20. How digital technologies boost value potential creation and value realization in CE: insights from a multiple case study across industries[1]

Sami Rusthollkarhu, Valtteri Ranta and Leena Aarikka-Stenroos

INTRODUCTION

Digital technologies and technological innovations have been identified as important catalysts for business model innovations that enable value creation while adhering to circular economy (CE) principles (Nascimento et al. 2019; Rosa et al. 2020; Ranta et al. 2021; Bocken et al. 2016). Although the concept of business models has often been used in the CE literature, its primary function has been to showcase a more holistic perspective on how CE principles can be implemented in business (see e.g. Lüdeke-Freund et al. 2019). Thus, the business models in the CE literature have mainly focused on value proposition (Manninen et al. 2018), value creation (Bocken et al. 2016), and value capture (Ranta et al. 2018) activities of companies that enable adhering to CE principles in business. The literature, however, has not given much attention to the models' primary role in describing customer value creation (Teece 2010) and the necessary participation of the customer in value creation (Vargo and Lusch 2004, 2016). In this chapter, we therefore discuss how digital technologies enable and boost customer value creation in CE. We give special attention to not only the effects of digital technologies in creating value potential for customer but also the effects in the customer's possibilities to realize this value.

As with business model innovations, the CE literature has approached digital technologies from a circularity and material efficiency perspective. Technologies have allowed companies to better utilize their supply chain data to track products and materials, potentially improving their ability to retain value (Lopes de Sousa Jabbour et al. 2019) and thus better fulfil the requirement for circularity (Ranta et al. 2020). However, adhering to CE principles does not determine a company's ability to succeed or even exist in the market. For this, the value perceived by the customer is considered fundamental (Slater and Narver 1994). For a business model to be applicable, it must create value for the customer and be able to capture a part of that value (Teece 2010).

The dominant approach to customer value considers it as something determined by the customer (Vargo and Lusch 2004, 2016) and created through interactions between the customer and the supplier (Lindgreen et al. 2009). The supplier is seen as a facilitator (Grönroos and Voima 2013), or proposer (Vargo and Lusch 2004, 2016), of value as well as an organizer of the value process (Aarikka-Stenroos and Jaakkola 2012). The customer realizes the value as co-creator and evaluator (Grönroos 2011; Grönroos and Voima 2013; Prahalad and Ramaswamy 2004; Vargo and Lusch 2016) by interacting with the supplier and using the products and services offered to them (Grönroos and Voima 2013; Vargo and Lusch 2004).

The chapter adopts this dominant approach, in which the customer is seen as the necessary co-creator of value. Customer-perceived value is then determined by two aspects: (1) the value potential created and (2) the customer's ability to realize that potential. We utilize these two aspects to examine the effects of digital technologies on value creation in the CE context. We aim to understand how digital technologies allow companies to develop and redesign their CE business by (1) improving the value potential of CE business and (2) improving the customer's ability to realize that value. Together, these two aspects explain how providers can utilize digital technologies to enhance customer value creation in order to strengthen CE innovations.

We conducted a multiple case study among six companies from different industries. The study examined their CE solutions, in which digital technologies were utilized for both customer value creation and adherence to CE principles. The interview data gathered were categorized according to different digital technologies as well as their effects on value potential and its realization.

This study aims to contribute to the literature on circular and sustainable business, CE innovations, and value creation by exploring the relationship between circularity, digital technologies, and customer value creation. In addition to introducing the topic of customer value creation in CE, this chapter provides managerial guidelines for practitioners in their innovative business endeavours.

VALUE CREATION IN THE CE CONTEXT

A business model's ability to provide realizable value for the customer determines the company's likelihood of remaining in the market (Teece 2010). In this section, we discuss creating and realizing customer value potential in relation to CE principles.

Creating and Realizing Value Potential

Customers have an active role in the process of value creation. The customer realizes value by interacting with the value proposition of the company (Vargo and Lusch 2004) and can also participate in the process in a more extensive manner as a co-producer, designer, developer, or marketer (Aarikka-Stenroos and Jaakkola 2012). The role of the company is to offer value propositions (Vargo and Lusch 2004) and facilitate the value process (Grönroos and Voima 2013). We emphasize that the creation and realization of value propositions take place in an ecosystem, meaning that propositions can be created by multiple actors (Vargo and Lusch 2016).

Furthermore, the customer's process of realizing value is guided by a broad range of inter- and intra-organizational interactions, not just those with value proposition. Thus, the value realized by the customer is not necessarily similar to the value proposition offered by the company (Rusthollkarhu et al. 2020). This is especially relevant in the context of CE, as the function of products and materials differs in different parts of the cycle. For example, recycled or reused goods can have functions for customers distinct from their original purposes (Ranta et al. 2020). To capture a more holistic view of customer-perceived value, we use the concept of value potential, which includes all the potential value the customer can realize while interacting with the physical good or service, including the intended value communicated by the value proposition. Next, we discuss the connection between value potential and CE activities.

Value Potential in CE Business

To understand CE characteristics in value creation, we use the four CE value creation logics described by Ranta et al. (2020): resurrect, share, optimize, and replace value. These logics are consistent with other CE business model categorizations (e.g. Ellen MacArthur Foundation 2015; Bocken et al. 2016; Lüdeke-Freund et al. 2019). However, while the other models primarily focus on improving the circularity of business, the value creation logics explicitly focus on value creation but from the perspective of the company (Ranta et al. 2020). Thus, the crucial activities within these value creation logics provide an understanding of the value-potential-building activities of CE business models. An important aspect of value creation logics is that while each describes core aspects of how certain activities aim to increase value potential, multiple value creation logics can and often are found simultaneously in a CE business model (Ranta et al. 2020).

In the *resurrect value logic*, the company focuses on reintroducing value back into resources, such as products, components, and materials. To leverage this logic, companies need to be able to reintroduce value cost efficiently so that the revitalization of value offers competitive value potential for customers compared to new resources while enabling profitable value capture for the company (Ranta et al. 2020). Crucial CE activities for this logic include the acquisition of the resources with diminished value in the value resurrecting process through, for example, take-back systems (Lewandowski 2016) or circular supply chains (Centobelli et al. 2020); the actual process of resurrecting value, be it maintenance, repairing, remanufacturing, or recycling (Lüdeke-Freund et al. 2019); and the sale of the resources back to the market (Ranta et al. 2018).

In the *share value logic*, the company focuses on enabling customers to move from the ownership of products toward using shared resources, which reduces the amount of resources and, thus, the materials needed to fulfil the needs of the customer base. To leverage this logic, companies need to overcome the existing customer preference for owning their own resources by providing a shared resource alternative with competitive value potential (Ranta et al. 2020). Crucial CE activities, thus, make it convenient and economically viable for customers to discover, access, and use shared resources. Companies can, for example, improve the discoverability of shared resources by implementing online marketplaces and ensuring the accessibility of shared resources. Companies using this logic can either own the resources themselves and fully manage the fleet of shared resources (Ranta et al. 2020), or they can enable resource sharing between customers with excess resources and customers with resource needs, following a sharing economy approach (Belk 2014).

In the *optimize value logic*, the company focuses on providing specialized knowledge and resources for the customer's use, enabling them to create more value with fewer resources. Companies can provide monitoring services that allow customers to identify waste in energy and material usage as well as services that allow customers to improve on identified issues. For example, monitoring data from an industrial machine enables the provision of predictive maintenance services, optimizing the uptime of the machine. To leverage this logic, companies need to have a sound understanding of both the resource for which value creation is to be optimized as well as the business of the customer in order to improve both the value potential of the resource and the customer's realization of that potential (Ranta et al. 2020). Important activities for this logic, thus, include the ones that deepen the customer's understanding of resource use in their value realization process.

In the *replace value logic*, the company focuses on providing an alternative resource that can fulfil the same customer needs as traditionally used resources while fulfilling the emerging sustainability needs related to CE principles. This logic is especially relevant concerning generally unsustainable resources; an example of it is the increasingly popular plant-based meat replacement products that help reduce the environmentally unsustainable levels of meat consumption while offering customers competitive value potential compared to actual meat (Ranta et al. 2020). Crucial activities for this logic involve identifying certain needs of the customer that if left unfulfilled would deter the customer from switching from the traditional resource to the replacement one. Such needs can be properties of the resource itself (e.g. the taste of the plant-based protein product), or they can be the qualities of the resource that make it suitable for the customer to use without other large investments, such as using waste oil-based diesel in the same vehicle as fossil fuel-based diesel. As this logic usually builds upon a novel innovation, research and development activities are often central to it.

Digital Technologies in CE

Digital technologies have been identified as having a key role in enabling CE principles in business (Pagoropoulos et al. 2017) by narrowing, slowing, and closing of resource loops (Ranta et al. 2021). In particular, the product-service systems (PSS) model, in which product-oriented offerings are transformed by supporting services or even by selling the product as a service (Tukker 2015), benefits from the implementation of digital technologies. In this context, digital technologies enable remote monitoring of the product, which, in turn, allows optimizing the provision of maintenance services for the customer, thus lengthening the product's lifecycle. Furthermore, as the product reaches the end-of-life stage, digital technologies enable the PSS provider to collect the product and identify whether reusing, remanufacturing, or recycling of the product is economically feasible through analysing the data collected from the product during the use phase or embedded in the product as a product passport (Alcayaga et al. 2019). Thus, in the PSS model, digital technologies facilitate closing the loop on the products and improving the ability to select the optimal revalorization route when products reach their end-of-life stage.

Five technology groups are identified as relevant in the context of CE: cyber-physical systems (CPS), Internet of Things (IoT), big data and analytics (BDA), additive manufacturing (AM), and simulation (Rosa et al. 2020). CPS refers to the embedded computers and networks used in monitoring physical processes (Lee et al. 2015). IoT technologies utilize modern wireless telecommunications (e.g. radio frequency identification [RFID], sensors, tags, actuators) to enable interaction among people, devices, and objects (Nasiri et al. 2017). BDA is an umbrella term for applications of advanced data analysis techniques applied to big data, including cloud storage and computing as well as AI analysis techniques (Soroka et al. 2017). AM describes technologies that allow production via layering or 3D printing (Dutta et al. 2001). Lastly, simulation refers to a wide range of mathematical programming techniques (Rosa et al. 2020).

RESEARCH DESIGN, CASES, DATA, AND ANALYSIS

To study how digital technologies enable and boost customer value creation in CE, we chose a qualitative multiple case study strategy. This approach enables us to develop a theoretical understanding of the focal phenomenon in its natural setting (Yin 1994) and to integrate conceptual research-based knowledge and empirical insights derived from the cases (Dubois and Gadde 2002). By selecting a multiple case study strategy with six cases from different industries with differing business models, we could uncover differences between the cases regarding how digitalization shapes value creation in the CE setting and identify similar patterns across different company cases. The case companies are headquartered in Northern Europe, although they conduct most of their business globally.

The case selection was purposive. First, by using maximum variation criteria (Patton 1990), we carefully selected cases from various CE-related businesses. These businesses used different business models and came from different industries; they also differed in terms of their size and types of digital tools used. Second, by choosing cases where diverse resource flow strategies and CE principles are followed – including narrowing, slowing, and closing resource flows – we ensured that our findings captured the full spectrum of CE business models. Third, we selected successful cases (see Patton 1990), as we assumed that by focusing on companies running feasible CE-related businesses, we would be able to analyse implemented digital technologies for CE and examine how this shapes value creation for all involved actors (suppliers, customers, other actors). Additionally, to improve case selection, we conducted a preliminary analysis of more than ten cases and then focused our analysis on the six cases (see Table 20.1) from different industries.

We built on both the primary and secondary data sources for each case. The primary dataset comprised 14 semi-structured face-to-face and remote interviews, conducted between July 2019 and January 2020 with key actors, such as business, logistics, technology, software, and project managers as well as experts directly involved in the use of digitalization and business development in the field of CE. The secondary dataset supported and extended each case; these data comprised internal and media-originated data, such as technical documents, articles, companies' websites, and other web pages concerning the solutions, the companies, and their evolving market and business environments.

In our case analysis, we first conducted a within-case analysis as we generated an overview of digital technologies used and their effect on value potential. Next, we conducted a cross-case analysis and generated more synthesized patterns by identifying similarities and differences across the cases. To improve quality of analysis and trustworthiness of the results, we applied a range of tools and tactics, such as a structured coding procedure as well as researcher triangulation with drafted tables and figures, which encouraged discussion among all involved researchers (Flick 2004).

DIGITAL TECHNOLOGIES IN CUSTOMER VALUE CREATION: CREATING AND REALIZING VALUE POTENTIAL IN THE CE CONTEXT

Next, we discuss the results gained from the six company cases. In Table 20.2, we summarize the results. We present the identified digital technologies, short descriptions of how the tech-

Table 20.1 The cases and their background information

Case	Company size (revenue)	Industry	Description	Interviews	Secondary data
Construction tool service	5,300 MEUR	Tools/construction	Provider of technologically leading tool products and digital solutions for professional construction sites.	Services & software, area sales manager	Company web pages, annual reports
			Digital solutions aim to improve resource efficiency in construction areas.		
Forest machinery and harvesting	610 MEUR	Machinery	Manufacturer of forest machinery.	Spare parts manager, HSE manager	Company web pages, annual reports
			It utilizes digital tools in harvesting solutions to optimize machine usage and provide maintenance services.		
Waste management	370 MEUR	Waste management (public)	A municipal body that develops resource efficient reuse processes for city waste.	Logistics manager, Landfill field manager, Project manager	N/A
Oil refinery	14,900 MEUR	Oil refinery and technology developer	Oil refinery producing refined oil products from renewable feedstock.	Chief information officer, Head of digital transformation	Company web pages, annual reports, news articles
Fertilizers and infra products	8 MEUR	Forestry and agriculture	Produces fertilizers for forestry and agriculture and products for groundworks and environmental construction from industrial side flows.	Technical sales specialist	Company web and social media pages, industrial area case report
Pulp refinery	10240 MEUR	Pulp refinery	Produces, refines, and markets pulp products and energy solutions.	Director of business, Partner company CEO, Partner company, head of circular economy,	Technical platform documents
			Applies tailored digital solutions to close flows and develops platforms for utilization of industry side flows.	Partner company environment chief, Partner company, technology platform manager	

nologies enable the value potential provided by the CE company in each case, and the different interfaces that enable the realization of the provided value potential. The interfaces are categorized as company-provided ones that are managed by the provider and third-party ones that are not owned by the company but through which customers can realize the value potential.

Five different technology categories were indicated in relation to creating value potential: IoT technologies, cloud technologies, enterprise resource planning (ERP) systems, artificial intelligence (AI), and automation. IoT included sensors and systems that enabled information gathering concerning production or customer machine use. Both cloud technologies and ERP were mentioned in the context of integrating information from multiple sources and allowing easy access to it. Because of their learning capabilities, AI tools were utilized in the analysis of vast datasets concerning forecasting tasks. One case company bundled their production technologies under the general term 'automation', including both the software and hardware components that enable autonomous actions in manufacturing. Our findings concerning technology categories are in line with Rosa et al.'s (2020) categorization. CPS, BDA, and simulations present themselves in descriptions of the use of cloud and AI systems. ERP systems were also brought up as a tool for lighter data storage and analysis. AI's forecasting capabilities were used to simulate the material flows in supply chains. AM was the only technology category that was not mentioned in the interviews, as none of the case companies relied on 3D printing/layering technologies in their manufacturing. Furthermore, interviewees highlighted the importance of cloud technology. Although cloud technologies do not form a separate category in Rosa et al.'s (2020) categorization, data storage and computing capabilities, such as cloud technologies, are inherently imbedded in categories of IoT, BDA, and simulation.

DISCUSSION

The Four Roles of Digital Technologies in CE Value Creation

All company cases analysed in this chapter utilize digital technologies for creating value potential, enabling value realization, and adhering to the CE principles, which supports the value logic of the company. Based on our results, we propose four roles for digital technologies in CE value creation: *digital technology acting as an interface*, *digital technology providing access to value potential*, *digital technology improving operational efficiency*, and *digital technology helping to understand value realization*. These four roles explain how companies with CE solutions can use digital technologies to enhance the value potential of their offerings and empower their customers in value realization through diverse digital tools.

Digital technology acting as an interface: Digital technology forms the communication interface between the customer and the company or other ecosystem actors. Convenient interfaces for customers are crucial for value realization in all CE value logics. API, mobile, and online interfaces utilized in the cases of construction tool service, forest machinery, and oil and pulp refinery demonstrate the technology's role as an interface. These solutions provide an example of how companies can utilize different digital interfaces to enable value realization in resurrect, share, optimize, and replace value logics.

Digital technology providing access to value potential: Digital technologies ensure that value potential is accessible to the customer through the interface. Cloud, IoT, and ERP technologies utilized in resurrect logics of construction tools and forest machinery and harvesting

Table 20.2 Digital technologies, value potential, and interfaces for value realization in CE setting

Case	Digital technologies	Value logic and technologies' effect on value potential	Link to CE principles	Company-provided interfaces for value realization and customer's actions	Third-party provided interfaces for customer's value realization
Construction tool service *Product-service system operator, tool manufacturer for the construction industry*	**IoT technologies** collect data from machines, providing machine health and location information. **Cloud** technologies integrate and show data to the company and customer, enabling the potential for offering context-specific maintenance services.	**Optimize: IoT** technologyenables tool tracking and data generation. Data allow the company to fulfil the needs of customers with fewer overall tools. Data from construction machines are used to provide higher quality maintenance service at a lower cost. **Resurrect: Cloud** technologies provide customers convenient, timely access to maintenance services, increasing demand and use of services.	**Narrow**[a] resource flows by serving customers with fewer tools and **slow**[b] flows by increasing the demand for maintenance service by making it accessible.	Tools and machines used in construction sites, mobile app, QR tags, online interface. Customer uses tools and interacts with mobile and online interfaces to conveniently access to maintenance services as well as tool location and use information.	Third-party tools and machines used in construction sites

Case	Digital technologies	Value logic and technologies' effect on value potential	Link to CE principles	Company-provided interfaces for value realization and customer's actions	Third-party provided interfaces for customer's value realization
Forest machinery and harvesting *Product service system operator, forestry machine manufacturer*	**IoT** technologies collect machine health and usage data. An **ERP system** integrates data for maintenance and product development operations. The **online ordering system** allows customers to directly order spare parts.	**Optimize: IoT** technologies allow gathering the data on the customer's use of the machine. The data can be utilized in product development to optimize a machine's fuel consumption and make the product more desirable and cost effective for the customer. **Optimize and resurrect:** **IoT** technologies enable data gathering on machine health and customer's machine usage. The **ERP system** allows data integration into maintenance and product development operations, enabling the provision of high quality and cost effective maintenance services and spare part ordering.	**Narrow** resource flows by optimizing fuel economy and **slow** them by increasing the efficiency of maintenance and spare part services.	Machines, online interface. Customer uses the machines and interacts with online interfaces to access spare part and maintenance services.	Third-party parts
Waste management *Material processor, municipality-owned waste and water management group*	**IoT** technologies provide data from vehicles used in logistics systems.	**Optimize: IoT** technologies enable tracking and data generation of the logistics system. Data can be utilized to identify opportunities for efficiency and cost reductions.	**Narrow** resource flows by increasing operational efficiency of logistics system.	Waste collection bins and stations. Customer interacts with waste collection bins and stations. Efficient logistics ensure that bins and stations are usable at all times.	No identified third-party interfaces

Case	Digital technologies	Value logic and technologies' effect on value potential	Link to CE principles	Company-provided interfaces for value realization and customer's actions	Third-party provided interfaces for customer's value realization
Oil refinery *Material processor, producer of refined products from renewable feedstock in the oil industry*	**IoT** technologies collect data from chemical processes and the supply chain **Cloud** technologies store, integrate, and analyse large volumes of data **AI** technologies provide forecasting capabilities.	**Replace: IoT** technologies enable the optimization of production and supply chain processes. This enables production with fewer materials, reducing costs while simultaneously improving the quality of the product. **Replace: Cloud** technologies allow the company to access larger volumes of data from the supply chain, increasing knowledge about its real-time operation, thus enabling a cost-effective, more reliable supply chain. **Replace: AI** technologies allow the company to better forecast supply for waste materials and demand for refined products, developing knowledge for supply chain management and reducing unnecessary warehousing and potential shortages.	**Narrow** and **close**[c] resource flows with more efficient production and supply chain processes.	Distribution substations, online interface for ordering, oil refinery logistics services. Customer uses refined oil products, interacts with online ordering system, logistics services and with distribution substation.	Third-party distribution substations, machines using the product

Case	Digital technologies	Value logic and technologies' effect on value potential	Link to CE principles	Company-provided interfaces for value realization and customer's actions	Third-party provided interfaces for customer's value realization
Fertilizers and infra products *Produces fertilizers for forestry and agriculture and products for groundworks and environmental construction from industrial side flows*	**Manufacturing automation** increases operational efficiency in production processes.	**Replace: Manufacturing automation** enables operational efficiency in production, where industrial side flows are utilized in the manufacturing of fertilizer and groundworks products, closing resource flows. Operational efficiency ensures the low cost of production and enables economic value for customer.	**Close** resource with more efficient production processes.	Fertilizers, infra products Customer uses fertilizers and infra products.	Agricultural and forest machinery/ services, machines and tools used in construction site
Pulp refinery *Producer of pulp and refined products, developing industry-wide platform for utilizing side streams*	**Cloud** technologies store, integrate, and analyse large volumes of data.	**Share: Cloud** technologies allow integrating real-time information on the side streams of individual companies closing resource flows.	**Close** resource flows by allowing shared use of side streams.	Online interface, application programming interfaces (APIs) with ERP and CRM when compatible. Customers interact with online interfaces to access side-stream information and to engage with the side-stream. APIs enable the automation of the interaction.	ERP and CRM systems

Notes: [a] Narrowing resource flows: using fewer resources per product (Bocken et al. 2016); [b] Slowing resource flows: extending the life of a product (Bocken et al. 2016); [c] Closing resource flows: through recycling, closing the loop between post-use and production (Bocken et al. 2016).

demonstrate this role. In these solutions, customers can realize value without interacting with the tools, machines, or service personnel of the company. Conveniently accessible interfaces combined with wide access to value potential allowed case companies to increase the demand for their CE services.

Digital technology improving operational efficiency: Digital technologies increase economic value for customers by lowering production costs. Illustrative examples in our study were production automation in the case of fertilizers and infra products; IoT, cloud, and AI technologies in supply chain efficiency in the case of oil refinery; and IoT technologies in logistics efficiency in the case of the waste management company. The operational efficiency also highlights that CE innovation does not need to be radical to be successful. Improvements in operational efficiency can take place in company processes without radically changing the business model.

Digital technology helping to understand value realization: Digital technologies monitor customer's use of the product or service improving the company's understanding of the customer's value realization process. The data gathered from the customer provides valuable information to guide further development and innovation. The final role is especially crucial to optimize logic, as the value potential in it is directly linked to customers' use of the product/service. IoT technologies in cases of construction tool service, forest machinery, and harvesting, are examples of digital technologies in enabling customer understanding in optimize value logic.

Practical Implications

The four roles of digital technology in CE value creation generate insights for managers on how to implement diverse digital technologies to develop their CE business and customer value. Therefore, managerial takeaways for each identified role of digital technology are presented. We suggest the four principles of digital CE value creation: relevance of interfaces, accessibility of the value potential, the efficiency of the processes, and analysis of value realization. Practitioners should consider these as guidelines for digital and business innovation in the field of CE.

1. Relevance of interfaces: Identify the interfaces that are most accessible for your customer and build service by utilizing those interfaces. For example, in the case of a construction tool service, the mobile application ensured that every worker on the construction site could interact with the service regardless of time or location.
2. Accessibility of the value potential: Ensure that the customer can realize the highest possible value potential through each interface. For example, in the case of the pulp refinery, cloud technologies ensured that the information on the side streams was accessible through both online and API interfaces.
3. Efficiency of the processes: Ensure a sufficient level of operational efficiency for a low production cost to provide economic value for the customer. For example, in the case of the oil refinery, IoT, cloud, and AI technologies were used to ensure that the supply chain worked efficiently.
4. Analysis of value realization: Build technologies and processes to understand the value realization processes of the customer for continuous improvement and further innovation. For example, in the case of the forest machinery and harvesting, IoT technologies were

used to monitor the customer's usage of the machine. This information was used in R&D and was also provided to the customers to help them optimize their own machine usage.

Theoretical Contributions and Directions for Future Research

Our study provides theoretical contributions to the literature on business and technology innovations in CE, to the literature on sustainable business, to the literature on the role of digital technology in CE business and to the literature on value creation. Prior circular and sustainable business literature covered technology and business innovation from the view of circularity (see e.g. Bocken et al. 2016; Lüdeke-Freund et al. 2019; Manninen et al. 2018; Ranta et al. 2018), leaving the realm of customer value creation unexplored. By taking the customer value approach and revealing aspects of value potential, as well as its realization, this chapter provides conceptualization for future studies focusing on customer value in circular and sustainable business as well as on business and technology innovations in CE.

The literature on the role of digital technologies in CE business has thus far been task and business model centric. These studies describe how various digital technologies enable the circulation of materials and products within CE business models (Pagoropoulos et al. 2017; Rosa et al. 2020) and analyse how the implementation of digital technologies enables incremental and radical sustainability and business model innovations (Ranta et al. 2021). Our study explicitly links digital technologies to the customer value by identifying the four roles of digital technologies in CE value creation. By doing so, the chapter has initiated a discussion for combining the customer value creation and CE principles; it has contributed to the literature on circular and sustainable business as well as to the literature on value creation, which have previously focused on the dynamics between the customer and provider (Aarikka-Stenroos and Jaakkola 2012; Grönroos and Voima 2013; Vargo and Lusch 2004) without explicit focus on the role of digital technologies.

For future research endeavours in the field of value creation in CE, we propose the following themes:

- The relevance of different roles of digital technology: Are all technology roles identified in this study equally relevant in other business environments?
- Customer-centric view on value realization: How is the customer's process of value realization and the customer's engagement with CE business models? Which technologies are used and how? Which actors participate in the value realization process?
- Processes with ecosystem actors: What kinds of roles do interactions with different ecosystem actors have in the creation of value potential or its realization in CE?

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