environmental, social, and competitive advantages (Benachio et al., 2020). The introduction of CE practices to mitigate the risks associated with climate change can provide a competitive advantage (Okorie et al., 2023). Hence, CE implementation could aid SMEs in lowering expenses, fostering innovation, and enhancing environmental performance (Prakash et al., 2023). By implementing CE practices, companies offer their customers more sustainable products and services than their competitors. Specifically, Mura et al. (2020) have shown that differentiation advantage might be a perceived competitive advantage for SMEs implementing CE practices. Environmentally mature companies have learned that environmental improvements, such as longer product life cycles, sustainable design, etc., may positively influence their reputation and profits (Ormazabal et al., 2016). The CE should be

integrated into SMEs' strategy to gain a competitive advantage by offering environmentally friendly products and services that provide greater value to customers compared to competitors' offerings (Prieto-Sandoval et al., 2019). Furthermore, the implementation of CE activities in an SME's business not only leads to environmental benefits but can also lead to economic benefits, such as increased cost savings and access to new business models and markets (Ormazabal et al., 2018; Rizos et al., 2016). Nevertheless, research on SMEs has shown that they recognize the benefits of improved resource efficiency, but they do not always manage to effectively link these benefits to the concept of CE principles (Rizos et al., 2016). The implementation of CE strategies might also lead to higher costs because additional equipment, organizational changes, or more expensive sustainable material is needed (Horbach & Rammer, 2020).

Razminiene (2019) suggests that resource efficiency is one of the most important ambitions and can work as an enabler of a CE for SMEs, gaining a competitive advantage at the same time. Their literature analysis revealed the importance of a CE in gaining a competitive advantage, especially for SMEs (Razminiene, 2019). Furthermore, Sharma et al. (2021) conducted interviews with representatives of SMEs and found that CE might lead to a competitive advantage. However, extensive empirical testing has failed to conclusively support that the implementation of CE practices and a competitive advantage are positively associated. Even when firms are pressured to implement these practices, they tend to generate heterogeneous responses (Berrone et al., 2013; Darnall & Edwards Jr, 2006). As SMEs usually have limited financial and technical resources, they may not be aware of the added value of CE measures. For this reason, it is important to analyze empirically whether CE provides a competitive advantage for SMEs. Hence, I propose the following:

Hypothesis 3. CE implementation is positively associated with a competitive advantage in SMEs.

4.3.4 Circular economy as a mediator

Based on the hypotheses derived so far, it can be concluded that CE implementation is a mediator between innovation capability and competitive advantage. One important difficulty that SMEs face is resource limits, which are comprehensively documented in the literature (Kirchherr et al., 2018). This impacts the potential for SMEs to innovate, as innovation is resource intensive. Increasing competition is pushing managers and owners of SMEs to

innovate their business models in order to remain competitive, flexible, and adaptable (Sehnem et al., 2022). Hence, SMEs need to develop more creative and inventive methods to operate. CE is likely a method that helps SMEs to gain a competitive advantage in this changing market. According to Okorie et al. (2023), sustainability and CE are among the primary drivers of innovation, and hence, the implementation of CE practices might be dependent on innovation capability.

Camisón and Villar-López (2014) assumed that innovation capabilities directly impact the performance of a company. Other research reckoned that innovation capabilities do not necessarily directly lead to improved performance (Rajapathirana & Hui, 2018). They pointed out that competitive advantage or improved performance does not rely on innovation capabilities themselves but rather on the resource configurations created by innovation capabilities. For example, new ideas and technologies can be developed through innovation capability that aim to reduce, slow, regenerate, and close resource cycles. These practices, which contribute to a CE, can lead to increased demand for products, leading to higher customer satisfaction and competitive advantage (Bhupendra & Sangle, 2016). Within CE, where product-as-a-service, product life extension, resource recovery, and regenerative business models are more likely to be implemented, companies need to ensure they have the right skills and resources for competitive advantage adaptation (Okorie et al., 2023). With the help of innovative capabilities, circular strategies can be found and implemented, which in turn provides a competitive advantage by differentiating from competitors. In summary, CE implementation serves as a mediator between innovation capability and competitive advantage for small businesses by enabling the translation of innovative ideas into practical solutions that enhance market positioning, operational efficiency, and long-term sustainability. Hence, I conclude:

Hypothesis 4. CE implementation mediates the relationship between innovation capability and competitive advantage in SMEs.

Figure 5 shows the research model.

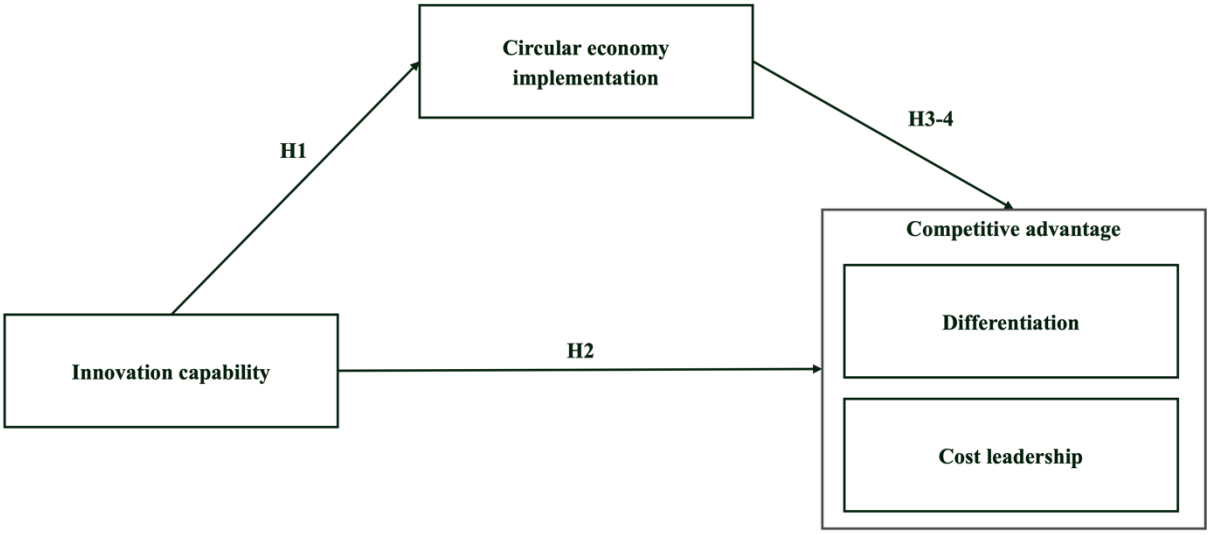

Figure 5

Research model Essay III

4.4 Methodology

4.4.1 Sample and data collection

This study employed a quantitative research method, in which data were collected by a questionnaire survey within German SMEs. To comply with the definition of SMEs, I have followed the EU-wide definition (European Commission, 2003). I concentrate on German firms because the empirical assessment of the collaborative determinants of CE implementation is especially effective in this context to the fact that Germany is known for a long tradition of environmental legislation and circularity and is often considered an important pioneer of CE-related politics (Geng et al., 2013).

Overall, 15.000 SMEs were contacted. The self-administered online survey was created by Qualtrics and distributed via email. The publicly available business and contact information of manufacturing as well as service SMEs provided by different Chambers of Crafts were used. I collected the data over six weeks from September to October 2023. Overall, 1.440 emails were undeliverable, three owners of the SMEs have retired, and five companies were permanently closed. I received a total of 196 responses and hence a response rate of 1.45 percent. Of the 196 returns, 186 surveys were completely and correctly filled out, which means the survey was

completed and there were no missing answers in the items. All questionnaires meet the criteria of an SME (< 250 employees) (European Commission, 2003). This results in a response rate of 1.24 percent and represents a comparable response rate for this research area (Kristoffersen et al., 2021a). Table 16 shows the descriptive statistics of the sample.

Table 16

Chapter 4: Descriptive statistics of the sample

Firm size (employees)	Frequency	%	Firm age	Frequency	%
1 (micro)	48	25.81	<= 5 years	23	12.37
2-4 (micro)	57	30.65	6-20 years	53	28.49
5-9 (micro)	32	17.20	21-35 years	53	28.49
10-19 (small)	29	15.59	>= 36 years	57	30.65
20-49 (small)	14	7.53			
50-250 (medium)	6	3.23			

4.4.2 Measurement

The questionnaire (see Appendix 7) was designed based on validated constructs established in the literature (see Appendix 8). Since the existing constructs were in English, the items first had to be translated into German. I carefully translated them into German and then back-translated them into English (Brislin, 1970). Furthermore, items were adapted and expanded in consultation with various experts close to the target group, which led to better comprehensibility of the questions. The revised items were then reviewed in pre-tests with employees from various trades and refined with examples.

Dependent & mediator variable. This study evaluates the dependent and mediator variable CE using the established scale by Rodríguez-Espíndola et al. (2022), which is based on Zeng et al. (2017). The scale contains all phases of CE implementation. I adapted the existing scale to address the specific circumstances of the sample population. Therefore, 18 items were included. I follow the literature and combine the items into one construct (Rodríguez-Espíndola et al., 2022). The survey of CE activities is based on a four-point, fully verbalized Likert scale. The complete verbalization increases both the reliability and the validity of the survey (Menold et al., 2014). Following previous work in the CE field (Rodríguez-Espíndola et al., 2022), the following nomenclature was chosen: completely disagree - disagree - agree – completely agree. The scale has a Cronbach's alpha of 0.86.

Independent variable. According to previous studies, I measured innovation capability as a one-dimensional variable (Saunila, 2020). I analyzed innovation capability through the items suggested by (Akman & Yilmaz, 2008). Akman and Yilmaz (2008) developed six questions for innovation capability according to its definition in the literature. These contain main characteristics of innovative capability like innovative organizational culture, characteristics of internal processes (sharing knowledge and co-ordinating knowledge rapidly, encouraging employers about innovation), and understanding capability of the external environment (adoption to changes in the external environment, to reflect innovation suggestions from the environment to internal processes). All items were slightly adjusted in wording to fit the underlying subject of the sample. Responses were scored on a four-point Likert scale: completely disagree - disagree - agree – completely agree. I have changed the Likert scale from a five-point to a four-point scale to adapt the questionnaire to the target group. The reliability analysis for innovation capability yielded a Cronbach's alpha of 0.79.

Dependent variable. In line with Su et al. (2017), I measured the competitive advantage by adapting the 9-item scale that has been applied by others (Khan et al., 2019). This scale includes the two competitive strategies: differentiation advantage (five items) and cost-leadership advantage (four items). I measured the competitive advantage based on established scales with a four-point response format ranging from completely disagree to completely agree. Again, I adjusted the Likert scale from a five-point to a four-point response scale to measure the variables consistently. Cronbach's alpha for the aggregated competitive advantage scale is 0.73, for the differentiation advantage is 0.81, and for cost-leadership is 0.70. Appendix 8 shows the different measurement scales.

Control variables. Several organizational factors can influence the integration of the CE into a firm's strategy and the competitive advantage. Previous studies have recommended to control the firm age, firm size, and firm industry (product and services) in the SME context (Anwar, 2018; Khan et al., 2019; Schmidt et al., 2021; Su et al., 2017). The implementation of CE activities may depend on the *firm age* which might also influence the competitive advantage. While older companies have a greater experience with entrepreneurial practices (Kyrgidou & Spyropoulou, 2013), which can promote the implementation of CE activities, younger companies have to exert more effort to survive and grow (Hamilton, 2012). However, the age of the company can also be a negative factor, as it leads to greater rigidity and causes less agility in the company (Lee, 2008). Therefore, I used the age of the firm measured as the number of years between the establishment of the firm and the survey date (Hernández-Linares

et al., 2021; Rodrigo-Alarcón et al., 2018). According to Longoni et al. (2018), I controlled for *firm* size by measuring the number of employees. Since larger companies have more resources and thus more human, time, and financial capacity to invest in CE activities. Research has also shown that larger companies generally show more engagement in sustainability activities (Block & Wagner, 2014). On the other hand, smaller firms may have more flexibility and the ability to develop capabilities more quickly (Drnevich & Kriauciunas, 2011). I further included the *firm industry*. As suggested by Saunila (2020), I distinguished between three categories: production, service, and companies that offer both. This is reasonable because CE activities can be implemented differently depending on whether companies offer tangible or intangible goods and SMEs' innovation capability depends on the industry.

4.4.3 Analysis of biases

Given that each data point was collected from a single source data single point in time, the possibility of biases exists (Podsakoff et al., 2003). To reduce these biases, I investigated the sample using a series of statistical tests applied by other researchers (Kristoffersen et al., 2021a; Saari et al., 2024; Weimann et al., 2020). First, to reduce the risk of common method bias (CMB) and social desirability, the participating companies were informed about their data protection rights and promised absolute confidentiality and anonymous evaluation of the data collected. To test if CMB could be a problem, Harman's one-factor test was performed, recommended by Podsakoff et al. (2003). The analysis yielded 9 factors with an eigenvalue greater than one that explained 64.63 percent of the total variance. The first factor declares 22.43 percent of the variance. Hence, no single factor emerged, so CMB was not a major problem. Second, variance inflation factor (VIF) statistics were run to deal with concerns about multicollinearity. None of the VIF values of the individual variables were found to be above the threshold of 3.3 when combined with the other variables (Hair et al., 2011; Johnston et al., 2018). Third, to confirm non-response bias, I utilized t-tests to compare early and late respondents (Armstrong & Overton, 1977). The concept is founded on the premise that the way late responders answer the questionnaires is similar to the way non-responders answer the questionnaires. For this purpose, the mean values of the first 25 percent of participants were compared with those of the last 25 percent. To ensure that no systematic bias occurred among the responses, the mean values of selected key figures of the early-responding participants were compared with those of the late-responding respondents from the sample (see Appendix 8).

The mean comparisons performed using t-tests showed no significant differences, thus invalidating concerns about non-response bias.

4.5 Empirical results

4.5.1 Preliminary analysis

In line with previous research, I verified the validity and reliability of the measurements before analyzing the hypothesis (Ganguly et al., 2019; Schmidt et al., 2021). As written above, I assessed indicator reliability with Cronbach's alpha above 0.70 for all constructs (Churchill & Gilbert, 1979). Furthermore, I found that composite reliability (CR) values for all constructs ranged above 0.70 (Bacon et al., 1995) from 0.70 to 0.87, meeting the criteria for internal consistency (see Table 17). Hence, I satisfied the validity and reliability standards. By conducting exploratory factor analysis using a varimax rotation with Stata 17, I verified the convergent validity of the variable constructs (Hair Jr et al., 2010) (see Appendix 9).

Table 17

Chapter 4: Validity and reliability indicators

	Number of items	**Cronbach's alpha**	**CR**
1 CE	18	0.86	0.87
2 IC	6	0.79	0.78
3 CA	9	0.73	0.70
3a CA_diff	*5*	*0.81*	*0.81*
3b CA_cost	*4*	*0.70*	*0.70*

The discriminant validity is evaluated by comparing the square root of the average variance extracted (AVE) with the pairwise correlation of the constructs. I showed that the square root of the AVE is a bigger value than the correlation between each construct pair (Fornell & Larcker, 1981) (see Appendix 10). It should be noted that the competitive advantage is formed from its subdimension differentiation and cost leadership and that the correlations between these are, therefore, higher.

4.5.2 Regression analysis

To analyze the collected data, I employed multiple linear regression analysis to test hypotheses 1, 2, 3, and 4 with control variables. Therefore, this study tested and verified the Gauss-Markov assumptions (Hallin, 2014). To structure the analysis, I started with regression models 1-2 containing CE implementation as a dependent variable. I continued with regression models 3-6, including competitive advantage as a dependent variable, and lastly, focusing on regression models 8-10 with differentiation and cost leadership advantage as dependent variables.

Model 1 contains control variables only and reveals that firm age (β = 0.00, p = 0.02) and the service industry (β = -0.34, p = 0.03) are significantly related to CE implementation. Furthermore, firm size with 5-9 employees (β = -0.28, p = 0.04) and 20-49 employees (β = -0.35, p = 0.03) are significantly negatively related to CE implementation. The other control variables do not have a significant relation.

Table 18

Chapter 4: Results of regression analysis (I)

CE as dependent variable	**Model 1**	**Model 2**
IC		0. 43***
Controls		
Firm size (1 employee as base)		
2 - 4 employees	-0.16	-0.20
5 - 9 employees	-0.28**	-0.30**
10 - 19 employees	-0.26	-0.35***
20 - 49 employees	-0.35**	-0.36***
50 - 250 employees	-0.18	-0.19
Firm age	0.00**	0.00***
Industry (production as base)		
Services	-0.34**	-0.21
Production & Services	-0.12	-0.07
R^2	0.09	0.29
F	2.26***	9.15***

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 186

Model 2 includes control variables, innovation capability, and CE implementation (hypothesis 1). Innovation capability is positively and significantly associated with CE implementation (β = 0.43, p = 0.00). Hence, hypothesis 1 can be confirmed. Firm size with 5-9 employees (β = -0.30, p = 0.01), 10-19 employees (β = -0.35, p = 0.00), and 20-49 employees (β = -0.36, p = 0.00) are significantly negatively related to CE implementation. None of the other control variables besides firm age (β = 0.00, p = 0.00) have a significant influence. All models are statistically significant (see Table 18).

Table 19

Chapter 4: Results of regression analysis (II)

CA as dependent variable	**Model 3**	**Model 4**	**Model 5**	**Model 6**
IC		0.29***		0.25***
CE			0.22***	0.09
Controls				
Firm size (1 employee as base)				
2 - 4 employees	-0.03	-0.07	0.00	-0.05
5 - 9 employees	-0.06	-0.07	0.00	-0.04
10 - 19 employees	0.15	0.08	0.20	0.11
20 - 49 employees	0.08	0.07	0.15	0.10
50 - 250 employees	0.21	0.20	0.25	0.22
Firm age	-0.00	-0.00	-0.00	-0.00
Industry (production as base)				
Services	-0.19	-0.10	-0.12	-0.08
Production & Services	-0.08	-0.04	-0.05	-0.04
R^2	0.06	0.20	0.12	0.21
F	1.48*	4.69***	2.14**	4.33***

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 186

In Table 19, model 3 contains control variables only and reveals that no control variable is significantly related to competitive advantage. In models 4 and 5, I analyzed the direct effect of innovation capability and CE implementation on competitive advantage to test hypotheses 2 and 3. Innovation capability (β = 0.29, p = 0.00) and CE implementation (β = 0.22, p = 0.00) are positively and significantly related to competitive advantage, supporting hypotheses 2 and 3. However, when studied simultaneously in model 6, only innovation capability reveals a

significant positive value (β = 0.25, p = 0.00), while CE implementation only shows insignificant results (β = 0.09, p = 0.23).

Models 7-9 focus on the dimensions of a competitive advantage, differentiation advantage (a) (see Table 20) and the cost leadership advantage (b) (see Table 21) as dependent variables. Innovation capability (β = 0.33, p = 0.00, model 7a) and CE implementation (β = 0.24, p = 0.01, model 8a) are positively and significantly related to differentiation advantage. Similar results can be seen when focusing on the relation of innovation capability (β = 0.24, p = 0.00, model 7b) and CE implementation (β = 0.19, p = 0.02, model 8b) on cost-leadership advantage. Regarding differentiation advantage, model 8a reveals that the firm sizes with 10-19 and 20-49 employees are significantly and positively related. Models 9a and 9b demonstrate that, when examined together, only innovation capability shows a significant positive effect, whereas CE implementation results are not statistically significantly.

Table 20

Chapter 4: Results of regression analysis (III)

CA_diff as dependent variable	**Model 7a**	**Model 8a**	**Model 9a**
IC	0.33***		0.30***
CE		0.24***	0.09
Controls			
Firm size (1 employee as base)			
2 - 4 employees	0.03	0.11	0.05
5 - 9 employees	0.06	0.14	0.08
10 - 19 employees	0.26	0.40**	0.29
20 - 49 employees	0.33	0.42**	0.36
50 - 250 employees	0.25	0.31	0.27
Firm age	0.00	-0.00	-0.00
Industry (production as base)			
Services	0.04	0.02	0.06
Production & Services	008	0.07	0.08
R^2	0.16	0.10	0.16
F	3.06***	1.88*	2.93***

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 186

Table 21

Chapter 4: Results of regression analysis (IV)

CA_cost as dependent variable	Model 7b	Model 8b	Model 9b
IC	0.24***		0.20**
CE		0.19**	0.09
Controls			
Firm size (1 employee as base)			
2 - 4 employees	-0.19	-0.13	-0.17
5 - 9 employees	-0.22	-0.16	-0.19
10 - 19 employees	-0.14	-0.04	-0.11
20 - 49 employees	-0.25	-0.18	-0.22
50 - 250 employees	0.13	0.18	0.15
Firm age	-0.00	-0.00	-0.00
Industry (production as base)			
Services	-0.28	-0.29	-0.26
Production & Services	-0.19	-0.20	-0.19
R^2	0.14	0.11	0.14
F	3.09***	2.26**	2.93***

Note. *p < 0.10 **p < 0.05 ***p < 0.01; N = 186

4.5.3 Mediation analysis

Hypothesis 4 suggests that the association of innovation capability with competitive advantage is mediated by CE implementation. According to Baron and Kenny (1986), I followed a three-step approach which is applied by others (Ed-Dafali et al., 2023; Kamukama et al., 2011). First, innovation capability is positively associated with a competitive advantage ($\beta = 0.29$, $p = 0.00$, model 4). Hence, there is an effect to be mediated. Second, innovation capability is positively related to the mediator, CE implementation ($\beta = 0.43$, $p = 0.00$, model 2), and CE implementation has a positive and significant coefficient for competitive advantage ($\beta = 0.22$, $p = 0.00$, model 5). However, when studied simultaneously, only innovation capability reveals a significant positive value ($\beta = 0.25$, $p = 0.00$, model 6), while CE implementation only shows insignificant results ($\beta = 0.09$, $p = 0.23$, model 6). Hence, CE implementation does not play a role as a mediator in this context, and hypothesis 4 cannot be accepted. To validate this

assumption, I followed the approach by Iacobucci et al. (2007) and found no mediation results after conducting the bootstrapping approach, namely the Monte Carlo approach, proposed by Jose (2013).

4.6 Discussion

In this study, I investigated to what extent innovation capability is related to competitive advantage in the context of German SMEs and if CE implementation mediates this relation. Table 22 provides an overview of the results.

Table 22

Chapter 4: Summary of results

Hypothesis	Content	Result
H1	Innovation capability is positively associated with CE implementation in SMEs.	Significant effect
H2	Innovation capability is positively associated with a competitive advantage in SMEs.	Significant effect
H3	CE implementation is positively associated with a competitive advantage in SMEs	Significant effect
H4	CE implementation mediates the relationship between innovation capability and competitive advantage in SMEs.	No significant effect

4.6.1 Interpretation of results

The results of this study reveal several findings. First, a direct relationship was found between innovation capability and CE implementation in German SMEs. Therefore, SMEs are more likely to implement CE practices when they are endowed with innovation capability. A high level of innovation capabilities enables an organization to design products, technologies, and more sustainable methods and aligned with CE principles. This means innovative SMEs are more likely to adopt CE practices such as designing more durable products, remanufacturing or refurbishing products' lifespan, and optimizing resource use. By embracing innovative techniques like eco-design and material recycling, SMEs can optimize resource usage, reduce waste generation, and develop products with extended lifespans. Hence, the findings confirm hypothesis 1 and align with prior studies indicating that innovation capability contributes to

the creation and discovery of new methods, technologies and a new variety of raw materials (Rajapathirana & Hui, 2018). These innovation activities positively impact the CE implementations. This is understandable, as the practices for implementing a CE are varied and may need to be implemented with completely new processes, products and services. (Kristoffersen et al., 2021b).

Second, the study reveals that innovation capability is related to competitive advantage and supports hypothesis 2. An organization with a culture that nurtures innovation will provide a path to create a broad, diverse set of ideas, especially converting them into profitable business concepts. This result is in line with Rajapathirana and Hui (2018, p. 52), stating that "innovation capability is the most important component for developing effective innovation outcomes". Innovation capabilities enable the application of resources and the continuous transformation of knowledge and capabilities into products, processes, and systems for the benefit of business and stakeholders. Hence, the organization's innovation capability is subsequently responsible for generating highly creative innovation outcomes and a competitive advantage.

Third, regarding the association between CE implementation and competitive advantage, hypothesis 3 can also be supported. These results align with previous research that demonstrated the positive influence of CE implementation on firm performance in large companies (Kristoffersen et al., 2021a; Kwarteng et al., 2022). For instance, by making advancements in material and process innovation, companies can reproduce waste materials into recycled products, effectively closing the production loop. This transition not only reduces waste generation but also enhances resource efficiency, bringing economic benefits. These results are further supported by Saari et al. (2024), who demonstrated the positive influence of both innovation capability and CE implementation on firm performance in large companies.

Fourth, although innovation capability positively influences CE implementation and CE implementation is associated with a competitive advantage for the company, I could not find any evidence that CE implementation acts as a mediator in this relationship. The reason why hypothesis 4 (CE implementation mediates the relationship between innovation capability and competitive advantage in SMEs.) was not supported is that innovation capability may not necessarily lead to competitive advantage via the implementation of CE practices. If innovation capability and CE implementation are considered together in terms of competitive advantage, innovation capability explains most of the effect. The ability to innovate is, therefore, a capability that leads directly to the creation of a competitive advantage. Although the

implementation of CE practices is positively influenced by innovation capability and has a positive impact on competitiveness, innovation capability is the greater driver of competitiveness in direct comparison. Hence, the results do not support the idea that CE implementation mediates the relationship between innovation capability and competitive advantage.

In addition to analyzing competitive advantage as a whole variable, I assessed the subdimensions of differentiation and cost-leadership. Interestingly, there are no differences in the results when focusing on one of the competitive strategies. Similar to the analysis before, innovation capability and CE implementation do have a significant and positive association with differentiation and cost-leadership. However, CE implementation does not mediate the relationship between innovation capability and differentiation, respectively, cost-leadership.

4.6.2 Theoretical contribution

Most research focuses on how to implement CE, along with the opportunities and challenges this process involves. Previous studies that look at managers and the implementation of CE as a unity have tended to concentrate on demographic factors, or the barriers and opportunities, as seen in the works by Rizos et al. (2015) and Ormazabal et al. (2018). However, this study not only concentrates at what influences CE implementation, but also at what the implementation of CE activities can lead to. In terms of the theoretical contribution, this paper shed light on two fields of research of current interest: the process involved in implementing CE practices through innovation capability and the controversial question of the competitive advantage of innovation capability and CE implementation. There is a need for empirical research through in-depth case studies and quantitative surveys to investigate CE implementation (Kristoffersen et al., 2020). Hence, this study enriches the discipline's knowledge of innovation capabilities, CE implementation, and competitive advantage in SMEs by providing an additional framework that is operationalized in the context of SMEs as an empirical research field. The theoretical contribution of this study is threefold.

First, this study contributes to expanding the existing literature stream on innovation capability and CE implementation. While theoretical studies emphasize how innovation capability enables CE and how their absence hinders CE implementations, empirical studies supporting the existing literature are scarce, particularly within SMEs (Yousaf et al., 2022). Furthermore, I respond to the call of Suchek et al. (2021) to expand and empirically underpin the field of

innovation and CE in terms of primary data. By conducting a survey, this study empirically validated the association between innovation capability and CE implementation, which was called for by the previous study (Sehnem et al., 2022).

Second, I extend the CE research field by analyzing the relationship between CE implementation and competitive advantage with its key strategies of differentiation and cost leadership. My analysis found that CE implementation is positively associated with competitive advantage. It is striking that the implementation of CE can lead to both cost leadership and differentiation advantage. These results are theoretically supported by Prieto-Sandoval et al. (2019). According to them, companies that implement CE strategies can offer more value to their buyers than their competitors through cost leadership or differentiation. This study makes a crucial contribution to existing research that recommends empirical studies on the current topic to prove that CE offers business opportunities for SMEs and is part of their business strategy (Ormazabal et al., 2018). Furthermore, this study contributes to investigating the value creation in SMEs and the increase of their competitive advantage by adopting the circular economy. Although, higher costs are the main barrier to CE for early adopters (Mura et al., 2020), Companies that adopt CE practices see them as a business opportunity rather than a cost, showing that CE can be a source of value creation for companies, especially SMEs. Due to the fact that CE implementation is a kind of business model innovation, my findings are in line with Anwar (2018), who empirically investigated that the innovation of a business model is positively related to a competitive advantage. Moreover, CE implementation has a significant association with both competitive advantages: differentiation and cost leadership. This analysis complements a previous study conducted by Holzer et al. (2021), who found that differentiation advantage is perceived as most important in the context of CE for Austrian SMEs. Hence, with this study, I can therefore close the gap between the perceived importance of competitive advantage and the perceived competitive advantage through CE implementation in SMEs. With this analysis, I contribute to Sehnem et al. (2022), who calls for building bridges to encompass research topics outside the traditional core of CE studies.

Third, by examining the mediation effect of CE implementation on the relationship between innovation capability and competitive advantage, the study advances the research regarding the competitive advantage of innovation capability. While previous research focused extensively on the relationship between innovation capability and competitive advantage and firm performance (Rajapathirana & Hui, 2018; Saunila, 2020), research in the context of CE is scarce. Specifically, through the demonstration that CE implementation does not act as a

mediator in the relationship between innovation capability and competitive advantage, it is shown that the implementation of CE measures has not yet brought as much of a competitive advantage as the ability to innovate per se. The competitive advantage is therefore not primarily promoted by CE practices but, first and foremost, by the ability to innovate. Hence, I investigated empirically an enabler of the CE and identified its impact on the firm's competitiveness. Herewith, I respond to the call of Seles et al. (2022) to identify resources, capabilities, or dynamic capabilities, leading firms, in a circular economy context, to a better competitiveness.

4.6.3 Managerial and practical implications

In summary, managers need to invest more in innovation capabilities to support new innovation efforts and increase competitive advantage. In addition, companies with successful CE implementation that reduces resources and waste and extends the life of products lead to a competitive advantage. In terms of practical relevance, managers and companies may find this research useful in three main areas.

First, this study shows that the implementation of CE requires the ability to innovate. The results have shown that companies that adopt CE practices are more likely to innovate and adapt their processes, products, and services faster and are, therefore, more open to change. To implement CE practices, SMEs must first develop an organizational culture that motivates innovative behavior and fosters internal coordination of resources to support the innovation mindset that transforms ideas and concepts into successful products/services, processes, business models, or systems. This allows SMEs to develop innovation capability and motivate and empower individuals within an organization to foster an innovative mindset. This, in turn, enables organizations to leverage technology and knowledge to implement CE strategies. In summary, innovation capability is crucial for SMEs to successfully implement CE practices by driving product and process innovation, business model innovation, technological innovation, collaboration and partnerships, customer engagement and communication, and continuous improvement. Therefore, SMEs should identify the resources, competencies, and skills that are useful for the implementation of CE and that enable them to build a competitive advantage (Del Río et al., 2016).

Second, this study can provide motivation for transitioning towards implementing CE practices. Managers seek competitive advantage using different resources and sources. This

study suggests that CE implementation is a significant driver that contributes to a firm's competitive advantage. Overall, embracing the CE can provide small enterprises with a competitive advantage by reducing costs, fostering innovation, differentiating their brand, accessing new markets, enhancing resilience, and ensuring regulatory compliance. Specifically, both competitive strategies, differentiation and cost-leadership, are fueled by CE implementation. Therefore, this research provides a strategic and economic rationale for the transition to a circular mode of operation. This can be particularly useful for forward-looking managers and early CE adopters who lack arguments or evidence for a change in operational strategy. The implementation of CE strategies should be part of the main strategy of SMEs to gain a competitive advantage by offering their customers added value with more environmentally friendly products and services than their competitors and by producing more resource-efficiently and possibly more cost-effectively. As a competitive advantage helps SMEs to create better value for customers, it contributes to business performance (Anwar, 2018), leading to sustainable success. The management of SMEs should be made more aware that CE offers, indeed, a business case.

Third, the study's results suggest that an organization's competitive advantage can be very high if it has a strong innovation capability. For example, I have argued that SMEs' investments in intangible resources and capabilities drive CE implementation and competitive advantage. However, the study's results offer no evidence that innovation capability only provides a competitive advantage through the implementation of CE practices. According to the data, the ability to innovate explains competitive advantage rather than CE implementation. However, CE implementation can create a feedback loop for innovation within small businesses. As they engage in circular practices, they may identify new opportunities for innovation, such as process improvements, product refinements, or new revenue streams, driving further innovation capability development. Hence, owners and managers of SMEs should closely examine the development of innovation capabilities and the possibilities of implementing CE strategies to achieve a competitive position on the market.

Policymakers need to incentivize SMEs' environmental orientation and ability to take up environmental concerns. Since the greatest leverage for embedding sustainable activities in small businesses is determined by economics, this study can help to show that the implementation of CE practices at different levels can provide a competitive advantage. In addition, government agencies can provide economic incentives for SMEs that adopt proactive

environmental practices and initiatives, such as tax credits and subsidies, to further drive the competitive advantage of circular businesses.

4.6.4 Limitations and future research

This study acknowledges several limitations. Firstly, the data collection is a cross-sectional design. Especially in the strategic literature, the cross-sectional design is widely used (Saari et al., 2024; Schmidt et al., 2021), but it limits the possibility to draw causal conclusions. While it is acceptable to utilize contemporaneous measures to test relationships with strong theoretical implications (Sidhu et al., 2007), a longitudinal dataset is needed to allow for the analysis of changes over time and capture causal relationships between constructs. Hence, a longitudinal research design could shed more light on the development of CE implementation and its antecedents and outcomes. Moreover, survey data can be combined with secondary data (such as content analysis of reports) to strengthen the reliability and validity of the findings. Secondly, I focused on German SMEs in the manufacturing and service sectors. An industry-specific study can provide a deeper understanding of the specifics of a particular industry. Furthermore, extending the scope of the study to an international context could potentially enrich the findings and further propel research in the domain of investigating cross-cultural comparisons. Thirdly, this study was based primarily on quantitative data. Future research could incorporate qualitative methods, such as interviews or case studies, to gain a deeper, more nuanced understanding of the relationship between innovation capability, CE implementation, and competitive advantage. As all responses of this study come from managers or owners of SMEs, it would be better to measure the competitive advantage by also involving respondents from suppliers, customers, and competitors. Lastly, the variation of R-strategies (e.g., reduce, reuse, recycle) or closing versus slowing versus narrowing of business models and how they are influenced by the diversity of innovation capability and CE strategic approaches could be analyzed in more detail in future research.

Furthermore, other factors not examined in this study could influence the relationship between innovation capability, CE implementation, and competitive advantage. Future research could consider potential moderating, mediating, or outcome variables, such as digital technologies or firm performance. Since a competitive advantage does not necessarily translate into superior firm performance (Ma, 2000), it is important for future research to find out whether, in the context of CE implementation, SMEs not only have a competitive advantage but whether this also leads to successful firm performance (Anwar, 2018). Although competitive advantage in

cost or differentiation may increase the likelihood of better performance, competitive advantage per se does not equate to performance/profitability (Ma, 2000).

4.7 Conclusion

The novelty of the paper lies in the attempt to empirically investigate the role of CE implementation regarding innovation capability and competitive advantage. By analyzing 186 German SMEs, the findings of the study revealed that SMEs with higher innovation capabilities positively influence CE implementation and competitive advantage. In this way, it aligns with earlier research findings according to which the ability to innovate is of central importance for the business activities of SMEs. Although the implementation of CE activities also leads to a competitive advantage, this effect disappears when innovation capability is included in the model. Thus, CE implementation is not a mediator and innovation capability is the main driver of competitiveness in SMEs. Innovation capability offers numerous benefits that can give small businesses a competitive edge in the marketplace, including product differentiation, cost efficiency, faster time-to-market, adaptability, enhanced customer value, brand reputation, and access to talent and partnerships. By fostering a culture of innovation and investing in resources and processes that support innovation, small businesses can strengthen their competitive position and achieve long-term success. Nevertheless, the CE is imperative for firms as it helps in boosting the differentiation and cost-leadership strategy growth and finally helps in gaining competitive advantage. Embracing the CE can provide small enterprises with a competitive advantage by reducing costs, fostering innovation, differentiating their brand, accessing new markets, enhancing resilience, and ensuring regulatory compliance. Hence, for sustainable development to be possible in the future, SMEs should try to align their CE strategies more with their competitive strategy so that in the future, they do not have to decide what to use their limited resources for, but that CE by nature sustains business and provides a competitive advantage.

5 | Conclusion

With my dissertation, I contribute to a better understanding of the CE in SMEs. In particular, the thesis shed light on different aspects, such as social interaction, digitalization, and competitiveness, and investigates the relation to implementing circular activities. While more and more attention is being paid to the topic of the circular economy in SMEs, there is still plenty of room for future development. As I have looked at the implementation of CE practices from different perspectives, I contribute to different strands of literature and research. In the following, I present a brief summary of the findings as well as the theoretical and practical implications of the three essays before highlighting the limitations of the dissertation and avenues for future research.

5.1 Main results and contribution

Chapter 2 focuses on the application of digital technologies for the implementation of a CE in German SMEs. It further considers the influence of commitment to sustainability on the interaction between digitalization and a CE. Digital technologies are instrumental in facilitating the transition to a CE by enhancing visibility, intelligence, and efficiency across various business processes (Antikainen et al., 2018; Legner et al., 2017). Despite its recognized potential, the practical adoption of digital technologies, particularly among SMEs, remains limited (Bag & Pretorius, 2022). While the theoretical literature extensively discusses the role of digitalization in supporting CE principles, empirical studies validating these theories are scarce, especially in the SME context (Alcayaga et al., 2019; Rosa et al., 2020). There is a growing consensus among researchers regarding the need for empirical investigations to elucidate the specific digital technologies that effectively support the implementation of CE practices (Liu et al., 2022). Although qualitative studies have hinted at the value of digital technologies in enhancing CE practices within SMEs, they often lack granularity in

distinguishing between different types of digital technologies (Chaudhuri et al., 2022). Further, while some research highlights the supportive role of digital technologies in the context of sustainable development, there is a notable gap in understanding how various digital technologies contribute specifically to CE implementation in SMEs (Ardito et al., 2021; Neri et al., 2023). To address this gap, empirical studies examining the relationship between different digital technologies and the adoption of CE practices in SMEs are necessary. Such research is essential for SME owners and decision-makers who increasingly recognize the potential benefits of technology adoption in driving circular initiatives within their organizations (Jansen et al., 2013; Simmons et al., 2008) .

Drawing on self-collected data from German SMEs allows us to unveil several findings. First, we find that digitalization breadth, the simultaneous application of different digital technologies, is positively associated with CE implementation. Second, however, each digital technology has a different impact on implementing CE practices. In particular, we highlight that the digitalization of operational and manufacturing processes and the use of e-commerce correlate positively and significantly with CE implementation. Specifically, while virtual platforms like e-commerce were found to promote CE implementation, using open data for product analysis, potentially facilitated by sensor technologies, yielded insignificant results. Furthermore, we reveal that process digitalization positively influences CE practices, but sensor technology's association was not significant when analyzed concurrently. This suggests that sensor technology adoption may be less common in small companies compared to large ones. Third, our results show that commitment to sustainability encourages environmentally friendly behaviors conducive to CE implementation in business processes. However, when testing the complementarity of digital technologies and commitment to sustainability, we found no significant evidence to support the assumption that the simultaneous pursuit of digital and environmental orientations enhances CE practice implementation. Drawing on the Resource-Based View framework, managing different resource types underlying digital technologies and commitment to sustainability poses challenges in allocating limited resources, potentially leading to issues in attention allocation, particularly among SME managers and employees.

In **Chapter 3**, we provide new empirical evidence on the relation between social capital, dynamic capabilities and CE implementation in German SMEs. In the vast landscape of research, numerous studies have delved into the multifaceted realm of social capital within firms, unveiling its pivotal role in fostering interfirm learning, stakeholder cooperation, resource acquisition, innovation, and entrepreneurial orientation (Ince et al., 2023; Molina-

Morales & Martínez-Fernández, 2010; Rodrigo-Alarcón et al., 2018). However, amidst this scholarly exploration, a significant gap persists regarding the nexus between social capital and the adoption of CE practices. While some case studies have provided insights into how firms leverage social capital for CE implementation (Germundsson & Gernandt, 2019), quantitative investigations that scrutinize the intricate mechanisms underlying social capital's impact on CE are conspicuously absent. Our study endeavors to bridge this gap by undertaking a comprehensive analysis of social capital's three-dimensional construct and its potential ramifications for CE implementation. In addition to unraveling the relationship between social capital and CE, our research also elucidates the crucial role played by dynamic capabilities in facilitating the utilization of social capital for CE practices. Dynamic capabilities offer invaluable insights for both large corporations and SMEs alike (Hernández-Linares et al., 2021; Khan et al., 2021). Moreover, qualitative investigations have underscored the significance of dynamic capabilities in propelling CE practices forward, particularly in the context of SMEs (Elf et al., 2022). By intertwining social capital, dynamic capabilities, and CE implementation, our study seeks to unravel the intricate web of relationships that underpin sustainable business practices. Through empirical analysis and theoretical synthesis, we aim to shed light on how firms harness social capital to identify opportunities, interpret information, and innovate, ultimately paving the way for the adoption of CE practices. In doing so, we contribute not only to academic discourse but also to practical endeavors aimed at fostering sustainability and resilience within firms across various sectors.

By analyzing primary data, we find that, first, social capital contributes to CE implementation in SMEs, specifically highlighting the significance of the subdimension structural capital. Structural capital, characterized by small and stable network structures in SMEs, facilitates resource sharing and connectivity within and between companies, thereby positively impacting CE implementation. However, the relationship between relational capital (trust) and CE implementation was not significant, suggesting that trust may already be inherent in SMEs interactions and may not significantly influence CE practices. Similarly, cognitive capital (shared values) showed no significant relationship with CE implementation, possibly due to the implicit nature of corporate culture in SMEs. Accordingly, it is difficult for outsiders to recognize and assess the culture and visions of other SMEs and to reconcile them with their visions. Second, dynamic capabilities were found to positively influence CE implementation, mediating the relationship between social capital and CE implementation. This underscores the

importance of dynamic capabilities in leveraging social capital to anticipate and respond to environmental changes, thereby facilitating CE practices in SMEs.

Chapter 4 investigates the relationship between innovation capability and competitive advantage within German SMEs and explores whether CE implementation mediates this relationship. SMEs encounter growing challenges in adhering to environmental and social standards stipulated by local and global regulations, which can impact their competitive edge. Additionally, environmental and social endeavors are often linked with considerable expenses (Dey et al., 2020). Prieto-Sandoval et al. (2019) observe that SMEs frequently grapple with limited technical and financial resources, potentially leading them to deprioritize CE practices, especially when they lack a comprehensive understanding of its advantages. While scholars and industry experts commonly assert that CE can confer competitive benefits to businesses, the transition to a circular model is intricate, involving organizational transformation and innovation (Sehnem et al., 2022; Suchek et al., 2021). Several studies have individually examined innovation capability, CE implementation, and competitive advantage in SMEs (Jakhar et al., 2019; Lieder & Rashid, 2016). However, existing research primarily relies on theoretical and conceptual frameworks, necessitating a connection between these variables. Suchek et al. (2021) advocate for expanding and empirically substantiating research on innovation and CE using primary data. Similarly, Sehnem et al. (2022) emphasize the importance of comparative studies and empirical validation of innovation capabilities within the CE context.

By analyzing a self-collected data set of SMEs, I firstly find a direct relationship between innovation capability and CE implementation in German SMEs. This indicates that SMEs with strong innovation capabilities are more inclined to adopt CE practices, enabling them to develop sustainable methods aligned with CE principles, such as designing durable products and optimizing resource usage. These findings confirm prior research highlighting the role of innovation capability in fostering CE practices. Secondly, the study demonstrates a connection between innovation capability and competitive advantage, affirming that organizations fostering innovation culture are better positioned to generate diverse ideas and translate them into profitable business concepts. This underscores the importance of innovation capability in driving competitive advantage. Thirdly, the association between CE implementation and competitive advantage is supported, indicating that CE practices positively influence firm performance by enhancing resource efficiency and reducing waste generation. These findings corroborate previous research demonstrating the positive impact of CE implementation on firm

performance. However, contrary to the hypothesis, the study did not find evidence that CE implementation mediates the relationship between innovation capability and competitive advantage. It suggests that while innovation capability positively influences both CE implementation and competitive advantage, the direct effect of innovation capability on competitive advantage is greater than the indirect effect mediated by CE implementation. Additionally, the analysis of competitive advantage subdimensions, namely differentiation and cost leadership, yielded similar results. Innovation capability and CE implementation were found to be positively associated with both differentiation and cost leadership, but CE implementation did not mediate these relationships.

5.2 Limitations and avenues for future research

In this dissertation, I employ quantitative research designs to investigate CE implementation, its determinants, and outcomes, addressing gaps in various literature streams. Firstly, I contribute to policy discussions by identifying factors facilitating CE adoption in SMEs and offering policy recommendations. Secondly, I enhance management literature by examining the contextual factors crucial for successful CE implementation and the organizational prerequisites. Thirdly, I offer insights on how institutions and associations can assist resource-constrained SMEs in adopting CE practices. While acknowledging the limitations inherent in empirical studies, this dissertation provides valuable insights and avenues for future research in each chapter. Since I used a quantitative, cross-sectional design for all three essays listed in chapters 2-4, similar limitations arise.

First, the reliance on cross-sectional data collection, while common in strategic literature (Saari et al., 2024; Schmidt et al., 2021), constrains the ability to establish causal relationships. While this design offers a snapshot of CE implementation and its determinants at a specific point in time, it may not capture the dynamic nature of sustainability practices, which evolve in response to changing regulatory landscapes and market dynamics. To address this limitation, future research could employ longitudinal designs to track the progression of CE adoption and its underlying factors over time, providing a more nuanced understanding of the causal relationships involved. While a cross-sectional design can test relationships with strong theoretical implications (Sidhu et al., 2007), a longitudinal dataset would be preferable to capture changes over time and elucidate causal links between constructs. Consequently,

adopting a longitudinal research design could provide deeper insights into the development of CE implementation and its antecedents and outcomes.

Second, this dissertation primarily relied on quantitative data, suggesting a potential benefit in incorporating qualitative methods, such as interviews or case studies, to gain a more nuanced understanding of the relationships and the research models. Furthermore, the data do not provide insights into the reasons why certain CE activities are not planned or implemented by SMEs. Understanding the underlying motives and barriers to CE adoption requires a more nuanced approach, potentially involving qualitative methods such as case studies or interviews. By delving deeper into the motivations and challenges faced by SMEs in implementing CE practices, case studies could elucidate the findings, particularly focusing on specific CE practices. Additionally, involving stakeholders beyond SME managers or owners, such as suppliers, customers, and competitors, could offer diverse perspectives. Hence, future research can provide actionable insights for policymakers and practitioners seeking to promote sustainability initiatives.

Third, my focus on German SMEs introduces potential limitations regarding the generalizability of the findings across different cultural contexts. While the insights gained from this study contribute valuable knowledge to the field, it's essential to replicate these findings in diverse SMEs and regions to assess their applicability in varying contexts. Furthermore, future research could validate the dissertation's findings across different company sizes and regions globally. Comparing the results with those of larger companies could offer insights into potential differences in CE implementation strategies based on company size. Industry-specific studies offer valuable insights, but extending the scope to an international context could enrich the understanding and foster cross-cultural comparisons.

Finally, future research could look at the implementation of CE practices in more detail, broken down into sub-dimensions. Examining how different CE strategies (e.g., reduce, reuse, recycle) are influenced by the diversity of variables warrants further investigation and promises fruitful insights. Overall, addressing these limitations and exploring additional avenues could advance our understanding of the complexities surrounding CE implementation and its implications for SMEs, institutions, and policy.

5.3 Concluding remarks

In my dissertation, I looked at various aspects of CE implementation in SMEs. I focused on three research models derived from theory that deal with the topics of digitalization, social interaction, and the capability to innovate for a competitive advantage. In terms of digitalization, I found that digital technologies are indeed positively related to the implementation of CE activities. Social interaction, manifested in social capital, is also positively associated with CE practices. Furthermore, my results are interesting for incentive formation, as I found that the implementation of CE practices is positively associated with competitive advantage. However, it is important to emphasize that, especially innovative SMEs have implemented CE practices. In the future, incentives must be created to sensitize the broad mass of SMEs to CE implementation and to make the advantages clear to them. Only if it is worthwhile for SMEs to work in a circular way, i.e., to regenerate, narrow, slow, and close material flows, the economic model of CE will be sustainable.

Appendix

Appendix to Essay I (Chapter 2)

Appendix 1

Chapter 2: Questionnaire[4]

Circular Economy und Digitalisierung im Handwerk	 
Einführung	
Herzlich willkommen und vielen Dank, dass Sie an unserer Befragung teilnehmen! Hinweise zum Ausfüllen des Fragebogens: - Die Ausfülldauer des Fragebogens beträgt ca. 8-12 min. - Die erhobenen Daten werden vertraulich behandelt, nicht weitergegeben und ausschließlich in anonymisierter und aggregierter Form verwendet. - Eine gewerbliche Nutzung jeglicher Art ist ausgeschlossen. - Die erhobenen Daten werden nach Abschluss der Analyse / gesetzlichen Aufbewahrungsfrist unwiderruflich gelöscht. - Die Teilnahme ist freiwillig und anonym. - Es gibt keine richtigen oder falschen Antworten. - Bitte füllen Sie den Fragebogen vollständig aus. - Aus Gründen der besseren Lesbarkeit wird im Folgenden auf die gleichzeitige Verwendung weiblicher und männlicher Sprachformen verzichtet und das generische Maskulinum verwendet. Mit Klick auf "Weiter" erklären Sie sich mit dem Umgang Ihrer Daten einverstanden.	
Persönliche Fragen	
Ihr Geschlecht?	☐ weiblich ☐ männlich ☐ divers
Ihr Geburtsjahr (bitte Jahreszahl angeben, z. B. 1980)	
Welche allgemeinbildenden und beruflichen Abschlüsse haben Sie? (Mehrfachnennungen möglich)	☐ Gesellenprüfung/Lehrabschlussprüfung (1) ☐ Meister/-Technikerabschluss (2) ☐ Bachelor oder vergleichbar (3) ☐ Master oder vergleichbar (4) ☐ Doktorgrad (5) ☐ nicht-handwerklicher Berufsabschluss (6) ☐ Sonstiges (bitte spezifizieren): (7)
In welchem Jahr wurde Ihr Betrieb gegründet? (Bitte Jahreszahl angeben, z. B. 1996)	
Seit wann sind Sie in Ihrem Betrieb tätig? (Bitte Jahreszahl angeben, z. B. 1996)	
Seit wann sind Sie in Ihrer Position tätig? (Bitte Jahreszahl angeben, z. B. 1996)	

[4] The survey was conducted online via Qualtrics. The illustration is only an example.

Fragen zum Betrieb		
Wie viele Mitarbeiter beschäftigt Ihr Betrieb (inklusive Inhaber und (unbezahlte) mitarbeitende Familienangehörige)?		
Welche Rechtsform hat Ihr Betrieb?	☐	Einzelunternehmen (1)
	☐	GmbH (2)
	☐	Personengesellschaften (KG, OHG, GbR, GmbH & Co. KG) (3)
	☐	Sonstige Rechtsformen (AG, KGaA, Genossenschaft) (4)
	☐	Sonstige (bitte spezifizieren): (5)
Wie hoch ist der Anteil von Familienangehörigen in der Unternehmensführung? (in %) (Hinweis: Falls Sie Einzelunternehmer sind, wären das 100%.)		
Wie viel Prozent des Betriebs ist in Familienbesitz? (in %) (Hinweis: Falls Sie Einzelunternehmer sind, wären das 100%.)		
In welchem Gewerk ist Ihr Betrieb hauptsächlich tätig?	☐	Dachdecker (1)
	☐	Maurer und Betonbauer (2)
	☐	Zimmerer (3)
	☐	Tischler / Schreiner (4)
	☐	Installateur und Heizungsbauer (5)
	☐	Metallbauer (6)
	☐	Feinwerkmechaniker (7)
	☐	Bäcker (8)
	☐	Sonstige: (9)
In welchem Segment ist Ihr Betrieb aktiv? (Mehrfachnennungen möglich)	☐	Produktion (Produkte) (1)
	☐	Dienstleistungen (2)
Wie hoch ist der jeweilige Anteil?		Anteil in % (1)
	Produktion (Produkte) (1)	
	Dienstleistungen (2)	
Wie hoch ist der jährliche Umsatz Ihres Betriebs?	☐	bis 22.000€ (1)
	☐	22.000 - < 50.000 (4)
	☐	50.000 - < 125.000 (5)
	☐	125.000 - < 250.000 (6)
	☐	250.000 - < 500.000 (7)
	☐	500.000 - < 2,5 Mio (8)
	☐	2,5 Mio - < 5 Mio (9)
	☐	über 5 Mio. € (10)
Circular Economy		
Bitte geben Sie an, inwieweit Sie die nachfolgenden Praktiken in ihrem Betrieb umsetzen.		
CE1 Designen und entwickeln Sie Produkte, die einfach repariert werden können? (Ersatzteil- und Reparaturmöglichkeiten vorhanden, Wirtschaftlichkeit der Reparatur gegeben)		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)
CE2 Designen und entwickeln Sie Produkte, die einfach instand gehalten werden können? (z. B. einfache Überwachung und Kontrolle der Funktionalität)		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)
CE3 Designen und entwickeln Sie Produkte, die recycelbar (z. B. einfach trennbar) sind?		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)

CE4 Verwenden Sie in Ihrem Betrieb Produkte (keine Verpackungen), die aus recyceltem Material sind?		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)
CE5 Designen und entwickeln Sie Produkte, die biologisch abbaubar* sind? (z. B. keine gefährlichen Substanzen, schnelle Zersetzung)		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)
CE6 Verwenden Sie in ihrem Betrieb Produkte (keine Verpackungen) die biologisch abbaubar* sind?		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)
*Biologisch abbaubar: Die biologische Abbaubarkeit umfasst die Eigenschaft eines Stoffes, durch Mikroorganismen in Anwesenheit von Luftsauerstoff zu Kohlendioxid, Wasser, Biomasse und Mineralien sowie unter Luftabschluss zu Kohlendioxid, Methan, Biomasse und Mineralien zersetzt zu werden. Beispiel: Die meisten organischen Materialien, wie z. B. Lebensmittelreste und unbeschichtetes Papier, sind biologisch abbaubar.		
CE7 Verwenden Sie in Ihrem Betrieb Verpackungen, die biologisch abbaubar und/oder wiederverwendbar sind?		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)
CE8 Gibt es geschlossene Kreisläufe in der Produktion? (z. B. Rückführung/Recycling von Produktresten in die Produktion, Abfall als Rohstoff)		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE9 Steigern Sie die Material- und Energieeffizienz Ihres Betriebs, indem Sie das gleiche Ergebnis mit weniger Material- und Energieeinsatz erreichen?		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)
CE10 Reduzieren Sie Ihren Abfall, indem Sie Nebenprodukte weitergeben? Nebenprodukte sind z. B. Produktionsreste oder Produkte, die bei einem Fertigungsverfahren anfallen, dessen Hauptzweck die Herstellung eines anderen Produktes ist.		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE11 Beziehen Sie Nebenprodukte von anderen Unternehmen/Organisationen?		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE12 Erbringen Sie Reparaturdienstleistungen für Kunden?		Bitte auswählen: (1)
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)

CE13 Erbringen Sie Instandhaltungsdienstleistungen für Kunden? (z. B. Überwachung und Kontrolle der Produktfunktionalität)	Bitte auswählen: (1)	
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)
CE14 Verwenden Sie Materialien, die schon einmal benutzt wurden (z. B. Altprodukte)?	Bitte auswählen: (1)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE15 (Ver-)leihen und teilen Sie Werkzeuge, Maschinen oder Räumlichkeiten?	Bitte auswählen: (1)	
	☐	nicht möglich in meinem Betrieb (6)
	☐	derzeit nicht geplant (1)
	☐	darüber nachgedacht (2)
	☐	bereits geplant (3)
	☐	mit der Umsetzung begonnen (4)
	☐	erfolgreich umgesetzt (5)

Commitment to Sustainability

		Trifft nicht zu (1)	Triff eher nicht zu (2)	Trifft eher zu (3)	Trifft zu (4)
CtS1a Bitte geben Sie für die folgenden Aussagen an, wie stark diese auf Sie zutreffen.	Bei strategischen Entscheidungen, die ein Produkt / eine Dienstleistung betreffen, ist die Umweltfreundlichkeit des Produkts / der Dienstleistung ein wichtiger Faktor. (1)	○	○	○	○
	Umweltfreundlichkeit ist ein wichtiger Aspekt bei der Planung der Wettbewerbsschwerpunkte für unsere wichtigsten Produkte, Dienstleistungen und Märkte. (2)	○	○	○	○
	Umweltfreundlichkeit und soziale Verträglichkeit sind bei dem Kauf und der Herstellung von Produkten und Dienstleistungen wichtig. (3)	○	○	○	○
		Trifft nicht zu (1)	Triff eher nicht zu (2)	Trifft eher zu (3)	Trifft zu (4)
CtS2b Bitte geben Sie für die folgenden Aussagen an, wie stark diese auf Sie zutreffen.	Nachhaltigkeit* ist ein wichtiger Bestandteil der Werte und der Philosophie unseres Betriebs. (1)	○	○	○	○
	Nachhaltigkeit* ist für mich ein vorrangiger Aspekt. (2)	○	○	○	○
	Überlegungen zur Nachhaltigkeit* haben Einfluss auf die strategische Planung in unserem Betrieb. (3)	○	○	○	○

*CtS *Nachhaltigkeit bedeutet, die Bedürfnisse der Gegenwart so zu befriedigen, dass die Möglichkeiten zukünftiger Generationen nicht eingeschränkt werden. Dabei ist es wichtig, die drei Dimensionen der Nachhaltigkeit – wirtschaftlich effizient, sozial gerecht, ökologisch tragfähig – gleichberechtigt zu betrachten.*

Digitalisierung						
		In meinem Betrieb nicht möglich (5)	sehr gering (1)	gering (2)	hoch (3)	sehr hoch (4)
DIG1 Bitte schätzen Sie in den folgenden Fragen wie ausgeprägt Sie die folgenden Technologien in ihrem Betrieb nutzen.	Wie ausgeprägt ist die Nutzung von Sensoren-Technologie (bspw. RFID oder QR Codes) zur Messung und Kontrolle in ihrem Betrieb? (1)	○	○	○	○	○
	Wie ausgeprägt ist die Sammlung und Analyse von Daten in ihrem Betrieb? (3)	○	○	○	○	○
	Wie ausgeprägt ist die Digitalisierung und Automatisierung von Dienstleistungs-/Betriebsprozesse in ihrem Betrieb? (bspw. Bestellvorgänge) (2)	○	○	○	○	○
	Wie ausgeprägt ist die Digitalisierung und Automatisierung von Produktionsprozessen in ihrem Betrieb? (z.B. computergestützte Fertigungsverfahren) (6)	○	○	○	○	○
	Wie ausgeprägt ist die Nutzung von (innovativen) digitalen Tools beim Produktdesign und -fertigung (z.B. 3D-Druck, Robotik, KI) in ihrem Betrieb? (9)	○	○	○	○	○
		In meinem Betrieb nicht möglich (5)	sehr gering (1)	gering (2)	hoch (3)	sehr hoch (4)
DIG2 Bitte schätzen Sie in den folgenden Fragen wie ausgeprägt Sie die folgenden Technologien in ihrem Betrieb nutzen.	Wie ausgeprägt ist die Nutzung von "smarten" Geräten in ihrem Betrieb? (z.B. Smartphones, Tablets, etc.) (1)	○	○	○	○	○
	Wie ausgeprägt ist die Nutzung von Social Media und Technologien, die die Zusammenarbeit unterstützen in ihrem Betrieb? (2)	○	○	○	○	○
	Wie ausgeprägt ist die Nutzung eines elektronischen Handels (z.B. eines Online-Shops) zum Kauf und Verkauf von Ware im Internet? (6)	○	○	○	○	○
	Wie ausgeprägt ist die Nutzung von digitalen Handelsplattformen für die Vermarktung von (qualitätsgeprüften) Sekundärmaterialien (z.B. Recyclate, bereits verwendete Materialien) in ihrem Betrieb? (8)	○	○	○	○	○

Postleitzahl		
Wie lautet die Postleitzahl des Hauptsitzes Ihres Betriebs?		
Abschlussfragen		
Herzlichen Dank, dass Sie an unserer Umfrage teilgenommen haben. Dürfen wir Sie bei Rückfragen kontaktieren?	☐	Ja
	☐	Nein
Vielen Dank! Bitte klicken Sie danach auf "Weiter", um die Umfrage zu beenden und den Fragebogen abzuschicken.		
	Bitte ausfüllen: (1)	
Name des Ansprechpartners & Betriebs (1)		
E-Mail-Adresse (2)		
Telefonnummer (3)		

Appendix 2

Chapter 2: Correlation table

Variable	M	SD	1	2	2a	2b	2c	2d	2e	2f	3	4	5	6	7
1 CE	3.2	1.0	1												
2 Digital tech.	2.3	0.7	0.24**	1											
2a Sensor storage	2.1	0.8	0.12**	0.77**	1										
2b Process dig.	2.3	1.0	0.27**	0.83**	0.62**	1									
2c Digital Tools	1.7	1.0	0.27**	0.65**	0.42**	0.62**	1								
2d Smart Devices	3.4	1.0	0.04	0.62**	0.39**	0.38**	0.23**	1							
2e Social Media	2.6	0.9	0.05	0.61**	0.39**	0.35**	0.21**	0.55**	1						
2f E-Com.	2.2	0.9	0.20**	0.65**	0.31**	0.33**	0.29**	0.28**	0.30**	1					
3 Com. to sust.	2.9	0.7	0.37**	0.20**	0.18**	0.14**	0.09**	0.13**	0.14**	0.15**	1				
4 Firm age	38. 8	40. 6	-0.03	-0.01	0.07	0.05	-0.04	-0.12**	-0.04	-0.02	0.01	1			
5 Firm size	9.0	19. 8	-0.03	0.19**	0.29**	0.18**	0.08*	0.12**	0.17**	0.06	0.05	0.23**	1		
6 Segment	2.1	0.7	-0.21**	0.01	-0.02	-0.01	0.05	0.03	-0.04	0.03	0.07*	-0.05	-0.00	1	
7 Industry	2.2	1.0	0.17**	0.10**	-0.02	0.09	0.13**	0.17**	0.03	0.06	-0.00	-0.18**	-0.13**	0.14**	1

Note. $*p < 0.10$ $**p < 0.05$ $***p < 0.01$; $N = 749$

Appendix to Essay II (Chapter 3)

Appendix 3

Chapter 3: Questionnaire[5]

Circular Economy im Handwerk		
Einführung		
Herzlich willkommen und vielen Dank, dass Sie an unserer Befragung teilnehmen! Hinweise zum Ausfüllen des Fragebogens: - Die Ausfülldauer des Fragebogens beträgt ca. 8-12 min. - Die erhobenen Daten werden vertraulich behandelt, nicht weitergegeben und ausschließlich in anonymisierter und aggregierter Form verwendet. - Eine gewerbliche Nutzung jeglicher Art ist ausgeschlossen. - Die erhobenen Daten werden nach Abschluss der Analyse / gesetzlichen Aufbewahrungsfrist unwiderruflich gelöscht. - Die Teilnahme ist freiwillig und anonym. - Es gibt keine richtigen oder falschen Antworten. - Bitte füllen Sie den Fragebogen vollständig aus. Mit Klick auf "Weiter" erklären Sie sich mit dem Umgang Ihrer Daten einverstanden.		
Angaben zum Betrieb/Person		
Geschlecht	☐	weiblich
	☐	männlich
	☐	divers
Geburtsjahr (bitte Jahreszahl angeben, z. B. 1980)		
Welche allgemeinbildenden und beruflichen Abschlüsse haben Sie? (Mehrfachnennungen möglich)	☐	Gesellenprüfung/Lehrabschlussprüfung (8)
	☐	Meister-/Technikerabschluss (9
	☐	Bachelor oder vergleichbar (10)
	☐	Master oder vergleichbar (16)
	☐	Doktorgrad (13)
	☐	nicht-handwerklicher Berufsabschluss (15)
	☐	Sonstiges (bitte spezifizieren): (14)
In welchem Jahr wurde Ihr Betrieb gegründet?		
Seit wann sind Sie in Ihrem Betrieb tätig?		
Seit wann sind Sie in Ihrer Position tätig?		
Wie viele Mitarbeiter beschäftigt Ihr Betrieb (inklusive Inhaber und (unbezahlte) mitarbeitende Familienangehörige)?		
Welche Rechtsform hat Ihr Betrieb?	☐	Einzelunternehmen (1)
	☐	Personengesellschaften (KG, OHG, GbR, GmbH & Co. KG) (4)
	☐	GmbH (5)
	☐	Sonstige Rechtsformen (AG, KGaA, Genossenschaft) (6)
	☐	Sonstige (bitte spezifizieren): (7)
Wie hoch ist der Anteil von Familienangehörigen in der Unternehmensführung? (in %)		
Wie viel Prozent des Betriebs ist in Familienbesitz? (in %)		
In welchem Gewerk ist Ihr Betrieb **hauptsächlich** tätig?		
In welchem **Segment** ist Ihr Betrieb aktiv? (Mehrfachnennungen möglich)	☐	Produktion (Produkte) (1)
	☐	Dienstleistungen (2)
Wie hoch ist der jeweilige Anteil?		Anteil in % (1)
	Produktion (Produkte) (4)	
	Dienstleistungen (5)	

[5] The survey was conducted online via Qualtrics. The illustration is only an example.

Wie hoch ist der jährliche Umsatz Ihres Betriebs?	☐	bis 22.000€ (1)
	☐	22.000 - < 50.000 (4)
	☐	50.000 - < 125.000 (5)
	☐	125.000 - < 250.000 (6)
	☐	250.000 - < 500.000 (7)
	☐	500.000 - < 2,5 Mio (8)
	☐	2,5 Mio - < 5 Mio (9)
	☐	über 5 Mio. € (10)
Circular Economy		
CE Bitte geben Sie an, inwieweit Sie die nachfolgenden Praktiken in ihrem Betrieb umsetzen.		
CE1 Designen und entwickeln Sie Produkte, die einfach repariert werden können?		Bitte auswählen: (13)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE2 Designen und entwickeln Sie **Produkte**, die **einfach instand gehalten** werden können?		Bitte auswählen: (13)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE3 Designen und entwickeln Sie Produkte, die recycelbar (z. B. einfach trennbar) sind?		Bitte auswählen: (13)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE4 Verwenden Sie in Ihrem Betrieb Produkte (keine Verpackungen), die aus recyceltem Material sind?		Bitte auswählen: (13)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE4a Wie hoch ist der ungefähre **Anteil** dieser Produkte? (in %)		
CE5 Designen und entwickeln Sie Produkte, die biologisch abbaubar* sind? (z. B. keine gefährlichen Substanzen, schnelle Zersetzung)		Bitte auswählen: (13)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE5a Wie hoch ist der ungefähre **Anteil** dieser Produkte am Umsatz Ihres Betriebs? (in %)		
CE6 Verwenden Sie in Ihrem Betrieb Produkte (keine Verpackungen), die biologisch abbaubar* sind?		Bitte auswählen: (13)
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE6b ***Biologisch abbaubar:** Die biologische Abbaubarkeit umfasst die Eigenschaft eines Stoffes, durch Mikroorganismen in Anwesenheit von Luftsauerstoff zu Kohlendioxid, Wasser, Biomasse und Mineralien sowie unter Luftabschluss zu Kohlendioxid, Methan, Biomasse und Mineralien zersetzt zu werden.		

CE7 Verwenden Sie in Ihrem Betrieb Verpackungen, die biologisch abbaubar und/oder wiederverwendbar sind?	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE8 Gibt es geschlossene Kreisläufe in der Produktion? (z. B. Rückführung/Recycling von Produktresten in die Produktion, Abfall als Rohstoff)	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE9 Steigern Sie die Material- und Energieeffizienz Ihres Betriebs, indem Sie das gleiche Ergebnis mit weniger Material- und Energieeinsatz erreichen?	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE10 Reduzieren Sie Ihren Abfall, indem Sie Nebenprodukte weitergeben? Nebenprodukte sind z. B. Produktionsreste.	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE11 Beziehen Sie Nebenprodukte von anderen Unternehmen/Organisationen ?	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE12 Erbringen Sie Reparaturdienstleistungen für Kunden?	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE13 Erbringen Sie Instandhaltungsdienstleistungen für Kunden? (z. B. Überwachung und Kontrolle der Produktfunktionalität)	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE14 Verwenden Sie Materialien, die schon einmal benutzt wurden (z. B. Altprodukte)?	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)
CE15 (Ver-)leihen und teilen Sie Werkzeuge, Maschinen oder Räumlichkeiten?	Bitte auswählen: (13)	
	☐	nicht möglich in meinem Betrieb (1)
	☐	derzeit nicht geplant (2)
	☐	darüber nachgedacht (3)
	☐	bereits geplant (4)
	☐	mit der Umsetzung begonnen (5)
	☐	erfolgreich umgesetzt (6)

Social capital					
SC1 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.		stimme überhaupt nicht zu (1)	stimme eher nicht zu (2)	stimme eher zu (3)	stimme voll zu (4)
	Wir stehen in ständigem **Kontakt** mit unseren **Geschäftspartnern** (z. B. Kunden, Lieferanten, etc.). (1)	○	○	○	○
	Wir kennen unsere **Geschäftspartner** auf einer **persönlichen** Ebene (z. B. Austausch von persönlichen/privaten Informationen). (6)	○	○	○	○
	Wir pflegen enge soziale Beziehungen zu unseren Geschäftspartnern (z. B. Treffen im privaten Bereich). (8)	○	○	○	○
SC2 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb. Unsere Geschäftsbeziehungen sind gekennzeichnet durch …		stimme überhaupt nicht zu (1)	stimme eher nicht zu (2)	stimme eher zu (3)	stimme voll zu (4)
	... eine enge persönliche Zusammenarbeit. (23)	○	○	○	○
	... gegenseitigen **Respekt**. (12)	○	○	○	○
	... gegenseitiges **Vertrauen**. (13)	○	○	○	○
	... **persönliche Freundschaft**. (14)	○	○	○	○
	... ein **hohes Maß an**	○	○	○	○
	Gegenseitigkeit (z. B. "Wie du mir, so ich dir."). (24)	○	○	○	○
SC3 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb. Unsere Geschäftspartner und wir ...		stimme überhaupt nicht zu (1)	stimme eher nicht zu (2)	stimme eher zu (3)	stimme voll zu (4)
	... haben eine ähnliche Unternehmenskultur/Werte und einen ähnlichen Führungsstil. (17)	○	○	○	○
	... teilen ähnliche Geschäftsphilosophien/-ansätze. (23)	○	○	○	○
	... haben übereinstimmende Ziele. (18)	○	○	○	○
	... teilen die gleichen Visionen. (26)	○	○	○	○

Dynamic capabilities					
DC1 Sie haben es fast geschafft! Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.		stimme überhaupt nicht zu (1)	stimme eher nicht zu (2)	stimme eher zu (3)	stimme voll zu (4)
	Wir beobachten unser Umfeld regelmäßig, um neue Geschäftsmöglichkeiten zu erkennen. (1)	○	○	○	○
	Wir überprüfen regelmäßig, wie Kunden auf Veränderungen in unserem Geschäftsumfeld reagieren. (37)	○	○	○	○
	Wir überprüfen regelmäßig unsere Produkte/Dienstleistungen, um sicherzustellen, dass sie den Wünschen der Kunden entsprechen. (38)	○	○	○	○
	Wir verwenden viel Zeit darauf, Ideen für neue Produkte/Dienstleistungen umzusetzen und unsere bestehenden Produkte/Dienstleistungen zu verbessern. (52)	○	○	○	○
DC2 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.		stimme überhaupt nicht zu (1)	stimme eher nicht zu (2)	stimme eher zu (3)	stimme voll zu (4)
	Wir haben geeignete Methoden, um neue Informationen und neues Wissen zu erkennen und zu bewerten. (40)	○	○	○	○
	Wir haben geeignete Methoden, um neue Informationen und neues Wissen einzuführen. (53)	○	○	○	○
	Wir können aus vorhandenen Informationen/Daten neue Erkenntnisse ableiten. (41)	○	○	○	○
	Wir können die gesammelten Informationen und Erkenntnisse in Produkten/Dienstleistungen anwenden. (54)	○	○	○	○
	Wir können neues Wissen entwickeln, das wir im Rahmen der Produkt-/Dienstleistungsentwicklung nutzen können. (55)	○	○	○	○

DC3 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.		stimme überhaupt nicht zu (1)	stimme eher nicht zu (2)	stimme eher zu (3)	stimme voll zu (4)
	Wir entwickeln uns weiter, indem jeder Einzelne seinen Beitrag leisten kann. (43)	○	○	○	○
	Die Beschäftigten verstehen die gegenseitigen Aufgaben und Verantwortlichkeiten. (44)	○	○	○	○
	Es ist bekannt, wer im Unternehmen über arbeitsrelevante Fähigkeiten und Fachkenntnisse verfügt. (45)	○	○	○	○
	Wir stimmen unser Handeln untereinander ab, um veränderten Bedingungen gerecht zu werden. (46)	○	○	○	○
	Die Mitarbeitenden schaffen es, ihre Aktivitäten erfolgreich miteinander zu verknüpfen. (53)	○	○	○	○
DC4 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.		stimme überhaupt nicht zu (1)	stimme eher nicht zu (2)	stimme eher zu (3)	stimme voll zu (4)
	Wir stellen sicher, dass die Arbeitsaktivitäten erfolgreich aufeinander abgestimmt sind. (47)	○	○	○	○
	Wir stellen eine angemessene Verteilung der Ressourcen (z. B. Informationen, Zeit, Berichte) innerhalb unseres Unternehmens sicher. (52)	○	○	○	○
	Die Mitarbeitenden erhalten Aufgaben und Informationen, die ihren Kenntnissen und Fähigkeiten entsprechen. (50)	○	○	○	○
	Wir achten darauf, dass die Fachkenntnisse der Mitarbeitenden auf die Arbeitsabläufe abgestimmt sind. (53)	○	○	○	○
	Insgesamt ist unser Unternehmen gut koordiniert. (51)	○	○	○	○
Angaben zur PLZ					
PLZ Wie lautet die Postleitzahl des Hauptsitzes Ihres Betriebs?					

Kontakt		
Herzlichen Dank, dass Sie an unserer Umfrage teilgenommen haben. Dürfen wir Sie bei Rückfragen kontaktieren?	☐	Ja
	☐	Nein
Kontakt Vielen Dank! Bitte klicken Sie danach auf "Weiter", um die Umfrage zu beenden und den Fragebogen abzuschicken.		
	Bitte ausfüllen: (1)	
Name des Ansprechpartners & Betriebs (1)		
E-Mail-Adresse (2)		
Telefonnummer (3)		

Appendix 4

Chapter 3: Measurement items, validity, and reliability indicators

Second-order construct	First-order construct	Indicator code	Indicator	Alpha	Loadings	CR	AVE
	CE	CE1	Do you design and develop products that can be easily repaired? (Spare parts and repair possibilities available, economic efficiency of repair given).	0.8237	0.8510	0.7843	0.2351
		CE2	Do you design and develop products that are easy to maintain (e.g., easy monitoring and control of functionality)?		0.8478		
		CE3	Do you design and develop products that are recyclable (e.g. easily separable)?		0.7854		
		CE4	Do you use products (not packaging) made from recycled material?		0.3574		
		CE5	Do you design and develop products that are biodegradable (e.g. no hazardous substances, fast decomposition)?		0.5894		
		CE6	Do you use products (not packaging) that are biodegradable?		0.4850		
		CE7	Do you use packaging that is biodegradable and/or reusable?		0.3875		
		CE8	Are there closed loops in production (e.g. return/recycling of product residues into production, waste as raw material)?		0.5649		
		CE9	Do you increase the material and energy efficiency of your business by achieving the same result with less material and energy input?		0.6172		
		CE10	Do you reduce your waste by passing on by-products (e.g. products resulting from a manufacturing process whose main purpose is to produce		0.5075		

			another product; production residues)?				
		CE11	Do you procure by-products from other companies/organizations?		0.3147		
		CE12	Do you provide repair services for customers?		0.8067		
		CE13	Do you provide maintenance services for customers? (e.g. monitoring and control of product functionality)		0.7629		
		CE14	Do you use materials that have been used before (e.g. old products)?		0.4600		
		CE15	Do you rent and share tools, machines, or facilities/rooms?		0.5491		
Social capital	Structural capital (social interaction ties)	SC-SC1	We are in constant contact with our business partners (e.g. customers, suppliers, etc.).	0.6583	0.4805	0.7087	0.4811
		SC-SC2	We know our business partners on a personal level (e.g. exchange of personal/private information).		0.7580		
		SC-SC3	We maintain close social relationships with our business partners (e.g. meetings in private).		0.7978		
	Relational capital (trust)	SC-RC1	The relationships are characterized by a close personal interaction between the parties.	0.7807	0.6060	0.7798	0.4437
		SC-RC2	The relationships are characterized by mutual respect between the parties.		0.9061		
		SC-RC3	The relationships are characterized by mutual trust between the parties.		0.8875		
		SC-RC4	The relationships are characterized by personal friendship between the parties.		0.6999		
		SC-RC5	The relationships are characterized by high		0.4190		

			reciprocity between the parties (e.g., "Tit for tat").				
	Cognitive capital	SC-CC1	Our business partners and we share a similar corporate culture/values and management style.	0.8738	0.8110	0.8739	0.6355
		SC-CC2	Our business partners and we share similar business philosophies/approaches.		0.8395		
		SC-CC3	Our business partners and we share converging and compatible goals.		0.7926		
		SC-CC4	Our business partners and we share the same visions.		0.8286		
Dynamic Capabilities	Sensing capability	DC-SC1	We regularly monitor our environment to identify new business opportunities.	0.7293	0.7491	0.7340	0.4170
		DC-SC2	We regularly review how customers respond to changes in our business environment.		0.8079		
		DC-SC3	We regularly review our products/services to ensure they meet customer needs.		0.6647		
		DC-SC4	We spend a lot of time implementing ideas for new products/services and improving our existing products/services.		0.5747		
	Learning capability	DC-LC1	We have appropriate methods to identify and evaluate new information and knowledge.	0.8348	0.7474	0.8340	0.5015
		DC-LC2	We have appropriate methods to introduce new information and knowledge.		0.7557		
		DC-LC3	We can derive new insights from existing information/data.		0.7596		
		DC-LC4	We can apply the collected information and insights in products/services.		0.7242		
		DC-LC5	We can develop new knowledge that we can use in the context of product/service development.		0.7395		

	Integrating capability	DC-IC1	We continue to develop by allowing each individual to contribute.	0.8615	0.5270	0.8629	0.5617
		DC-IC2	Employees understand each other's roles and responsibilities.		0.7354		
		DC-IC3	It is known who in the company has work-relevant skills and expertise.		0.7156		
		DC-IC4	We coordinate our actions with each other to meet changing conditions.		0.7719		
		DC-IC5	Employees manage to successfully link their activities with each other.		0.7777		
	Coordinating capability	DC-CC1	We ensure that work activities are successfully coordinated.	0.8805	0.7461	0.8738	0.5879
		DC-CC2	We ensure an appropriate distribution of resources (e.g. information, time, reports) within our company.		0.6983		
		DC-CC3	Employees are given tasks and information appropriate to their knowledge and skills.		0.8282		
		DC-CC4	We make sure that the expertise of the employees is aligned with the work processes.		0.8265		
		DC-CC5	Overall, our company is well coordinated.		0.6663		

Note. after Varimax Rotation; CR = composite reliability; AVE = average variance extracted

Appendix 5

Chapter 3: Correlations and discriminant validity

Variable	M	SD	1	2	2a	2b	2c	3	4	5	6	7
1 CE	3.1	1.2	**0.48**									
2 SC	2.9	0.5	0.20**	**0.60**								
2a Structural capital	3.0	0.6	0.20**	0.77**	**0.69**							
2b Relational capital	3.9	0.7	0.16**	0.88**	0.59**	**0.67**						
2c Cognitive capital	2.7	0.6	0.13**	0.81**	0.42**	0.52**	**0.80**					
3 DCs	3.2	0.4	0.14**	0.19**	0.14**	0.20**	0.12**	**0.58**				
4 Employees	8.0	16.3	-0.03	0.03	0.04	0.01	0.03	-0.06	-			
5 Firm sales	3.8	1.9	-0.07*	0.12**	0.16**	0.10**	0.04	-0.13**	0.55**	-		
6 Firm age	38.3	42.6	-0.00	0.01	0.03	0.01	-0.01	-0.07*	0.22**	0.35**	-	
7 Segment	2.2	0.8	0.21**	0.06	0.07*	0.02	0.02	0.04	-0.03	0.03	-0.01	-

Note. $*p < 0.05$ $**p < 0.01$. *SD* = standard deviation. Diagonal is the square root of AVE (= discriminant validity)

Appendix 6

Chapter 3: Early versus late responders

Variable	**Early responders**	**Late responders**	**t-value**	**95 percent confidence interval**	
	N = 254	**N = 254**			
Employees	9.13	7.25	1.24	-1.09	4.84
Firm age	22.21	21.38	0.70	-1.50	3.17
CEO age	53.09	53.11	-0.02	-1.97	1.94

Appendix to Essay III (Chapter 4)

Appendix 7

Chapter 4: Questionnaire[6]

Innovationsfähigkeit, Circular Economy und Wettbewerbsvorteil	
Einführung	
Herzlich willkommen und vielen Dank, dass Sie an unserer Befragung teilnehmen! Hinweise zum Ausfüllen des Fragebogens: - Die Ausfülldauer des Fragebogens beträgt ca. 8-12 min. - Die erhobenen Daten werden vertraulich behandelt, nicht weitergegeben und ausschließlich in anonymisierter und aggregierter Form verwendet. - Eine gewerbliche Nutzung jeglicher Art ist ausgeschlossen. - Die erhobenen Daten werden nach Abschluss der Analyse / gesetzlichen Aufbewahrungsfrist unwiderruflich gelöscht. - Die Teilnahme ist freiwillig und anonym. - Es gibt keine richtigen oder falschen Antworten. - Bitte füllen Sie den Fragebogen vollständig aus. Mit Klick auf "Weiter" erklären Sie sich mit dem Umgang Ihrer Daten einverstanden.	
Angaben zum Betrieb/Person	
Geschlecht	☐ weiblich ☐ männlich ☐ divers
Geburtsjahr (bitte Jahreszahl angeben, z. B. 1980)	
Welche allgemeinbildenden und beruflichen Abschlüsse haben Sie? (Mehrfachnennungen möglich)	☐ Gesellenprüfung/Lehrabschlussprüfung (8) ☐ Meister-/Technikerabschluss (9 ☐ Bachelor oder vergleichbar (10) ☐ Master oder vergleichbar (16) ☐ Doktorgrad (13) ☐ nicht-handwerklicher Berufsabschluss (15) ☐ Sonstiges (bitte spezifizieren): (14)
In welchem Jahr wurde Ihr Betrieb gegründet?	
Seit wann sind Sie in Ihrem Betrieb tätig?	
Seit wann sind Sie in Ihrer Position tätig?	
Wie viele Mitarbeiter beschäftigt Ihr Betrieb (inklusive Inhaber und (unbezahlte) mitarbeitende Familienangehörige)?	☐ 1 ☐ 2-4 ☐ 5-9 ☐ 10-19 ☐ 20-49 ☐ 50-250 ☐ > 250
Welche Rechtsform hat Ihr Betrieb?	☐ Einzelunternehmen (1) ☐ Personengesellschaften (KG, OHG, GbR, GmbH & Co. KG) (4) ☐ GmbH (5) ☐ Sonstige Rechtsformen (AG, KGaA, Genossenschaft) (6) ☐ Sonstige (bitte spezifizieren): (7)
Wie hoch ist der Anteil von Familienangehörigen in der Unternehmensführung? (in %)	
Wie viel Prozent des Betriebs ist in Familienbesitz? (in %)	
In welchem Gewerbe ist Ihr Betrieb **hauptsächlich** tätig?	☐ Bauhauptgewerbe (wie z. B. Maurer:in, Dachdecker:in) ☐ Ausbaugewerbe (wie z. B. Maler:in, Lackierer:in, Tischler:in) ☐ Handwerke für den gewerblichen Bedarf (wie z. B. Metallbauer:in, Gebäudereiniger:in) ☐ Kraftfahrzeuggewerbe (wie z. B. Fahrzeugbauer:in, Zweiradmechaniker:in) ☐ Lebensmittelgewerbe (wie z. B. Bäcker:in, Fleischer:in, Müller:in) ☐ Gesundheitsgewerbe (wie z. B. Augenoptiker:in, Zahntechniker:in) ☐ Gewerbe für den privaten Bedarf (wie z. B. Schornsteinfeger:in, Friseur:in)

[6] The survey was conducted online via Qualtrics. The illustration is only an example.

Wie hoch ist der jeweilige Anteil?				Anteil in % (1)	
	Produktion (Produkte) (4)				
	Dienstleistungen (5)				
Wie hoch ist der jährliche Umsatz Ihres Betriebs?	☐ bis 22.000€ (1) ☐ 22.000 - < 50.000 (4) ☐ 50.000 - < 125.000 (5) ☐ 125.000 - < 250.000 (6) ☐ 250.000 - < 500.000 (7) ☐ 500.000 - < 2,5 Mio (8) ☐ 2,5 Mio - < 5 Mio (9) ☐ über 5 Mio. € (10)				
Circular Economy					
CE1 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.		trifft überhaupt nicht zu (1)	trifft wenig zu (2)	trifft etwas zu (3)	trifft voll und ganz zu (4)
	In unserem Betrieb haben wir nicht nachhaltige Rohstoffe durch erneuerbare Rohstoffe ersetzt.	○	○	○	○
	In unserem Betrieb haben wir nicht nachhaltige Rohstoffedurch recycelbare Rohstoffe ersetzt.	○	○	○	○
	In unserem Betrieb haben wir nicht nachhaltige Rohstoffe durch biologisch abbaubare Rohstoffe ersetzt.	○	○	○	○
	In unserem Betrieb haben wir alternative Verwendungsmöglichkeiten für unsere Produkte eingeführt, nachdem sie ihren ursprünglichen Zweck erfüllt haben.	○	○	○	○
	Wir erbringen Instandhaltungsdienstleistungen für Kund:innen.	○	○	○	○
	In unserem Betrieb haben wir geschlossene Kreisläufe in der Produktion (z. B.: Rückführung/Recycling/Wiederverwendung von Produktresten/Rohmaterial in die Produktion, Abfall als Rohstoff).	○	○	○	○
CE2 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.		trifft überhaupt nicht zu (1)	trifft wenig zu (2)	trifft etwas zu (3)	trifft voll und ganz zu (4)
	In unserem Betrieb haben wir neue Einnahmequellen für Produkte gefunden, nachdem sie ihren ursprünglichen Zweck erfüllt haben (Angebot neuer Geschäftsmodelle).	○	○	○	○
	In unserem Betrieb haben wir die Verwendung von wiederverwertbaren Rohstoffen in unseren Prozessen erhöht.	○	○	○	○
	In unserem Betrieb haben wir die Produktion von einfach reparierbaren/instand haltbaren Produkten erhöht.	○	○	○	○
	In unserem Betrieb verwenden wir umweltfreundliche Verpackungen (z. B. wiederverwendbar, biologisch abbaubar, weniger Verpackung).	○	○	○	○
	In unserem Betrieb verwenden wir Prozesse mit geringen Umweltauswirkungen.	○	○	○	○
	In unserem Betrieb arbeiten wir mit unseren Lieferant:innen, Kolleg:innen, Kund:innen etc. zusammen, um Wege zu finden, wie wir ausgediente Produkte wieder in unsere oder die Wertschöpfungskette eines anderen Unternehmens einbringen können.	○	○	○	○

		trifft überhaupt nicht zu (1)	trifft wenig zu (2)	trifft etwas zu (3)	trifft voll und ganz zu (4)
CE3 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.	Wir verleihen/teilen Werkzeuge, Arbeitsutensilien, Maschinen oder Räumlichkeiten.	○	○	○	○
	Wir reduzieren unseren Abfall, indem wir Nebenprodukte weitergeben (Nebenprodukte sind z. B. Produkte, die bei einem Fertigungsverfahren anfallen, dessen Hauptzweck die Herstellung eines anderen Produkts ist; Produktionsreste).	○	○	○	○
	Wir beziehen Nebenprodukte von anderen Unternehmen/Organisationen.	○	○	○	○
	In unserem Betrieb gibt es Initiativen, um Produktreste von Kunden zu sammeln, zu recyceln und/oder wiederzuverwenden.	○	○	○	○
	In unserem Unternehmen verwenden wir recycelte Materialien oder Altmaterialien als Input für unsere Prozesse.	○	○	○	○
	Wir erbringen Reparaturdienstleistungen für Kund:innen.	○	○	○	○
Competitive Advantage					
		stimme überhaupt nicht zu (1)	stimme nicht zu (2)	stimme zu (3)	stimme voll zu (4)
CA1 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.	Wir heben uns erfolgreich von unserer Konkurrenz durch unsere Produkte/Dienstleistungen ab, die einen höheren Nutzen (Qualität, Service) für die Kunden haben.	○	○	○	○
	Wir unternehmen große Anstrengungen zum Aufbau eines starken Markennamens.	○	○	○	○
	Wir heben uns erfolgreich durch wirksame Werbung und Werbekampagnen von unseren Konkurrenten ab.	○	○	○	○
	Wir heben uns erfolgreich von anderen Konkurrenten durch ein einzigartiges Design ab (z. B. Produkt, Markenidentität).	○	○	○	○
	Wir bieten stets einen allgemeinen Differenzierungsvorteil (z. B. herausragende Produktqualität, guter Service).	○	○	○	○
		stimme überhaupt nicht zu (1)	stimme nicht zu (2)	stimme zu (3)	stimme voll zu (4)
CA2 Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.	Unsere Herstellungskosten sind niedriger als die der Konkurrenz.	○	○	○	○
	Unsere interne Betriebsorganisation senkt die Kosten für unsere Produkte.	○	○	○	○
	Dank unseres Größenvorteils können wir einen Kostenvorteil erzielen.	○	○	○	○
	Wir bieten stets niedrigere Preise für unsere Kunden als unsere Konkurrenz.	○	○	○	○

Innovation Capability					
IC Sie haben es fast geschafft! Bitte bewerten Sie folgende Aussagen in Bezug auf Ihren Betrieb.		trifft überhaupt nicht zu (1)	trifft wenig zu (2)	trifft etwas zu (3)	trifft voll und ganz zu (4)
	Unser Betrieb verfügt über eine Kultur, die Innovationen unterstützt und fördert, indem oft neue innovative und kreative Ideen ausprobiert werden.	○	○	○	○
	In unserem Betrieb wird Wissen aus unterschiedlichen Ressourcen effizient und schnell für die Produkt- oder Dienstleistungsentwicklung genutzt.	○	○	○	○
	Unser Betrieb ist in der Lage, Änderungen der Marktbedingungen (z. B. Änderungen von Kundenwünschen) schnellstmöglich auf die eigenen Produkte, Dienstleistungen und Prozesse abzubilden.	○	○	○	○
	Die Mitarbeitenden unseres Betriebs (falls vorhanden) werden an Aktivitäten wie Produkt-/Dienstleistungsentwicklung und Verbesserung von Innovationsprozessen beteiligt.	○	○	○	○
	Neue Ideen von Kunden, Lieferanten usw. werden kontinuierlich bewertet und in die Produkt- und Dienstleistungsentwicklung einbezogen.	○	○	○	○
	Unser Betrieb kann sich leicht und in kurzer Zeit an Umweltveränderungen anpassen, indem wir geeignete Verbesserungen/Innovationen an unseren Produkten, Dienstleistungen und Prozessen vornehmen.	○	○	○	○
Angaben zur Postleitzahl					
Wie lautet die Postleitzahl des Hauptsitzes Ihres Betriebs?					
Kontakt					
Herzlichen Dank, dass Sie an unserer Umfrage teilgenommen haben. Dürfen wir Sie bei Rückfragen kontaktieren?	☐ Ja				
	☐ Nein				
Kontakt Vielen Dank! Bitte klicken Sie danach auf "Weiter", um die Umfrage zu beenden und den Fragebogen abzuschicken.					
	Bitte ausfüllen: (1)				
Name des Ansprechpartners & Betriebs (1)					
E-Mail-Adresse (2)					
Telefonnummer (3)					

Appendix 8

Chapter 4: Early versus late responders

Variable	Early responders N = 47	Late responders N = 47	t-value	95 percent confidence interval	
Employees	2.57	2.28	1.10	-0.24	0.84
Firm age	31.57	36.98	-0.88	-17.62	6.82
CEO age	50.21	53.02	-1.14	-7.69	2.07

Appendix 9

Chapter 4: Measurement items, validity, and reliability indicators

Second-order construct	First-order construct	Indicator code	Indicator	Alpha	Loadings	CR	AVE
	CE	CE1	In our company, we have replaced non-sustainable raw materials with renewable raw materials.	0.86	0.79	0.87	0.29
		CE2	In our company, we have replaced non-sustainable raw materials with recyclable raw materials.		0.82		
		CE3	In our company, we have replaced non-sustainable raw materials with biodegradable raw material.		0.78		
		CE4	In our company, we have introduced alternative uses for our products after they have fulfilled their original purpose (e.g. product parts installed in new products).		0.65		
		CE5	In our company, we have found new sources of revenue for products after they have fulfilled their original purpose (offering new business models/services).		0.61		
		CE6	In our company, we have increased the use of recyclable raw materials in our processes.		0.58		
		CE7	In our company, we have increased the production of easily repairable/durable products (spare parts and repair options available, cost-effectiveness of repair given).		0.47		
		CE8	In our company, we use environmentally friendly packaging (e.g. reusable, biodegradable, less packaging).		0.53		

		CE9	We use processes with a low environmental impact in our company.		0.55		
		CE10	In our company, we work together with our suppliers, colleagues, customers, etc. to find ways to reintroduce used products into our value chain or that of another company.		0.61		
		CE11	We lend/share tools, work utensils, machines or premises.		0.43		
		CE12	We reduce our waste by passing on by-products (by-products are, for example, products resulting from a manufacturing process whose main purpose is the manufacture of another product; production residues).		0.63		
		CE13	We purchase by-products from other companies/organizations.		0.65		
		CE14	Our company has initiatives in place to collect, recycle and/or reuse product waste from customers.		0.56		
		CE15	In our company, we use recycled materials or used materials as input for our processes.		0.60		
		CE16	We provide repair services for customers.		0.91		
		CE17	We provide maintenance services for customers.		0.93		
		CE18	In our company, we have closed loops in production (e.g: Return/recycling/reuse of product residues/raw material in production, waste as raw material).		0.43		
	Innovation capability	IC1	Our company has a culture that supports and encourages innovation by often trying out new innovative and creative ideas.	0.79	0.91	0.78	0.38

		IC2	In our company, knowledge from different resources is used efficiently and quickly for product or service development.		0.89		
		IC3	Our company is able to reflect changes in market conditions (e.g. changes in customer requirements) in its own products, services and processes as quickly as possible		0.52		
		IC4	The employees of our company (if any) are involved in activities such as product/service development and improvement of innovation processes.		0.71		
		IC5	New ideas from customers, suppliers, etc. are continuously evaluated and incorporated into product and service development.		0.85		
		IC6	Our company can adapt easily and quickly to environmental changes by making appropriate improvements/innovations to our products, services and processes.		0.72		
Competitive advantage	Differentiation advantage	CA-DIF1	We successfully differentiate ourselves from our competitors through our products/services, which have a higher benefit (quality, service) for the customer.	0.81	0.67	0.81	0.47
		CA-DIF2	We are making great efforts to build a strong brand name.		0.83		
		CA-DIF3	We successfully differentiate ourselves from our competitors through effective advertising and promotional campaigns.		0.81		
		CA-DIF4	We successfully differentiate ourselves from other competitors through a unique		0.81		

			design (e.g. product, brand identity).				
		CA-DIF5	We always offer a general differentiation advantage (e.g. outstanding product quality, good service).		0.61		
	Cost leadership advantage	CA-CL1	Our production costs are lower than those of our competitors.	0.70	0.77	0.70	0.36
		CA-CL2	Our internal company organization reduces the costs of our products.		0.72		
		CA-CL3	Thanks to our economies of scale, we can achieve a cost advantage.		0.66		
		CA-CL4	We always offer lower prices for our customers than our competitors.		0.72		

Note. After Varimax Rotation; CR = composite reliability; AVE = average variance extracted

Appendix 10

Chapter 4: Correlations and discriminant validity

Variable	M	SD	1	2	3	3a	3b	4	5	6
1 Innovation capability	2.9	0.6	**0.62**							
2 CE	2.3	0.6	0.47**	**0.54**						
3 Competitive advantage	2.3	0.5	0.41**	0.28**	**0.52**					
3a Differentiation	2.5	0.6	0.34**	0.20**	0.84**	**0.69**				
3b Cost leadership	2.1	0.6	0.27**	0.23**	0.68**	0.16*	**0.60**			
4 Employees	2.6	1.4	0.05	-0.06	0.12	0.19*	-0.04	-		
5 Firm age	33.9	30.1	-0.03	0.11	0.01	0.06	-0.07	0.42**	-	
6 Industry	2.1	0.6	0.01	0.00	-0.01	0.04	-0.07	-0.02	0.03	-

Note. *$p < 0.05$ **$p < 0.01$. *SD* = standard deviation. Diagonal is the square root of AVE (= discriminant validity)

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