Developing a Capability Model for Circular Economy Implementation

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Award date:
2023

EINDHOVEN UNIVERSITY OF TECHNOLOGY

Department of Industrial Engineering & Innovation Sciences
Innovation Management

Master Thesis

Developing a Capability Model for Circular Economy Implementation

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in partial fulfillment of the requirements for the degree of
Master of Science in Innovation Management

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Eindhoven, December 2022

Abstract

A seismic shift from a linear to a circular economy is essential to reduce ecological pressure and enhance the security of primary raw material supplies. The rise of the circular economy urges organizations to reconsider their linear value chains and investigate their circular potential. To leverage this circular potential, organizations require capabilities. However, a comprehensive and empirically validated overview of relevant capabilities is scarce. This research adopts the design science research methodology to design a capability model that guides organizations in the circular transition. The proposed capability model presents a comprehensive and intuitively arranged set of capabilities for implementing circular practices, supporting organizations in assessing their capability base and navigating discussions. A systematic literature review and a Delphi study with domain experts were carried out to arrive at the proposed capability model. Focus groups with the anticipated end-users confirmed utility for assessing organizational capability bases and facilitating discussion on a capability base's state. This research contributes to the literature that seeks to investigate the circular economy in conjunction with capabilities.

Keywords: circular economy, capability model, capabilities, reference model.

Executive Summary

A radical transition from a linear to a circular economy is necessary to reduce ecological pressure and improve the security of primary raw material resources (Neves & Marques, 2022). In the circular economy, material and energy loops are slowed, closed, and minimized to reduce input resources, disposal, emissions, and energy loss (Geissdoerfer et al., 2017). By decoupling consumption from economic prosperity, the concept may be seen as an endeavor to counteract the ever-increasing scarcity of natural resources (Ghisellini et al., 2016; Manninen et al., 2018). For organizations to participate in the circular economy, the execution of concrete, circular-based actions is required (Castro et al., 2022).

To advance the adoption of circular economy practices, companies must abandon their long-held emphasis on the linear value chain (Fehrer & Wieland, 2021) and reevaluate how material value could be increased to minimize natural resource exploitation (Kraaijenhagen et al., 2016). This process necessitates appropriate organizational and managerial capabilities (Hopkinson et al., 2018; Sandkuhl & Stirna, 2018).

Although prior publications have investigated the role of specific capabilities in conjunction with different aspects of the circular economy, a comprehensive and empirically validated overview of capabilities for engaging in circular practices is scarce. This research addresses this gap by developing an empirically validated capability model for implementing circular practices. The remainder of this chapter elaborates on the adopted research methodology, the proposed model, its evaluation and the conclusion of this research.

Research Methodology

The design science research methodology of Peffers et al. (2007) is aligned with the maturity model development guidelines of Becker et al. (2009) for the construction of the proposed capability model. For confining the projected end-users, a distinction is made between groups that may take an interest in the circular economy capability model. On the one hand, a group that is interested in transitioning towards the circular economy (e.g., industry) and, on the other hand, a group that takes an interest in other parties transitioning to the circular economy (e.g., consultants and policymakers).

Concerning the process for developing and evaluating the model; first, a systematic literature review was conducted to provide insight into the essential and pertinent capabilities for implementing circular practices. From the findings of this review an initial model was synthesized that was further enhanced and extended through a three-round Delphi study with 11 domain experts from consultancies, governmental bodies, industry, and universities. This process yielded the proposed circular economy capability model. Finally, two focus groups with anticipated end-users were conducted to evaluate the capability model and, thus, to understand whether the predefined solution objectives were achieved.

Circular Economy Capability Model

The proposed capability model consists of four dimensions, 10 categories, and 32 capabilities accompanied by corresponding definitions. Figure 1 presents an overview of the model displaying its four dimensions at the center encircled by the 10 categories. Under each category, individual capabilities are allocated. An extended overview of the model and a link to the web version is available in Appendix C. The remainder of this section elaborates on the model's elements.

Figure 1: Circular Economy Capability Model

The **strategy** dimension comprises four categories: *corporate*, *reporting & compliance*, *organization*, and *circular ecosystem*. The *corporate* category concentrates on capabilities for developing a sound strategy, exhibiting social responsibility, and managing financial assets. The *reporting & compliance* category encompasses capabilities that relate to understanding and acting upon policies and regulations, developing appropriate indicators for assessing an organization's impact, and providing accurate information. The *organization* category is devoted to capabilities for managing an organization's resources, managing change within the value chain, and managing projects and processes. Last, the *circular ecosystem* category focuses on the capabilities for governance of the ecosystem and the establishment of partnerships.

The **people** dimension constitutes the *human resources* and *culture & leadership* category. The *human resources* category considers the capabilities involved with the recruitment, training, and retention of employees. The *culture & leadership* category shows capabilities related to the organization's culture, the commitment of leadership, and the configuration of teams.

The **business development** dimension includes the *circular business model* and *market & customer* category. The *circular business model* category portrays the capabilities involved with the experimentation and development of business models aligned with circular principles. The *market & customer* category exhibits capabilities connected to understanding and managing customer expectations and keeping track of market trends and developments.

The **business operations** dimension contains the *logistics & manufacturing* and *research & development* category. The *logistics & manufacturing* category describes the capabilities involved with designing, manufacturing, and distributing a circular product or service and managing accountability along the lifecycle. The *research & development* category reveals capabilities connected to improving and innovating products and services, managing and sharing knowledge, and learning by utilizing technologies.

Evaluation

The circular economy capability model was evaluated through the execution of two focus groups with the anticipated end-users. The focus groups yielded insight into the model's performance on four criteria: completeness, appropriateness, understandability, and usefulness. First, the model was assessed on its completeness. Participants perceived the model as generally complete, while it was explicitly commented that full completeness is considered improbable. Second, the appropriateness of the model was examined. Participants found the model missing a profound layer that elaborates on the implementation strategy for each capability and therefore less appropriate. Third, the understandability of the model was evaluated. The majority of the participants described the model as *"intuitive"* and *"clear"*; hence it was deemed understandable. Fourth, the usefulness for assessing an organization's capability base and developing strategies for improvement were considered. Participants recognized use for the model when assessing capability bases and facilitating discussions on the capability base's state. For developing improvement strategies, limited use was recognized. In conclusion, the results show that the circular economy capability model provides utility when assessing an organization's capability base and when facilitating dialogue for implementing or improving circular strategies.

Conclusion

To conclude, the proposed circular economy capability model represents a supportive instrument for organizations transitioning to the circular economy. The model demonstrates an exhaustive and intuitively arranged collection of capabilities for implementing circular strategies. The results indicate that the model has limited utility for assisting the improvement of circular strategies; instead, the model provides use for assessing an organization's capability base and facilitating discussion on the state of the capability base. Consequently, the research objective is concluded as partly satisfied.

Furthermore, this research contributes to the circular economy research domain by responding to an identified literature gap indicating a scarcity of empirically validated tools mapping capabilities for implementing circular strategies. In doing so, it provides an exhaustive up-to-date systematic literature review of capabilities for implementing circular strategies. Additionally, this research empirically advanced and evaluated the model which goes beyond the contribution of related work.

Finally, this research provides two implications for practice. As stated before, it can be used to assess and map an organization's capability base and it supports formative discussion regarding the distribution of responsibilities and an organization's readiness for advancing in circular practices. Organizations that implement circular strategies will be more sustainable and resilient in the future as they are increasingly being compelled to account for and justify their environmental impact. The circular economy transition requires inventiveness and a shift in focus to long-term objectives. Thus, management should wait no longer and act on the organization's circular potential.

Preface

Before you lies the master thesis "Developing a Capability Model for Circular Economy Implementation". It has been submitted in partial fulfillment of the Master Innovation Management and concludes my time at the Eindhoven University of Technology. This research aims to design a model that supports organizations in the challenging transition toward the circular economy. A topic that is perhaps more relevant than ever due to energy and natural resource supply insecurities. On this page, I want to thank the people who guided and supported me throughout this process.

To start, I would like to express my gratitude to my supervisor Dr. Baris Ozkan. Thank you for your excellent guidance, unquestionable support, and for making time for me during your holidays. Your feedback has been valuable and guided me in the right direction whenever I needed it. I also want to thank my second supervisor Dr. Duygu Keskin. Your constructive feedback has been essential to the final report.

Furthermore, I would like to thank my coach from PwC, Pranav Tewari, with your support and effort, I look back on a joyful and educational period that has been very valuable to me. I very much appreciate the warm adoption of the PwC Risk Assurance team that I experienced and the skiing trip is something that I will uphold in my memory.

Accordingly, I would like to thank everyone who participated in my research for their time and valuable inputs. Your effort has significantly contributed to the attained quality of the developed model. Moreover, you provided me with many insights and perspectives from which I have been able to learn.

Finally, as this thesis marks the end of my educational career, I would like to thank my friends and family for their presence and support. My friends have provided me with welcome distractions, and memorable moments that I will cherish forever. My family, whom I would like to especially thank, for their unconditional support and love that I received during these years.

Thank you, I hope you enjoy your reading.

Daan Jansen
Eindhoven, December 2022

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Chapter 1

Introduction

Sustainability and the circular economy are becoming more popular among academics, legislators, and industry experts (Geissdoerfer et al., 2017; Homrich et al., 2018; Pieroni et al., 2019). Sustainability intends a balanced combination of economic performance, social inclusion, and environmental resilience. The circular economy is frequently viewed as a technique for attaining sustainability with an emphasis on the economic and environmental aspects (Geissdoerfer et al., 2017; Pieroni et al., 2019). In the circular economy, material and energy loops are slowed, closed, and narrowed to reduce input resources, waste, emissions, and energy leakage. The concept can be understood as an initiative for combatting the ever-increasing scarcity of natural resources by decoupling consumption from economic growth (Ghisellini et al., 2016; Manninen et al., 2018). For organizations to engage in the circular economy, the implementation of concrete acts, often based on circular principles, is demanded (Castro et al., 2022).

Circular principles have received widespread acceptability from governments highlighting the need for businesses to alter their way of value generation (Wade et al., 2022). Policymakers developed circularity plans and legislation such as the "Green Deal" and "European Circular Economy Action Plan" commissioned by the European Union (European Commission, 2019, 2020) and the Chinese "Circular Economy Promotion Law" (Lieder & Rashid, 2016). Such legislative interventions force organizations to acknowledge the reality of finite resources and urge the redesign of linear 'take-make-use-dispose' practices (Geissdoerfer et al., 2017; Hopkinson et al., 2018; Nußholz, 2018).

Apart from legislative pressure, underlying advantages provide a rationale for organizations to implement circular strategies. Embracing circularity contributes to organizations' resilience and is accompanied by economic benefits (Hopkinson et al., 2018). For retail enterprises, adopting circular strategies increases long-term survivability chances (Uribe-Toril et al., 2022). In the food, construction, and mobility sector, cost savings from 40 to 60 percent can be achieved (Ellen MacArthur Foundation, 2012). Organizations can enhance their potential for service delivery, risk distribution, shared accountability, and profit from circular strategies through a business model that accounts for its inter-organizational network and collaborative partners (Parida & Wincent, 2019).

Circular principles, however, are still niche phenomena adopted by only a limited number of organizations within a small proportion of industries (Panwar & Niesten, 2020). Adopting these strategies remains challenging for many organizations due to the involvement of divergent disciplines (Kajikawa et al., 2014) and the required innovative concepts and actors (Ghisellini et al., 2016). Hence, many firms fail to leverage their circular potential (Khan et al., 2021). To foster the adoption of circular economy principles, organizations must transcend long-held emphases on the linear value-chain (Fehrer & Wieland, 2021) and reconsider how material value can be enhanced to reduce natural resource exploitation (Kraaijenhagen et al., 2016). This process often involves innovation and experimentation (Wade et al., 2022), requiring specific capabilities of organizations and managers (Hopkinson et al., 2018; Pieroni et al., 2019; Sandkuhl & Stirna, 2018).

Thus, organizations must develop and review their capabilities to facilitate the adoption and

improvement of circular principles. Capabilities enable businesses to gain a long-term competitive advantage by combining people, processes, and physical assets in novel ways (Wang & Ahmed, 2007). Conceptualizations and paradigms of the capability notion have been widely employed throughout the previous two decades (Sandkuhl & Stirna, 2018). In the business domain, academics and practitioners use the word to denote a skill that may persuade a company to undertake something (Balasubramanian et al., 2000). Generally, a capability is explained as the expertise to address objectives (Sandkuhl & Stirna, 2018) and, thus, inherently crucial for adopting circular principles. In some cases, adopting circular principles renders existing capabilities obsolete (Antikainen & Valkokari, 2016; Ghisellini et al., 2016), illustrating organization's challenges.

Some publications have investigated the role of specific capabilities in conjunction with different aspects of the circular economy. Nevertheless, an overview of capabilities for engaging in circular strategies is scarce. Prior studies have developed diverging models for the circular economy focusing on the role of capabilities within a specific industry (Chari et al., 2022; Kusumowardani et al., 2022) or in relation with specific concepts (Sehnem et al., 2022; Belhadi et al., 2022). Although circularity is widely understood from a technical point of view, most of what is published in business management literature relates to macro-level concepts, indicators, and business models (Wade et al., 2022). What is lacking is an overview of capabilities related to implementing circular principles (Kusumowardani et al., 2022). The latter is echoed by Panwar & Niesten (2020), who argue that understanding the required capabilities is fundamental for overcoming circular strategy implementation barriers. Consequently, the problem statement for this research is formulated as follows:

Problem statement:
In the last decade, the circular economy has become an increasingly important concept. Organizations are forced to cope with the reality of finite resources and must redesign their linear systems to implement circular practices. Research on the capabilities for implementing these practices has focused on specific industrial sectors or contributions of specific constructs. However, a comprehensive overview of relevant capabilities for implementing circular practices is scarce.

Responding to the increasing relevance of the circular economy, the literature gap, and the problem statement, this research aims to develop a circular economy capability model that builds on the characteristics of a reference model. Reference models accurately define an application domain and strive to provide a blueprint for an organization's environment; therefore, it promotes descriptive and prescriptive use (Frank, 2007). The descriptive use of the model should enable businesses to assess their capability base, while the prescriptive application should enable organizations to create improvement objectives and plans. It is believed that such a capability model contributes to the literature in its current advancement and provides guidance when implementing or improving circular strategies. Therefore, the research objective is formulated as follows:

Research objective:
Develop a circular economy capability model to support organizations with the implementation of circular strategies.

In this research, the design science research methodology was adopted to design a circular economy capability model that represents a helpful tool to practitioners. Within the transition toward the circular economy, the proposed model provides insights into the relevant capabilities for implementing circular practices and facilitates discussion. The remainder of this study is structured as follows: Chapter 2 provides the theoretical foundation for the discussed concepts, Chapter 3 elaborates on the adopted methodology, Chapter 4 and 5 demonstrate the activities for the development of the proposed model, Chapter 6 presents the circular economy capability model, Chapter 7 discusses the evaluation process, and Chapter 8 concludes this research.

Chapter 2

Theoretical Background

This section provides a theoretical underpinning for the proceeding of this work by elaborating on the capability concept, maturity models, circular strategies, and related work. First, the capability concept and its relevance and definition are discussed. Then, maturity models are explained as the capability model is built upon one of its elements. Third, circular strategies and prevalent circular economy principles are highlighted to elaborate on the focus of this research. At last, related work is discussed and the contribution of current work is positioned.

2.1 Capability Concept

The term 'capability' has been widely employed in research throughout the previous two decades and is often explained as the expertise to address objectives (Sandkuhl & Stirna, 2018). For developing the circular economy capability model, the capability definition from Wang & Ahmed (2007), which originates from the resource-based view is adopted. Following their definition, a capability can be considered an ordinary or a core capability. An ordinary capability is "the ability to deploy resources and attain a desired goal" (p. 36). In contrast, a core capability is defined as "a bundle of a firm's resources and capabilities that are strategically important to its competitive advantage at a certain point" (p. 36).

Throughout the last decades, organizations have been consistently forced to adapt, renew, reconfigure, and re-create their resources and capabilities to remain competitive. The focus on resources and capabilities as the foundation of competitive advantage is at the core of the resource-based view (Barney, 1991). This view proposes that enterprises may be considered collections of resources, that these resources are distributed unevenly, and that resource inequality sustains over time (Eisenhardt & Martin, 2000).

Extending the resource-based view to a 'dynamic' environment, where resource inequality does not persist and thus must be renewed to sustain competitive advantage, Teece et al. (1997) introduced the dynamic capabilities concept. The underlying organizational processes by which managers adapt their resources to develop new value-creating strategies are known as dynamic capabilities (Eisenhardt & Martin, 2000). Dynamic capabilities can be broken down into sensing, seizing, and reconfiguring capacities, supported by microfoundations representing a composition of diverse competencies, procedures, and organizational operations (Teece, 2007).

However, there has been much theoretical debate on dynamic capabilities as it is criticized for being contradictory, inconsistent, and vague (Wade et al., 2022). Wang & Ahmed (2007) argue that the concept has not converged to a shared definition, given the ambiguous usage and interpretation of the terminology, and aim to propose a hierarchical distinction between resources, capabilities, core capabilities, and dynamic capabilities. First, resources are the 'zero-order' element of the hierarchy and are, in dynamic environments, not considered a source of sustainable competitive advantage on their own. Second, ordinary capabilities are the 'first order' element and are considered interchangeable with skills and competencies. Third, core capabilities are men-

tioned as 'second order' element. Integrating resources and capabilities following a firm's strategic goals is central to building second-order core capabilities. Moreover, it is crucial to understand that core capabilities can become obsolete due to environmental changes (Leonard-Barton, 1992). Hence, fourth, dynamic capabilities represent the 'third-order' in the hierarchy as it emphasizes "a firm's constant pursuit of the renewal, reconfiguration, and re-creation of resources, capabilities, and core capabilities to address the environmental change" (Wang & Ahmed, 2007, p. 36).

As a result, for developing the circular economy capability model, this research takes guidance from the definitions of Wang & Ahmed (2007) and focuses on capabilities that can be considered either a core or an ordinary capability. This research will aim to incorporate both capability variations in the model and thus employs both definitions to identify a capability.

2.2 Maturity Models

This research builds on the notion of maturity models to develop the circular economy capability model. Maturity models are increasingly applied within information systems as an informed approach for continuous advancement (Mettler, 2011). This study focuses on developing the first component of a maturity model: a reference model. In line with the objective of this research, such a model represents a tool that assists organizations in understanding their capability base and deriving improvement objectives.

In the domain of Information Systems maturity models are considered instruments that enable benchmarking, highlight the potential for improvement, and offer guidelines throughout the process of organizational development and growth (Lasrado et al., 2015). The definition of maturity is "the state of being complete, perfect or ready" (Mettler et al., 2010, p. 334). Numerous variations of maturity models have have been developed since their introduction in research. The Capability Maturity Model is perhaps the most well-known maturity model (Mettler et al., 2010) and has been adopted over a wide range of problem areas (Lasrado et al., 2015).

Typically, a maturity model can act on a descriptive, prescriptive, and comparative basis during its lifecycle (de Bruin et al., 2005; Becker et al., 2009). To start, the model allows for comprehension of the current state of the domain hence the descriptive characteristic (Becker et al., 2009). Second, the model can become prescriptive as there is an understanding of the present situation and successive stages (de Bruin et al., 2005). The theory of proximal learning is the foundation for this argument (Uhrenholt et al., 2022). Last, when various organizations apply the model, adequate information may be acquired, allowing for a comparative purpose (de Bruin et al., 2005).

A maturity model comprises three elements (Salah et al., 2014): (1) reference model: a collection of dimensions that represent the core components that should be evaluated during an assessment; (2) performance scale: that enables evaluation of the performance of a specific component; (3) assessment procedure: that serves as a guide for assessors to capture the performance for a certain component.

The scope of this research is limited to developing the first element of a maturity model: a reference model. The purpose of reference models is to offer accurate descriptions of an application area. The objective of reference models, on the other hand, is to provide blueprints for designing information systems and associated organizational settings. Consequently, they are both descriptive and prescriptive (Frank, 2007). Descriptive, by aiding organizations to understand relevant capabilities. Prescriptive, by illuminating unanticipated capability areas that should be further developed or exploited and, thus, may provide ground for developing improvement strategies.

For the development of the reference model presented in this research, it was decided to build on maturity model development guidelines. Only three articles detail how to develop a maturity model's elements theoretically. To specify, Mettler (2011) identified that two apply a top-down (de Bruin et al., 2005; Becker et al., 2009) and one a bottom-up approach (Mettler et al., 2010). A bottom-up approach starts with developing assessment items and then defines the model structure, opposite to the top-down approach (Lasrado et al., 2015). Since a reference model does not contain assessment items, top-down maturity model development was adopted for this research.

Consequently, it was decided to apply the procedural model from Becker et al. (2009) as the authors follow the design science research development process in their guidelines.

2.3 Circular Strategies

The term *circular strategies* is adopted to refer to organizational endeavors with the underlying goal of implementing or improving circular economy principles. This term is applied to create a shared understanding concerning the efforts supported by the capabilities in the model.

The most prevalent characterization of circular economy principles comprises three activities, also referred to as the 3R principles: *reduce*, *reuse*, and *recycle* (Ghisellini et al., 2016; Reike et al., 2018). However, Kirchherr et al. (2017) inductively added the *recover* principle after an exhaustive analysis of circular economy core principles, leading to the 4R framework. As European legislators and policymakers adopt this framework (Kirchherr et al., 2017), this framework is assumed as a reference for circular principles. Below is a breakdown of the 4R framework presented.

- The *reduce* principle intends to reduce the use of primary energy, raw materials, and waste by increasing the efficiency of manufacturing and consumption processes (Ghisellini et al., 2016). An example would be maintaining or increasing the value of a good while minimizing its environmental effect. Increasing value and mitigating environmental effect value could be accomplished respectively by utilizing fewer resources per unit or replacing toxic compounds (Figge et al., 2014);
- The *reuse* principle relates to "any operation by which products or components that are not waste are used again for the same purpose for which they were conceived" (European Union, 2008, p. 10). Reuse is particularly attractive from an environmental point of view since it consumes fewer resources, less energy, and less labor than producing new products from raw materials (Ghisellini et al., 2016);
- The *recycle* principle is "any recovery operation by which waste materials are reprocessed into products, materials, or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations" (European Union, 2008, p. 10). Recycling allows the use of resources that are still usable and decreases the amount of waste that must be processed or disposed of, reducing the associated environmental effect (Ghisellini et al., 2016);
- The *recover* principle refers to "any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfill a particular function, or waste being prepared to fulfill that function, in the plant or in the wider economy" (European Union, 2008, p. 10). Recovery recognizes waste as a resource and contributes to the prevention of environmental impact. Hence it is an integral part of the circular economy as it encourages organizations to recover resources from waste by, for example, applying cutting-edge technologies (Ghisellini et al., 2016).

As such, this research focuses on capabilities that support the integration of the 4R principles in an organization. As the integration of these principles may require organizational proficiencies that are indirectly related to the principle itself, the term *circular strategies* is adopted. Circular strategies are defined as *"organizational endeavors that support the integration of one or more of the four circular economy principles"*. Hence, the objective of this research refers to the implementation and improvement of circular strategies.

2.4 Related Work

This paper contributes to the stream of research that aims to develop an artifact supporting organizations in the circular economy transition. A search was conducted in the Scopus and Web

of Science databases that identified four related works. Although these works made substantial contributions, this paper goes beyond what has been done. The contribution of the current research is demonstrated by summarizing and mapping prior work and highlighting this paper's contributions.

Belhadi et al. (2022) present a self-assessment model to evaluate and guide the integration of industry 4.0 technologies within the circular economy. The model allows for a system-level assessment of the integration of the circular economy and industry 4.0 approached from a dynamic capability perspective. A categorization of 'beginner', 'ongoing', and 'performing' can be derived from the results. As the study narrowed its focus to integrating industry 4.0 techniques within the circular economy domain, it deviated from current work.

Chari et al. (2022) examined how the dynamic capability theory may support circular and resilient supply chains. Literature was reviewed to identify capabilities that assist in developing resilient and circular manufacturing supply chains. The authors present three main findings: a dynamic capability model, causal relationships between capabilities, and validated propositions for resilient and circular supply chains. As the deployed search query in the review contained keywords focusing specifically on the manufacturing and supply chain domain, it deviates from the objective and anticipated outcomes of the current work.

Kusumowardani et al. (2022) developed a circular capability framework by studying growers, distributors, and retailers in the agri-food supply chain. Their research views food loss and food waste prevention through the circular economy lens and proposes a framework with capabilities relevant to tackling food loss and food waste. Current work differs from this study as it studies capabilities beyond the scope of food loss and food waste prevention.

Uhrenholt et al. (2022) developed a circular economy maturity reference model that links the progression of circular maturity to principles of expertise and the systems perspective. Their model aims to aid organizations in advancing their level of circular economy integration to a successive level. The study identifies organizational dimensions and defines corresponding maturity levels based on the microeconomic perspective. Current research differs twofold from this study; (1) it empirically evaluates the proposed model, and (2) it focuses explicitly on the capabilities that are relevant for the implementation of circular strategies rather than the organizational dimension.

As such, the current study is positioned within the capability model development research stream and offers multiple noteworthy advancements to the literature. Prior studies have developed diverging maturity and capability models for, among others, the agri-food sector (Kusumowardani et al., 2022) and circular supply chains (Chari et al., 2022). This research adopts a holistic approach to develop a generic circular economy capability model not limited by a specific type of industry or sector. Moreover, the circular economy capability model will be empirically evaluated. The empirical evaluation of such a model is novel compared to what has been done in related work. Therefore, this research's main contribution is developing a holistic circular economy capability model that is empirically evaluated.

2.5 Chapter Conclusion

This chapter elaborates on the theoretical foundations for developing the circular economy capability model. First, it discusses the capability concept by highlighting its origin and the adopted perspective in this research. As different views on the capability concept coexist, it was decided to take guidance from the definitions of a core and ordinary capability as defined by Wang & Ahmed (2007). Here it is argued that an ordinary capability represents "the ability to deploy resources and attain a desired goal" (p. 36). A core capability is understood as "a bundle of a firm's resources and capabilities that are strategically important to its competitive advantage at a certain point" (P. 36). Consequently, when developing the capability model, these definitions were considered.

Second, the notion of maturity models is discussed as it was decided to take guidance from maturity model development guidelines for developing the circular economy capability model. Generally, a maturity model consists of three elements (Salah et al., 2014): a reference model,

a performance scale, and an assessment procedure. This research aims to develop the foremost element: a reference model, and takes guidance from the procedural guidelines of Becker et al. (2009).

Third, the term 'circular strategies' is introduced to create a shared understanding regarding the efforts that the capabilities are supporting. For defining the term, the 4R Principles: *reduce, reuse, recycle,* and *recover* were adopted as a reference. As a result, circular strategies were defined as *"organizational endeavors that support the integration of one or more of the four circular economy principles"*. Thus, the circular economy capability model focuses on capabilities that support implementing circular strategies.

Finally, related works are identified to position the contribution of current work. Prior studies produced diverging capability and maturity models for various specific industries. However, it is understood that a holistic, empirically validated capability model is missing. This research aims to contribute to the existing body of literature by addressing this gap.

Chapter 3

Research Methodology

This research implements the design science research methodology as proposed by Peffers et al. (2007). Design science research addresses practical problems by developing artifacts to answer the identified problem (Hevner et al., 2004). An evaluated artifact represents the result of the design science research process. Any developed object with a constructed solution to a recognized research problem is considered an artifact (Peffers et al., 2007). In this research, the designed artifact is the circular economy capability model.

The methodology of Peffers et al. (2007) includes six stages: (1) identifying the research problem, (2) defining solution objectives, (3) design and development, (4) demonstration, (5) evaluation, and (6) communication. Since this research is triggered by an identified research problem addressed with the development of an artifact, it has a problem-centered initiation (Peffers et al., 2007). As the purpose of this study is to construct the first component of a maturity model, a reference model, it was decided to build on Becker et al. (2009)'s maturity model development guidelines, which adhere to the design science research methodology. An overview of the methodology, the aligned guidelines, and the adopted techniques is provided in Figure 3.1. The remainder of this chapter describes the approach for the methodological stages.

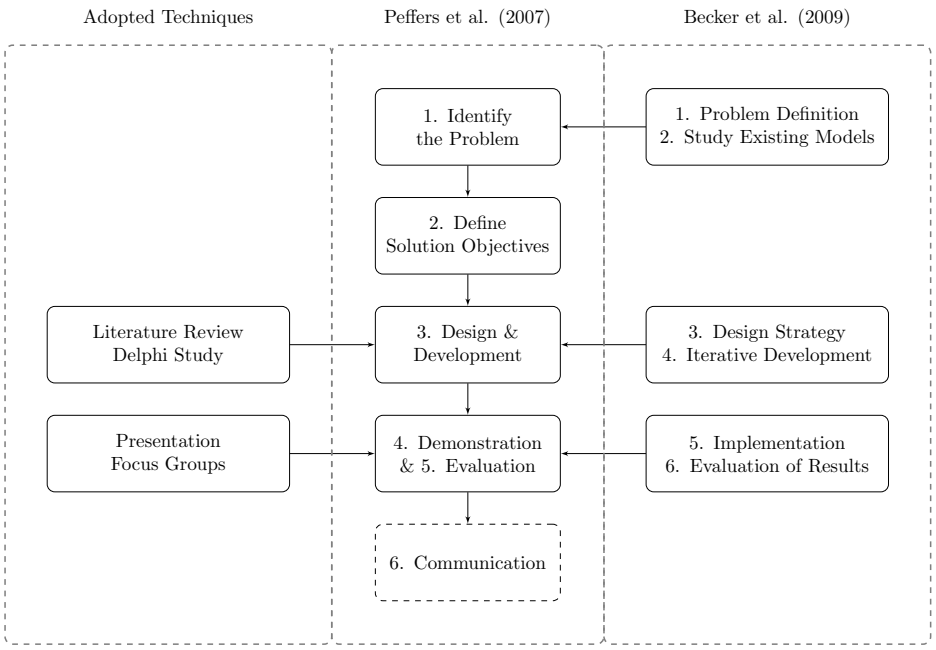


Figure 3.1: Research Design

3.1 Stage 1: Identify the Problem

The first step of this research relates to the identification of the problem. This step aligns with the first two guidelines of Becker et al. (2009): problem definition and the study of existing models. The introduction (Chapter 1) elaborates on the identified problem by providing a problem statement. It was concluded that the circular economy demands organizations to adapt their 'linear' practices while an overview of relevant capabilities for this transition is scarce. The theoretical background (Chapter 2) discusses prior works and existing models. It was deduced that prior studies developed diverging models for various industries; however, a holistic, empirically validated capability model is considered missing. This study intends to add to the current body of literature by developing a circular economy capability model.

3.2 Stage 2: Define Solution Objectives

This stage elaborates on the intended audiences and the instantiation of the solution objectives. For determining the intended audiences, a distinction is made between groups that may take an interest in the circular economy capability model. On the one hand, a group that is interested in transitioning towards the circular economy (e.g., industry) and, on the other hand, a group that is interested in others transitioning to the circular economy (e.g., consultants and policymakers). As the shift to the circular economy may require reorganizing capabilities and assets, executive and managerial positions may have the highest relevance from the industry perspective. As a result, the intended audiences are defined as executives, managers, consultants, advisors, and policymakers.

Subsequently, the model's self- and third-party-assisted application are foreseen. Organizations may internally apply the model through self-application, while consultants may utilize the model for a third-party-assisted application. Policymakers may use the model to identify areas where policies might be developed or improved to propel society toward the circular economy.

The solution objectives are derived from the inherent attributes of a reference model and the literature gaps. Reference models accurately describe an application area and aim to deliver a blueprint for an organizational setting; hence, it facilitates descriptive and prescriptive use (Frank, 2007). First, for an accurate description of the circular economy domain, the capability model should present the capabilities that support the implementation of circular strategies (SO1). Second, the model should be comprehensive and understandable for the intended audiences (SO2). Third, descriptive use of the model should allow organizations to assess their capability base (SO3). Fourth, prescriptive use should enable organizations to derive improvement objectives and strategies for enhancing their ability to implement circular strategies (SO4). Consequently, the following solution objectives were formulated:

SO1: The model should present a set of capabilities that support the implementation of circular strategies
SO2: The model should organize the capabilities in an understandable and comprehensive manner
SO3: The model should enable organizations to assess their capability base
SO4: The model should support organizations in their ability to improve circular strategies

Defining the solution objectives allows for determining the design strategy in the subsequent section and serves as input for evaluating the artifact.

3.3 Stage 3: Design and Development

The central part of this research describes the design and development process of the model. This stage is aligned with guidelines three and four of Becker et al. (2009): determining the design strategy and implementing an iterative development method. Concerning the determined strategy, it was decided to generate a comprehensive set of capabilities and organize them in an

understandable manner through a systematic literature review. Then, a Delphi study was deployed as an iterative development method.

A systematic literature review was conducted to elicit capabilities that support the implementation of circular strategies. A systematic review provides a fair assessment of a research topic by applying a reliable, rigorous, and auditable technique (Kitchenham & Charters, 2007). The review was employed to provide an answer to two research questions: (1) *"what capabilities do studies in the existing literature identify that support the implementation or improvement of circular strategies?"* and (2) *"to what dimensions and categories can capabilities that support the implementation or improvement of circular strategies be related?"*. Answering these questions provides the basis for synthesizing an initial capability model and, thus, represents the input for the iterative development method. Chapter 4 elaborates in-depth on the review and synthesis process.

A Delphi study was deployed to advance the capability model that yielded from the systematic literature review. As it is considered improbable that the literature review delivers enough information for a comprehensive model, it is recommended to consider exploratory research techniques for model advancement (de Bruin et al., 2005). The Delphi study is an exploratory research technique aiming to achieve consensus based on focus-group-based research (Ritchie et al., 2003). It is an established technique for improving and validating novel management models (Martinek-Jaguszewska & Rogowski, 2022) and is considered appropriate for solution development (Ritola et al., 2022). Additional advantages are anonymity, which encourages honest responses, quickness and efficiency, and flexibility, as it can be conducted remotely (Brown, 2018).

The Delphi technique is considered appropriate and valuable when the research is: (1) addressing a complex issue where knowledge is required from people that are informed about the political, social, and economic challenges (Okoli & Pawlowski, 2004); (2) combining perspectives to perform decision-making (Hasson et al., 2000); and (3) developing a concept or model (de Bruin et al., 2005). The consideration of the circular economy as a complex domain that involves different socio-economic perspectives and the absence of empirically validated models promote the suitability of the Delphi technique for this research. Over a hundred definitions of circularity have been cataloged, resulting in the word having diverse meanings for many individuals (Kirchherr et al., 2017). Therefore, the circular economy is a complex concept involving diverse perspectives from different stakeholders. By performing a Delphi study, these perspectives were combined for decision-making. The procedures and results of the Delphi study are reported in Chapter 5.

3.4 Stage 4 and 5: Demonstration and Evaluation

In this section, the steps for the evaluation of the artifact are discussed. The evaluation should examine whether the model yields the anticipated benefits and provides a solution to the identified issue (Hevner et al., 2004). The demonstration and evaluation stage are aligned with the implementation and evaluation of results guidelines (Becker et al., 2009). Presentations with focus groups were performed to demonstrate and evaluate the model.

This study builds on the evaluation strategy of Venable et al. (2016), which is an appropriate evaluation technique for design science research. Their strategy consists of four steps: (1) elucidate the evaluation goals, (2) select the most suitable evaluation approach, (3) determine the properties that should be evaluated, and (4) design strategies to assess the individual properties.

- The goal of the evaluation (step 1) is to demonstrate whether the solution objectives have been satisfied. In other words, it should be revealed whether the proposed artifact is complete, comprehensible, and helpful for assessing a circular capability base and developing improvement strategies;
- The chosen evaluation strategy (step 2) is based on a summative and ex-post approach. A summative approach assesses to what degree the artifact matches the expectations and is commonly applied at the end of the evaluation process (Venable et al., 2016); hence, an ex-post approach was adopted. For the evaluation, an approach was adopted that corresponds with

the characteristics of a naturalistic and artificial summative evaluation approach. Naturalistic, as the evaluation was conducted with the actual anticipated end-users and, artificial, as the evaluation took place within an artificial scenario. With naturalistic evaluation, the performance of the artifact is explored within its natural application environment and provides a higher face validity while assuring rigorous assessment (Venable et al., 2016). In contrast, artificial evaluation assures that the perceived performance can be devoted to the artifact, not external factors (Venable et al., 2016);

- Four properties for evaluation were derived (step 3) from the solution objectives. Prat et al. (2015) propose a taxonomy for evaluating design science research artifacts. From the criteria for evaluating an artifact's 'structure', *completeness* and *understandability* were derived. From the taxonomy's 'people' branch, the *usefulness* criterion was adopted. Alternatively, criteria for evaluating reference models by Frank (2007) were considered leading to the adoption of the *appropriateness* criterion.

  The properties derived from the first solution objective are *completeness* (Prat et al., 2015) and *appropriateness* (Frank, 2007). As the model should present the supporting capabilities for actualizing circular strategies, it should fully encompass the circular economy domain. Moreover, the identified dimensions, categories, capabilities, and definitions should be of appropriate depth and relevant to the circular economy domain. For the second objective, *understandability* (Prat et al., 2015) is recognized as a crucial property of the artifact. For solution objectives three and four, *usefulness* (Prat et al., 2015) was identified as property. Table 3.1 provides an overview of the criteria connected to the solution objectives (SO);

Table 3.1: Evaluation Criteria

SO	Criterion	Definition
SO1	Completeness	the degree to which the model's structure contains all necessary elements (Prat et al., 2015).
SO1	Appropriateness	the degree to which the model stresses an appropriate level of detail (Frank, 2007).
SO2	Understandability	the degree to which the model can be comprehended, both at a global level and at the detailed level of the elements (Prat et al., 2015).
SO3	Usefulness	the degree to which the model positively impacts the assessment of an organization's capability base (Prat et al., 2015).
SO4	Usefulness	the degree to which the model positively impacts an organization's ability to improve circular strategies (Prat et al., 2015).

- For the evaluation of the identified properties, two focus groups were conducted (step 4). Focus groups are a credible and rigorous evaluation method and can be effectively employed to assess the usefulness of the artifact (Tremblay et al., 2010). It was decided to conduct two focus groups aligned with the identified audiences. The first group included prospective end-users from consultancies and governmental bodies, and the second focus group consisted of prospective end-users from the industry. Further information on the execution of the focus groups is reported in Chapter 7.

3.5 Chapter Conclusion

This chapter elaborates on the design stages of the current research. In the first stage, the identified problem and existing works are summarized. The second stage discusses the instantiation of the solution objectives and the intended audiences for the artifact. The third stage describes the design and development process to arrive at the proposed artifact. Last, stages four and five discuss the

demonstration and evaluation procedures to which the artifact was subject. The circular economy capability model was presented and evaluated by completing the subsequent stages. The next chapter will start the third stage by elaborating on the systematic literature review that was conducted.

Chapter 4

Systematic Literature Review

In literature, many publications focus on circular strategies, while an up-to-date overview of capabilities for engaging in such strategies is scarce. Although circularity is widely understood from a technical point of view, most of what is published in business management literature relates to macro-level concepts, indicators, and business models (Wade et al., 2022). What is lacking is an understanding of capabilities related to adopting circular strategies (Kusumowardani et al., 2022). The latter is echoed by Panwar & Niesten (2020), who argue that understanding the required capabilities is fundamental for overcoming circular strategy implementation barriers. Therefore, a systematic literature review was employed to provide the basis for developing an initial capability model. A systematic literature review offers an appropriate assessment of a research topic by employing a consistent, rigorous, and transparent methodology (Kitchenham & Charters, 2007). This literature review aims to present capabilities that support the implementation or improvement of circular strategies in an initial model. Based on this objective, two research questions were formulated:

1. What capabilities do studies in the existing literature identify that support the implementation or improvement of circular strategies?

2. To what dimensions and categories can capabilities that support the implementation or improvement of circular strategies be related?

The remainder of this chapter is as follows. First, studies related to this review are discussed in the related work section. Then the deployed search strategy is elaborated, and the general findings are discussed. Accordingly, the development process of the initial model is elaborated, and the individual elements of the model are discussed. Finally, an overview of the initial capability model is presented.

4.1 Related Literature Reviews

This systematic literature review adds to the research stream investigating the circular economy in conjunction with capabilities. Although earlier publications made substantial contributions, this work goes beyond what has previously been done. The latter is demonstrated through outlining and mapping the contributions of previous related work and emphasizing the contribution of this research. Publications that performed systematic reviews on capabilities in the context of the circular economy were considered related work. A methodological search was deployed using the Scopus and Web of Science databases to identify related work. The executed protocol for this search is illustrated in Figure 4.1 and starts with developing the search query.

The keywords *"circular"* and *"capabilities"* connected with the *"AND"* operator, together with keywords that indicate the execution of a systematic literature review, represented the search query. Publications that performed a systematic review of the literature to identify circular

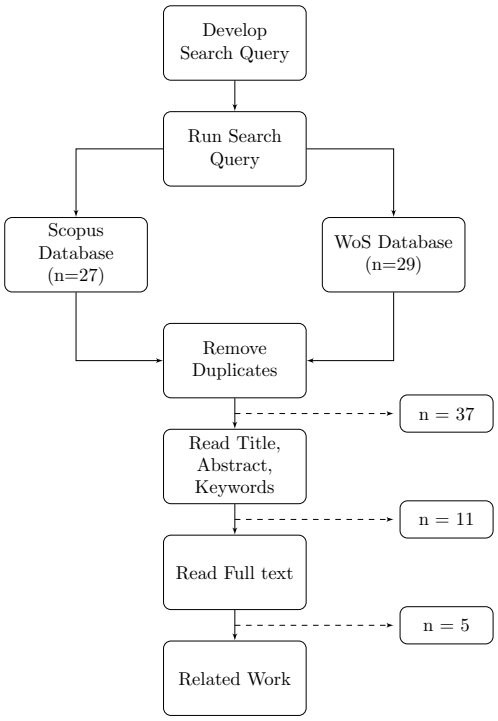


Figure 4.1: Systematic Approach for Identification of Related Literature Reviews

economy-related capabilities were included. Details of the conducted search are presented in Table 4.1. The identified papers along with the contributions of this work are discussed below.

Table 4.1: Specifications of Search for Related Work

Feature	Specification
Search query	*(circular AND capabilities AND ("literature review" OR "systematic review" OR "systematic literature review"))*
Inclusion criteria	Articles that systematically review literature for capabilities related to the implementation of circular strategies
Databases	Scopus and Web of Science

Bertassini et al. (2021) investigated the relationships between the circular economy and organizational culture by performing a systematic review. Their findings were presented in a framework consisting of five building blocks (mindsets, values, behaviors, capabilities, and competencies) that must be developed to create a culture focused on the circular economy. To guide the development of these blocks, the authors propose a leadership agenda comprising required activities and competencies. The current work extends its focus beyond organizational culture.

Ingemarsdotter et al. (2019) analyzed how businesses implemented internet of things (IoT) for circular strategies and how these implementations relate to the prospects previously forecasted. Building on the literature, the authors present a framework that clusters IoT-enabled circular strategies based on IoT capabilities and circular strategies. The scope of the current work, however, goes beyond IoT capabilities and IoT-enabled strategies.

Lopes de Sousa Jabbour et al. (2019) highlighted how operations management knowledge could facilitate businesses' transition toward the circular economy. To support managers on their journey towards the circular economy, the authors identify the required adjustments to operations management decision-making in terms of capabilities, work processes, relationships, and technology. The most crucial decision-making factors have been emphasized and analyzed, together with

how these decisions may support circular principles. At last, the skills that practitioners should acquire to enhance business alignment with circular strategies were defined. Although valuable, the focus of the current work is broader than operations management activities.

Seles et al. (2022) adopted the resource-based view, capability theory, and dynamic capability perspective to assess the enablers of the circular economy as portrayed in the literature. The authors deployed a systematic literature review and categorized the enablers among dimensions presented in an overview allowing businesses to identify the required resources and competencies while maximizing those they currently possess. Among the related work, Seles et al. (2022) provide the most comprehensive framework by identifying 18 capability categories allocated to three dimensions (management and people; structure, product, and process; and relationship with stakeholders). Other related studies developed frameworks that provide less holistic and more demarcated presentations of dimensions and categories. Nevertheless, as the systematic literature review of the paper was performed in February 2020 and the number of publications in the circular economy research field is rising fast (Ferasso et al., 2020), current work contributes by including recent work and by applying a deviating keywords combination. Furthermore, the current work aims to empirically validate the model, which is beyond the scope of this publication.

Sehnem et al. (2022) reviewed the conceptual framework of the circular economy and innovation constructs within the circular economy research field. This study improved comprehension of innovation-triggered consequences of adjustments in favor of a circular economy. To illustrate, the authors argued that the support and development of infrastructures and solutions could be seen as the primary functions of innovation when shifting from a linear to a circular business model. As a result, innovation can bring alternative approaches to manufacturing, waste management, value retention, commercialization, customer interaction, and after-sales activities. As this research examines explicitly and advances the understanding of the role of innovation within the circular economy, its purpose differs from the current study.

Current literature review offers multiple noteworthy advancements beyond what prior related literature has achieved. It provides an update on the advancements made so far compared to when prior reviews were performed. The latter is especially relevant since the number of articles published in the circular economy research domain has rapidly increased in the last decade (Geissdoerfer et al., 2017). Furthermore, this study takes a broad focus and holistic approach by not posing constraints for a specific construct or type of circular strategy. This is in contrast with studies such as Lopes de Sousa Jabbour et al. (2019), Bertassini et al. (2021), and Sehnem et al. (2022), where the relevance and influence of a specific construct on the implementation of circular strategies is assessed. By analyzing, combining, and synthesizing the current state of segregated knowledge, this study goes beyond what has previously been done.

4.2 Review Methodology

This systematic literature review followed the guidelines from Kitchenham & Charters (2007) that support the construction of a rigor review. According to the authors, the most important steps to undertake are: developing a research protocol, defining the research questions, defining the search strategy, determining the selection strategy, and defining the data to be extracted. Building on these guidelines, a protocol for this review was defined and documented, as displayed in Figure 4.2. The remainder of this section discusses the protocol-driven steps that were taken to extract and synthesize relevant data from literature.

The introduction of this chapter elaborates on the identified research problem (step 1) and subsequently introduces the formulated research questions (step 2). In short, an holistic overview of capabilities that support integrating circular strategies is considered scarce. For addressing this 'gap', two research questions were defined: (1) *"what capabilities do studies in the existing literature identify that support the implementation or improvement of circular strategies?"* and (2) *"to what dimensions and categories can capabilities that support the implementation or improvement of circular strategies be related?"*.

As the search was facilitated by electronic resources, the dominant process for obtaining liter-

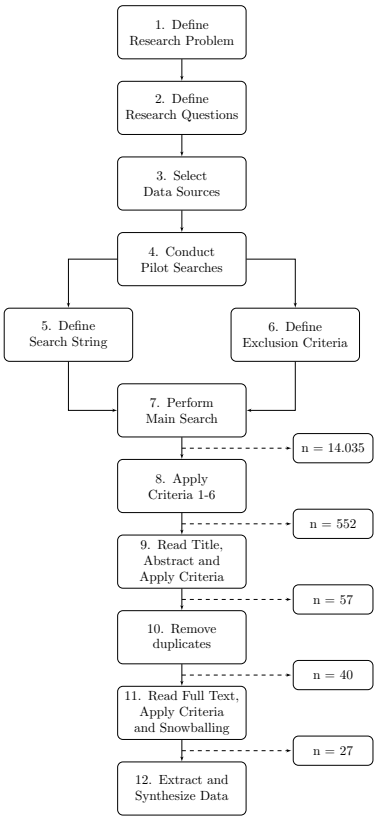


Figure 4.2: Systematic Literature Review Protocol

ature (Okoli, 2015), step 3 focuses on selecting the data sources. The databases were selected by analyzing previously conducted literature reviews focusing on circular strategies or capabilities, complemented by databases covering business or environmental research areas recommended by Kitchenham & Charters (2007). The analysis of priorly conducted reviews (Appendix A.1) shows that nearly all review papers included the Scopus and Web of Science databases as sources for their literature review. This finding is in line with Chadegani et al. (2013), who argue that Scopus is one of the most comprehensive databases. Since the Scopus database includes research published in Elsevier, Emerald, Springer, and Wiley (Parida, Sjödin & Reim, 2019), the list of databases was narrowed down to Scopus and Web of Science. Although Google Scholar may assist in retrieving articles and discovering grey literature, it was excluded as the results are based on prior search queries and, therefore, are not replicable (Kraus et al., 2020). By performing pilot searches (step 4), the search query was developed by connecting the term circular and capabilities with the boolean AND operator, which led to the following search query: *"circular AND capabilities"* (step 5).

The exclusion criteria (step 6) were guided by the research questions and further developed with pilot searches. Since the Ellen MacArthur Foundation published the influential report (Geissdoerfer et al., 2017; Kirchherr et al., 2017; Lieder & Rashid, 2016) on the circular economy in 2012 (Ellen MacArthur Foundation, 2012), this year was selected as the cut-off point for studies. The pilot search verified that the criteria were suitable for consistent application and appropriate classification. Apart from criteria concerning the language and type of publication, this search led to the development of additional criteria. Technical articles on chemistry, mathematics, material science, and construction were excluded. Articles that discussed capabilities but not the implementation of circular strategies were also excluded. To illustrate, Bekrar et al. (2021) and Centobelli et al. (2021) examined capabilities relevant to integrating blockchain technology in circular supply chains. All applied criteria are displayed in Table 4.2.

Table 4.2: Exclusion Criteria for Literature Review

	Criterion
1	Exclude publications in languages other than English
2	Exclude publications published before 2012
3	Exclude publications in the grey literature
4	Exclude publications with subject areas such as architecture, chemistry, biology, material science, computer science, astronomy, mathematics, health, construction, physics, pharma, and robotics
5	Exclude publications from the following journals: scientific reports, aerospace science and technology, journal of microelectromechanical systems, IEEE transactions on aerospace and electronic systems, and Plos one
6	Exclude publications with no relation to the circular economy, circular strategies, or circular principles
7	Exclude publications that do not discuss or present capabilities in the context of circular strategies

The search query was applied to the title, keywords, and abstracts of the publications in the databases, which yielded over 14.000 results (step 7). The first six exclusion criteria were applied within the online environment of the electronic databases (step 8), reducing the number of publications to 552. Examining the titles, abstracts, and keywords from the remaining papers (step 9), allowing the application of criteria seven and eight, reduced the number to 57 publications. Accordingly, duplicates were removed (step 10), which left 40 publications that were examined by their full text (step 11) to see if they matched the criteria. This process resulted in a selection of 25 papers to which the backward and the forward snowballing process was applied. Backward snowballing refers to examining the reference list for new publications, while forward snowballing examines the publications that cite the paper (Wohlin, 2014). In total, 27 articles were selected for inclusion. Table 4.3 provides an overview of the selection procedure.

Table 4.3: Application of Exclusion Criteria and Snowballing Method

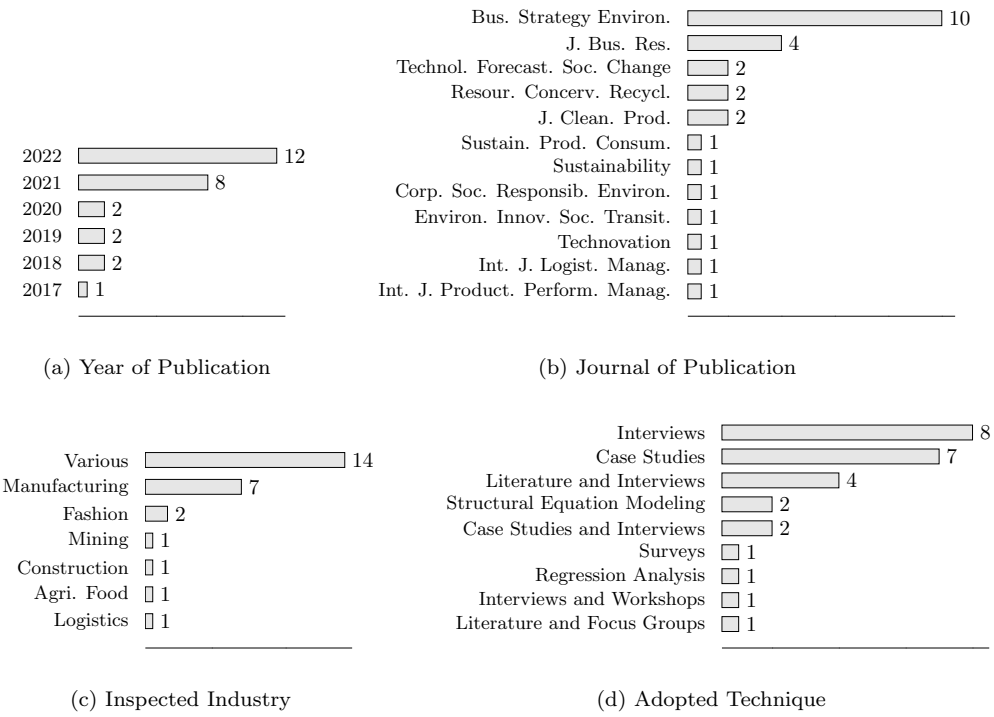
	Scopus	Web of Science	Total
Search: *"circular AND capabilities"*	7947	6088	14035
Apply criteria 1	7597	6043	13640
Apply criteria 2	4812	4238	9050
Apply criteria 3	3302	3316	6618
Apply criteria 4	786	379	1165
Apply criteria 5	316	379	695
Apply criteria 6	227	325	552
Read titles, abstract and keywords			
Apply criteria 7	114	250	364
Apply criteria 8	22	35	57
Remove duplicates			40
Read full text			
Re-apply criteria			25
Apply snowballing			27

The extraction and synthesis of the data represent step 12 of this review. The articles were examined for capabilities with an extraction template (Appendix A.2). This examination provided an extensive overview of capabilities with related definitions, dimensions, categories, and contexts. Accordingly, each capability was interpreted and, in some cases, rewritten to develop a coherent formulation structure. As discussed in the related work section, Seles et al. (2022) provide a comprehensive framework used as a starting point for data synthesis. Building on this framework, the constant comparative technique (Glaser & Strauss, 1967) was adopted to develop distinctive categories by coding and analyzing data simultaneously. This frequently applied research technique

builds on the principles of inductive reasoning (Grove, 1988). When applying this technique, capabilities were interpreted and intuitively allocated to categories and dimensions of the existing framework of Seles et al. (2022). In some cases, however, it was decided to reformulate an existing, or develop a new, category or dimension. As the analysis iteratively progressed, categories became more apparent, and intuitive distinctions were made, which yielded an initial model consisting of four dimensions and 12 capability areas.

4.3 General Findings

This section elaborates on the profile of the 27 studies (Appendix A.3) from the systematic literature search. Inspection of the publication years shows that the studies were published between 2017 and July 2022, as shown in Figure 4.3a. Moreover, the figure shows that most included studies were published after 2020. Among the included journals, Business Strategy and the Environment and Journal of Business Research provide most of the publications, as illustrated in Figure 4.3b. In terms of sectors and industries, Figure 4.3c displays the focus of the publications. Most publications did not focus on a single industry and obtained information from various industries in their study. Alternatively, the figure illuminates that the manufacturing industry gained much attention from scholars. At last, Figure 4.3d sheds light on the techniques adopted by the studies to arrive at the proposed capabilities. Figure 4.3d highlights that most studies performed either interviews or case studies.



(a) Year of Publication

(b) Journal of Publication

(c) Inspected Industry

(d) Adopted Technique

Figure 4.3: Profile of the Primary Studies

4.4 Development of the Initial Model

To address the first research question of this literature review, the publications were analyzed and the results were documented, yielding an extensive list of capabilities that support the implementation or improvement of circular strategies. In total, 318 capabilities were identified from primary studies that fit the description of a (core) capability. In addition, related work was analyzed for capabilities, and if not included by primary studies, these were added to the capability list.

As the capabilities are divergently formulated in the analyzed studies, all capabilities were interpreted and, in some cases, rewritten to develop a coherent formulation structure that allows for comparison. To illustrate, Kristoffersen et al. (2021) formulated a capability as 'Bundling' in the context of datasets, while Prieto-Sandoval et al. (2019) formulated a capability as *"Develop effective green marketing to open new markets"*. Such difference in formulation hampers comparison; hence the 'Bundling' capability was interpreted and reformulated to *"Bundle or enrich existing datasets within the firm"*. This coherent formulation structure allowed for comparison and analysis.

The second research question of this literature review was addressed by building on the priorly established framework of Seles et al. (2022) and applying the constant comparison technique. This way, capabilities were grouped and categorized, yielding a draft of the initial framework. Capabilities were interpreted, compared, and intuitively allocated to categories and dimensions of the established framework. In this process, the initial elements of the framework were modified to assign the capabilities to intuitive categories or dimensions. As the analysis iteratively progressed, elements became more apparent, and a first draft of the capability model was developed.

When the capabilities were allocated to dimensions and categories, identical capabilities were then merged. For example, the development of a 'vision for sustainability' is a capability that was merged as it was articulated by Khan et al. (2020), Elf et al. (2022), Sumter et al. (2021), Kristoffersen et al. (2021), and Santa-Maria et al. (2021). This process yielded a draft of the initial model with 285 capabilities allocated to 12 categories distributed over four dimensions. Each study's relative contribution to the model's corresponding dimensions is visualized in the alluvial diagram (Figure 4.4) that was created with the Python programming language (Srinath, 2017). The diagram includes the primary studies of this review complemented by secondary studies and displays its allocation to a specific dimension.

4.4.1 Synthesis of Capabilities

New capabilities were synthesized to ensure comprehension of the model. The vast number of capabilities and the intersecting definitions provided a rationale for defining and formulating new capabilities that can be comprehensively presented in a model. Within the defined categories, capabilities that focused on similar subjects were consolidated, and a definition was formulated. As an example, 'Regulatory compliance' was synthesized with the definition *"the ability to comprehend, anticipate, and comply with the regulatory landscape"* from the capabilities of the draft model depicted in Table 4.4. It should be noted that, in this specific example, the capabilities emerged from a single source. This inductive process led to the development of 34 new capabilities with corresponding definitions adopted in the initial model. As such, the initial model comprises four organizational dimensions, 12 capability categories, and 34 capabilities and represents the tangible result of the review.

Table 4.4: Example of Capability Synthesis

New capability	Capabilities	Sources
Regulatory compliance	Comply to environmental policies and certificates	Jayarathna et al. (2022)
	Anticipate and respond to changes in regulation	Santa-Maria et al. (2021)
	Develop and comply to CE-relevant standards and certifications	Fernandez de Arroyabe et al. (2021)
	Comprehend regulatory landscape	Sousa-Zomer et al. (2018)

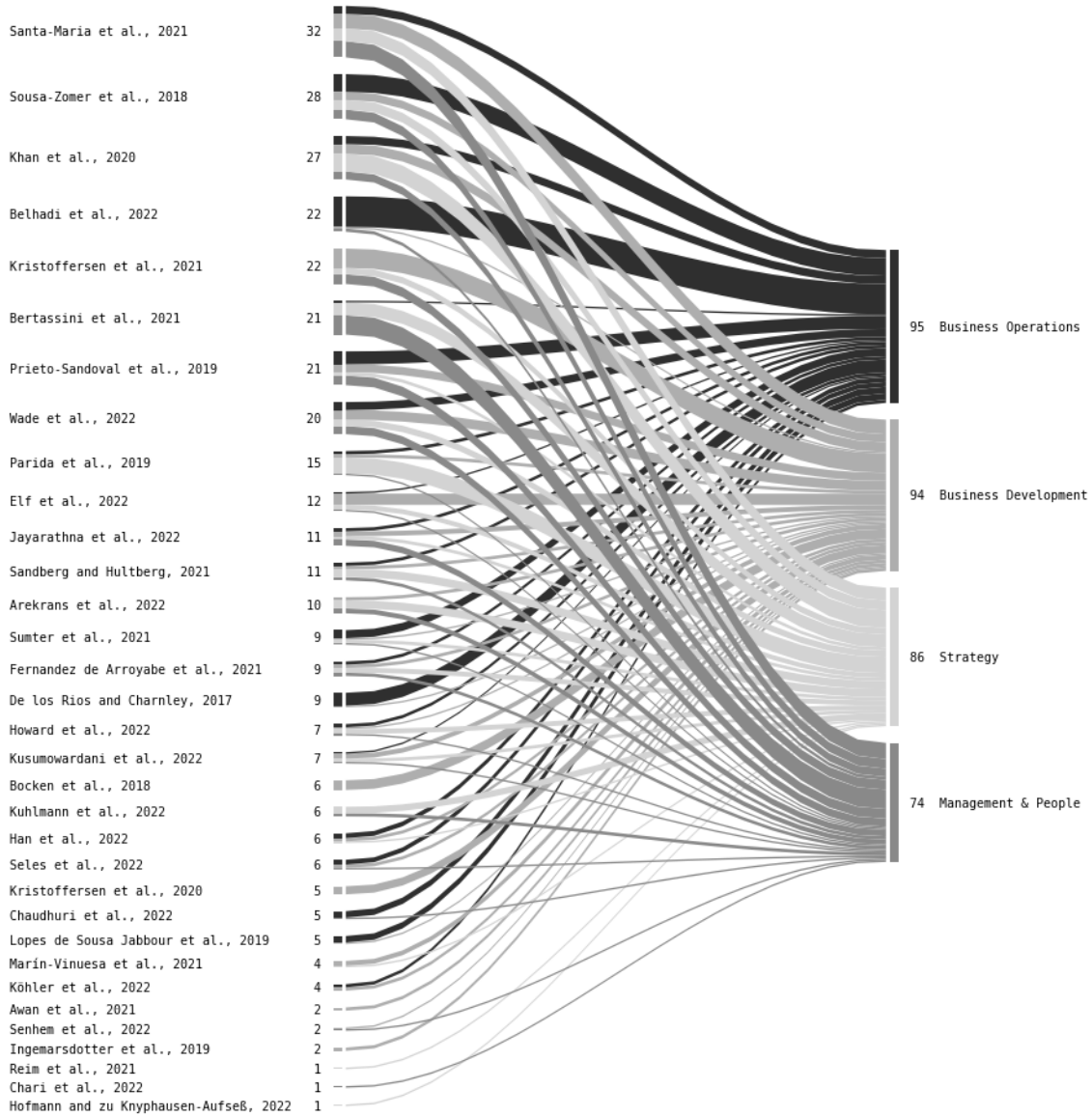


Figure 4.4: Alluvial Diagram of Authors' Relative Contribution

4.5 Overview of Initial Capability Model

In this section, an overview of the initial capability model is presented. Figure 4.5 portrays the capabilities of the initial model structured according to the allocation to overarching categories and dimensions.

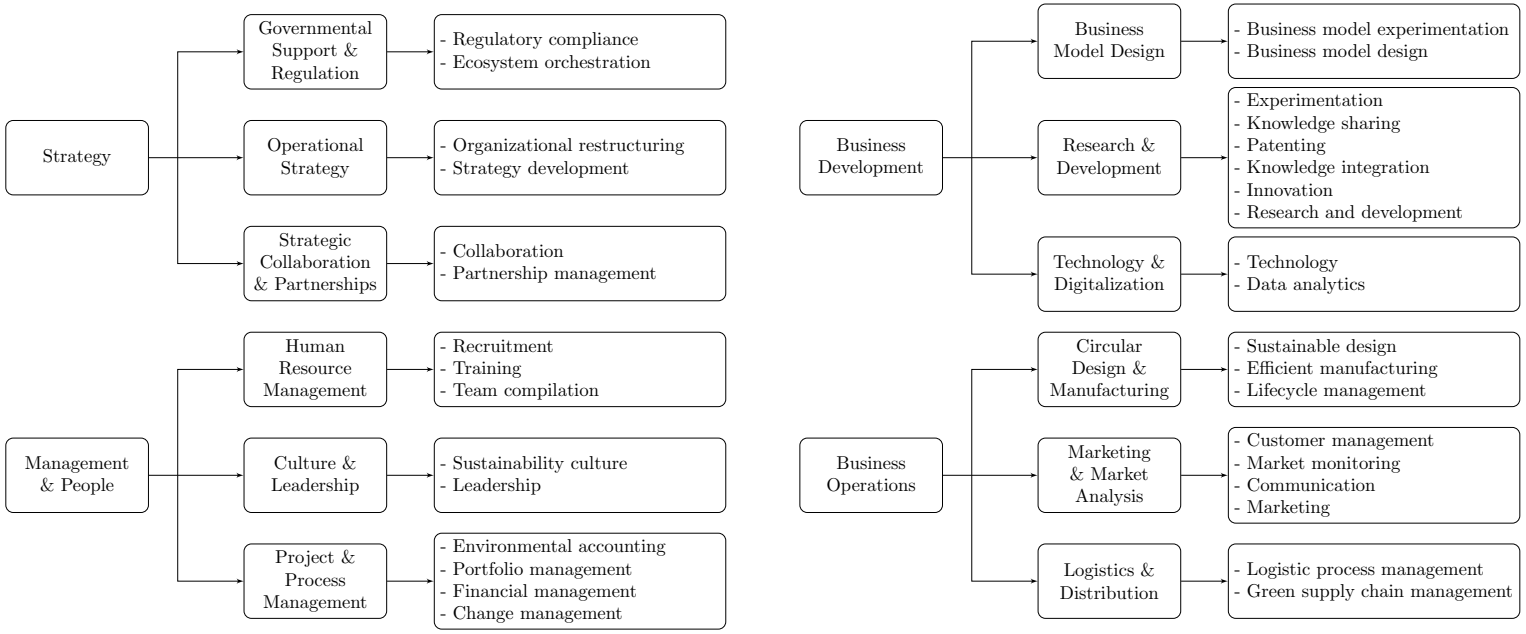


Figure 4.5: Initial Circular Economy Capability Model

4.6 Elements of Initial Capability Model

This section elaborates on the synthesized model elements by outlining the content of the dimensions, categories, and capabilities synthesized from the systematic review. A category is regarded as a collection of capabilities inductively clustered based on the content of the capability. Similarly, a dimension represents of a group of categories that are arranged based on the category's content. This section is structured according to the four dimensions of the initial model.

4.6.1 Strategy

Three capability categories are allocated under the strategy dimension. First, *governance support and regulation* focuses on compliance and ecosystem orchestration. Second, *operational strategy* concerns organizational reconfigurations and the development of a sound strategy. Last, *strategic collaborations and partnerships* as these must be developed since many organizations depend on external resources or capabilities.

Governance Support and Regulation

- **Regulatory compliance** - Comprehending and complying with regulations and policies is believed to benefit businesses in the circular economy. Extended producer responsibility, eco-label requirements, and carbon taxation are examples of environmentally focused policies that may encourage industry-wide partnerships and sustainable innovation in businesses (Santa-Maria et al., 2021). Complying with environmental policies and certificates enhances the company's reputation and helps it remain viable (Jayarathna et al., 2022). Moreover, comprehension of the regulatory landscape is required to meet the legal requirements for novel and innovative payment and asset ownership constructions (Sousa-Zomer et al., 2018). Therefore, the *regulatory compliance* capability was derived with the following definition: *the ability to comprehend, anticipate, and comply to the regulatory landscape.*
- **Ecosystem orchestration** - Orchestration of the circular ecosystem is considered relevant when aiming for policy changes, developing business sector objectives, and aligning incentives and investments. When aiming for policy change, more pressure on policymakers can be exercised when collaborative networks or partnerships within the ecosystem are formalized and represent the voice of an industry rather than an individual organization (Sandberg & Hultberg, 2021). Moreover, the transition to the circular economy forces organizations to adapt their business models and strategies while also persuading their ecosystem partners to accompany them in the circular economy transition (Parida, Burström et al., 2019). In this way, business sector objectives can be clearly defined (Howard et al., 2022) and rules for circular ecosystem established (Parida, Burström et al., 2019). Consequently, routines to orchestrate collaboration with partners in the ecosystem to design logistic processes are considered part of a mature ecosystem (Reim et al., 2021). As a result, the *ecosystem orchestration* capability was identified with the following definition: *the ability to create, govern and improve sustainable business ecosystems.*

Operational strategy

- **Organizational restructuring** - Organizational restructuring is essential in pursuing the circular economy (Khan et al., 2020). This includes the integration, planning, and modification of organizational structures. Examples of the restructuring of assets are the abandonment of a subsidiary, acquisition of a firm, addition of a new facility (Khan et al., 2020), and development of business units and formal procedures (Bertassini et al., 2021). In some cases, changing the governance structure (e.g., restructuring the board of directors) is required to foster collaboration (Khan et al., 2020). Following these competencies, the *organizational restructuring* capability is defined as *the ability to evaluate, prioritize, and adapt organizational resources and competencies.*

- **Strategy development** - The development of a sustainable strategy is recognized as a fundamental activity in the circular transition. Activities related to the formalization and execution of such strategy comprise integrating sustainability into the organization's core, acquiring knowledge regarding strategy development (Chari et al., 2022), and prioritizing resources (Santa-Maria et al., 2021). To fully integrate circular economy goals, organizations should develop a sustainable strategy aligned with the organizational culture (Bertassini et al., 2021). Strategy development also includes the development of growth strategies as scaling plays a decisive role in the transition to circular practices (Sandberg & Hultberg, 2021). Moreover, developing, adapting, and articulating a clear and ambitious vision are recognized as practices that guide organizations (Santa-Maria et al., 2021; Elf et al., 2022) and represents a catalyst for organizational change (Elf et al., 2022). This process involves motivating employees with a vision of how the organization should appear in a circular state and integrating the perspective of stakeholders (Bertassini et al., 2021). Adopting a proactive sustainable strategy and vision is believed to fuel innovation (Khan et al., 2020), and thus, the circular transition. As a result, the *strategy development* capability was identified with the following definition: *the ability to develop and communicate a strategic roadmap for the circular transition.*

Strategic Collaborations and Partnerships

- **Collaboration** - Organizations should collaborate across the value network to accelerate the shift to the circular economy (Sumter et al., 2021). The rationale for this necessity is that the circular transition demands communication and coordination among the network of stakeholders (Bertassini et al., 2021). Organizations can develop synergistic solutions such as shared infrastructures and reverse logistic processes (Han et al., 2022). Other examples of industrial symbiosis are the cascading use of resources (Fernandez de Arroyabe et al., 2021), research and development collaboration (Marín-Vinuesa et al., 2021), and co-investment (Kristoffersen et al., 2021; Wade et al., 2022). Collaboration contributes to the stakeholders' involvement in the circular economy (Khan et al., 2020; Jayarathna et al., 2022). Conditions for successful collaborations are a low threshold for participation (Sandberg & Hultberg, 2021) and relational interdependences to reduce the prospect of conflicts (Parida, Burström et al., 2019). The *collaboration* capability is *the ability to build connections and collaborative practices around circular economy activities.*
- **Partnership management** - Management of partnerships is an essential activity for developing beneficial and sustainable partnerships. Partnerships may be required for the acquisition of specialized competences (Bertassini et al., 2021), funding for research and development (Fernandez de Arroyabe et al., 2021; Sousa-Zomer et al., 2018), or influencing the adoption of sustainable practices (Sousa-Zomer et al., 2018). Activities that come with the management of partnerships are the identification of a shared agenda with critical stakeholders (Arekrans et al., 2022), the identification of mutually beneficial relationships (Parida, Burström et al., 2019), and the reevaluation of relationships with existing partners (Arekrans et al., 2022). Recommended practices are assessing the inclusion of new partners based on a risk and benefit analysis (Parida, Burström et al., 2019) and balancing multiple goals that might be in conflict (Bertassini et al., 2021). Moreover, openness toward external collaborations (Sandberg & Hultberg, 2021) and geographical proximity to stakeholders (Prieto-Sandoval et al., 2019) are considered enablers of sustainable partnerships. As a result, the *partnership management* capability is defined as *the ability to assess, develop, and sustain strategic partnerships.*

4.6.2 Management & People

Regarding the management and people dimension, three categories were identified. First, *human resource management* focuses on employee recruitment, training, and the composition of adequate teams. Second, the *culture and leadership* discusses the importance of a sustainability culture and active leadership. Last,*project and process management* covers processes that require a high level of managerial attention.

Human Resource Management

- **Recruitment** - Adequate recruitment and talent selection support the transition to the circular economy (Khan et al., 2020; Kristoffersen et al., 2021). In the recruitment process, organizations should aim to adapt the employee structure by using organizations' core values for selecting candidates with a compatible mindset and environmental values (Prieto-Sandoval et al., 2019; Bertassini et al., 2021). Organizations should anticipate changes in their workforce as the circular transition may create new job opportunities (Howard et al., 2022) or declare jobs obsolete (Prieto-Sandoval et al., 2019). Moreover, organizations should account for the compilation of multidisciplinary teams to foster the implementation of circular practices and hire accordingly (Elf et al., 2022). The *recruitment* capability is defined as *the ability to recruit personnel that aligns with the environmental and core values of the organization and possesses relevant skills.*
- **Training** - Training is identified as a fundamental practice for the circular transition. Training on sustainability topics is believed to create employee empowerment to propose improvements leading to bottom-up innovations (Prieto-Sandoval et al., 2019; Khan et al., 2020; Santa-Maria et al., 2021). Furthermore, actors across the value chain should be trained to, for example, ensure the execution of best practices at recycling centers or facilitate the implementation of complex blockchain systems (Chaudhuri et al., 2022). Moreover, training facilitates the transformation of obsolete jobs into new employment (Prieto-Sandoval et al., 2019). The *training* capability is defined as *the ability to train and retrain people across the value chain, and increase employees' ability to propose improvements.*
- **Team compilation** - The compilation of multidisciplinary teams and allocating adequate resources to support them reinforces the circular transition in considerable ways. Sustainability-oriented innovation can be promoted by forming decentralized innovation teams (Santa-Maria et al., 2021) with relevant skills and knowledge regarding business model innovation, product design, and the development of circular strategies (Bertassini et al., 2021; Santa-Maria et al., 2021). The *team compilation* capability is defined as *the ability to build (decentralized) multidisciplinary teams with relevant knowledge and skills.*

Culture and Leadership

- **Sustainability culture** - A sustainability culture boosts the implementation of the circular economy from inside an organization (Prieto-Sandoval et al., 2019). The concept is based on a green organizational culture that promotes an environmental ideology for economic, social, and environmental development and is believed to generate employee and stakeholder engagement, facilitate knowledge integration and diffusion, and avoid premature satisfaction (Bertassini et al., 2021). Practices relevant to developing a sustainability culture are: prioritizing customer value creation, nurturing mutual trust and respect, and encouraging employees to pursue the circular economy vision and goals (Bertassini et al., 2021). Thus, to support the transition toward the circular economy, it is vital to generate employee awareness and build a work environment that stimulates economic, social, and environmental performance (Bertassini et al., 2021). The *sustainability culture* capability is defined as *the ability to create a culture that encourages, engages, and influences employees and stakeholders to put the circular economy vision into effect.*
- **Environmental leadership** - Environmental leadership is focused on the commitment, involvement, and support of leaders within the organization for implementing circular principles (Santa-Maria et al., 2021; Chari et al., 2022). Environmental leadership is expected to ensure top management sponsorship (Seles et al., 2022) and inspire employees to commit to sustainable and ecological objectives (Belhadi et al., 2022). Furthermore, corporate social responsibility is embedded in environmental leadership. By exercising corporate social responsibility, an organization takes ownership and responsibility with appropriate significance, engages in social and environmental issues (Sandberg & Hultberg, 2021), and considers the responsibilities regarding environmental sustainability (Kusumowardani et al., 2022). Such behavior is aimed at

sustainable consumption of natural resources and economic prosperity distribution (Belhadi et al., 2022). The *environmental leadership* capability is defined as *the ability to take appropriate ownership of organizational activities, engage in environmental and social issues, and create commitment to an organization's circular goals.*

Project and Process Management

- **Environmental accounting** - Environmental accounting encapsulates the measurement and assessment of organizational sustainability performance (Jayarathna et al., 2022; Sumter et al., 2021); definition of goals and metrics (Arekrans et al., 2022); development of new costing models and criteria that are aligned with the circular economy (Kristoffersen et al., 2021); and the assessment and evaluation of the impact on human, environment, and resources (Belhadi et al., 2022). Measuring and assessing sustainability improves corporate image and contributes to corporate sustainability (Jayarathna et al., 2022). The *environmental accounting* capability is defined as *the ability to develop, assess, and evaluate indicators that measure the impact of organizations' actions on human, environment, and resources.*

- **Portfolio management** - Portfolio management is based on product and project management activities. The development and management of circular economy projects is an essential competence as it supports the development of appropriate products and services (Fernandez de Arroyabe et al., 2021; Prieto-Sandoval et al., 2019). Part of this competence is the definition of project procedures (Sousa-Zomer et al., 2018) and the management of the corresponding processes (Chari et al., 2022). The AFNOR XP X30-901 certification, for example, is a managerial tool that facilitates dialogue across organizations and stakeholders to recognize the production and consumption through a shared language and definitions, allowing for planning, executing, evaluating, and improving circular projects (Fernandez de Arroyabe et al., 2021). The *portfolio management* capability is *the ability to manage and define product and project management procedures.*

- **Financial management** - Financial management comprises investment planning, capital budgeting, and cost comprehension. Investment planning and capital budgeting are essential for engaging in newly identified circular opportunities (Khan et al., 2020). Investments in eco-innovation, renewable energy sources, and research and development are enablers of the circular transition and facilitate new product development (Wade et al., 2022). On the other hand, cost efficiency contributes to the success probability of circular businesses (Chari et al., 2022). Calculating and measuring the financial impact of products and services is critical to comprehend the costs along the product or service's lifecycle (Sousa-Zomer et al., 2018). Understanding costs allows for risk assessment which is especially relevant for business models that incorporate leasing or renting activities as the financial risk is passed from the consumer to the producer (Sousa-Zomer et al., 2018). The *financial management* capability is defined as *the ability to strategically plan investments, assess costs and financial risks.*

- **Change management** - Management of change is considered relevant as the alteration of existing routines (Bertassini et al., 2021), adoption of acknowledged best practices, and implementation of new working methods are facilitators of the circular transition (Khan et al., 2020). Therefore, organizations should adhere to innovations and promote change when transitioning to the circular economy (Sehnem et al., 2022). Examples of best practices that can be implemented are the reduction of packaging (Khan et al., 2020), the introduction of a zero-waste program (Sousa-Zomer et al., 2018), and the implementation of sustainability guiding frameworks (Khan et al., 2020; Santa-Maria et al., 2021). To encourage the integration of these practices, organizations should acquire a change management proficiency (Santa-Maria et al., 2021) and form coalitions of change agents who implement the planned changes (Bertassini et al., 2021). The *change management* capability is defined as *the ability to form a coalition of change agents and implement the planned changes.*

4.6.3 Business Development

The business development dimension is concerned with three capability categories. First *research and development*, which facilitates experimentation and innovation. Second, the focus on developing a new business model suitable for the circular economy is accompanied by capabilities discussed in the *business model design* category. Last, *technology and digitalization*, where the importance of leveraging novel technologies is stressed and elaborated.

Research and Development

- **Experimentation** - Experimentation supports organizations in moving toward circularity as it is widely recognized by researchers in sustainability fields as an essential practice for organizations aiming to reduce their environmental impact (Wade et al., 2022). Especially organizations that focus on circular business and product innovation benefit from experimentation (Wade et al., 2022). In general, experimentation decreases uncertainty and risk, validates assumptions, and facilitates organizational learning before scaling practices (Santa-Maria et al., 2021). Operational risk reduction may be achieved by investigating customers' behavior, identifying barriers, and responding appropriately before product launches (Sousa-Zomer et al., 2018). Organizations should, therefore, actively engage in experimentation (Elf et al., 2022) and develop experimentation plans to safeguard economic and financial business viability (Sousa-Zomer et al., 2018). The *experimentation* capability is *the ability to implement experiments and pilots to validate, learn, and adapt quickly.*
- **Knowledge sharing** - Knowledge and intellectual property exchange encourage complementary innovation and enable the broader ecosystem to achieve its circular goals (Parida, Burström et al., 2019). Knowledge sharing promotes cooperation in three ways: by offering a platform for communication, channeling knowledge, and promoting efficient governance (Köhler et al., 2022). Central agencies may examine and disseminate knowledge to benefit the ecosystem (e.g., forecasts for purchases are made using trend and sales data from various retailers) (Sandberg & Hultberg, 2021). Knowledge-sharing practices collect and provide circular economy-relevant knowledge (Fernandez de Arroyabe et al., 2021), establish non-hierarchical knowledge-sharing routines, and adopt open innovation-sharing mechanisms (Köhler et al., 2022). Nonetheless, the involvement in open innovation practices must be carefully balanced with the pursuit of competitive advantage (Köhler et al., 2022). The *knowledge sharing* capability is defined as *the ability to effectively develop knowledge sharing routines and strategically share knowledge.*
- **Knowledge integration** - Integration of knowledge is crucial for executing the circular economy (Khan et al., 2020). Employing cognitive abilities to sense new opportunities (Wade et al., 2022), accumulated experiences, intellectual property, and know-how within the organization are positively associated with the circular transition (Santa-Maria et al., 2021). Knowledge may be integrated into enterprises by reconfiguring how resources, work, and other business practices are organized (Elf et al., 2022). Organizations may utilize their collaboration with research institutions for knowledge exploitation (Khan et al., 2020). The *knowledge integration* capability is *the ability to employ accumulated experience, know-how, and intellectual property.*
- **Patenting** - Patenting intellectual property is considered a relevant element within the circular economy as it may improve organizations' competitive advantage. Moreover, patenting may indicate circular economy performance as it demonstrates the investments in intangible assets that aim to close the material loop (Marín-Vinuesa et al., 2021). To promote patent development, organizations should collaborate with research and development institutes, exercise a strong persistence in patenting, and develop territorial linkage within their territory (Marín-Vinuesa et al., 2021). Therefore, the *patenting* capability is the *the ability to comprehend and deploy patent development procedures.*
- **Innovation** - Innovation has the potential to guide organizations toward circularity (Wade et al., 2022) by initiating new routines, procedures, and practices (Marín-Vinuesa et al., 2021; Sehnem et al., 2022). The concept of circularity requests innovations that contribute to more efficient

use of resources (Sehnem et al., 2022). Innovations related to circular principles, eco-design, and process design are required to enable the design and development of sustainable products and processes (Seles et al., 2022). The primary role of innovation within the circular economy transition can be considered as the support and generation of novel methods for producing goods and managing waste while retaining the value of resources. However, the shift from linear models to the circular economy enabled by innovation is a complicated topic, given the many actors, networks, relationships, and organizational structures involved (Sehnem et al., 2022). Conventional commercial and economic logic can embody a barrier to circular economy innovations' success (Sehnem et al., 2022). Applying tools such as a life cycle analysis or participating in conferences, seminars, trade shows, and brainstorming sessions (Khan et al., 2020) increases the likeliness of generating ideas and accomplishing innovation. Therefore, idea generation, relating to the organizational desire to innovate and transform circular practices, is an important aspect (Elf et al., 2022). In addition, other innovative activities are considered to commercialize, collect customer data, and manage maintenance and support (Sehnem et al., 2022). Furthermore, product (Chari et al., 2022) and technological (Kusumowardani et al., 2022) innovation enabled by stakeholder cooperation are important assets for the circular economy transition. The *innovation* capability is defined as *the ability to develop new products and processes through absorption of knowledge.*

- **Research and development** - Research and development is considered an essential facet of a circular organization as it is believed to support knowledge creation and innovation (Khan et al., 2020; Elf et al., 2022; Chari et al., 2022). The practices that are associated with research and development are researching resources and other industries (Elf et al., 2022; Wade et al., 2022); monitoring technological developments (Khan et al., 2020); leveraging technological and scientific developments (Santa-Maria et al., 2021); developing enabling technologies to recover materials (Seles et al., 2022); and developing solutions to complement the product and service offering (Elf et al., 2022; Han et al., 2022; Kusumowardani et al., 2022). Furthermore, the development of protocols to assess product and service durability, performance, and quality is incorporated within research and development activities (Sousa-Zomer et al., 2018). Research and development may be facilitated by, for example, partnering with governments (Sousa-Zomer et al., 2018). The *research and development* capability is defined as *the ability to conduct research on resources and other industries and leverage scientific and technological developments.*

Business Model Design

- **Business model experimentation** - Organizations engaging in the circular economy may need to adapt their existing business model as they acknowledge that the current business model is no longer viable (Arekrans et al., 2022). In other words, business model evolution (Wade et al., 2022), business model improvement (Prieto-Sandoval et al., 2019), or business model innovation (Elf et al., 2022) may be necessary, which demands the recognition of alternative business model configurations. Business model experimentation is identified as a relevant proficiency to arrive at an alternative business model configuration. Practices for business model experimentation are: the value proposition experiment, where insights are collected and tests are executed to explore whether offerings exist; the value deliver experiment, where, from a customer perspective, is determined how the business is brought to the market; the value creation experiment where the needs of stakeholders that take the offering to the market are identified; and the value capture experiment where business cases should be analyzed for the involved stakeholders (Bocken et al., 2018). The *business model experimentation* capability is *the ability to explore the most viable strategy to bring the product or service offering to the market.*
- **Business model development** - Organizations must modify their strategies and business models to respond adequately to the circular economy's potential and persuade their ecosystem partners to do the same (Parida, Burström et al., 2019). Redesigning business models is fundamental to the circular transition (Khan et al., 2020). Organizations should aim to leverage strategic value and market opportunities (Kristoffersen et al., 2021). Example practices for

designing a circular business proposition are the definition of pricing models for different customer segments and the definition of sales processes and channels (Sousa-Zomer et al., 2018). Organizations should aim for a mix of products and services to satisfy customer needs jointly (Sousa-Zomer et al., 2018). The *business model development* capability is *the ability to design and implement sustainable business models.*

Technology and Digitalization

- **Technology** - Technological developments such as the internet of things, big data, and data analytics are important facilitators of the circular economy transition (Kristoffersen et al., 2020). More specifically, using technologies may support the design of a circular business model (Reim et al., 2021). Important aspects are the upgradation of technology (Khan et al., 2020), the assurance of connectivity, and the development of digital proficiency (Chari et al., 2022). Furthermore, the importance of traceability within the circular value chain is acknowledged by multiple studies (Ingemarsdotter et al., 2019; Prieto-Sandoval et al., 2019; Lopes de Sousa Jabbour et al., 2019; Kusumowardani et al., 2022). Traceability enables organizations to monitor, track, and control products' location, composition, and condition (Ingemarsdotter et al., 2019). The *technology* capability is defined as *the ability to utilize technology to leverage opportunities such as the control of product functionality and traceability.*
- **Data analytics** - The relevance of data analytics within the circular economy is widely recognized (Kristoffersen et al., 2020; Awan et al., 2021; Ingemarsdotter et al., 2019). Data analytics may support organizations with the optimization of operations using advanced algorithms (Ingemarsdotter et al., 2019) or assist with the execution of business intelligence analytics (Awan et al., 2021). Recommended practices for data analytics are to develop an understanding of the nuances of data analytics (Awan et al., 2021), automate data collection, develop data sharing infrastructures, and utilize feedback data for organizational learning (Kristoffersen et al., 2021). The *data analytics* capability is *the ability to diagnose, discover patterns, predict, and prescribe based on data.*

4.6.4 Business Operations

The business operations dimension focuses on the day-to-day operational activities and comprises three capability categories. First, *circular design and manufacturing processes* where the capabilities regarding design and manufacturing activities are elucidated. Second, *marketing and market analysis* which is concerned with the dynamic market environment. Last, *logistics and distribution* where the importance of a green and resilient supply chain is stressed.

Circular Design and Manufacturing Process

- **Sustainable design** - As the transition toward the circular economy is accompanied by circular product and service development practices, design and creativity are fundamental for delivering a competitive offering (Chaudhuri et al., 2022). If the design is not aligned with the circular economy, solutions may not be suitable for repair, re-manufacturing, or reprocessing while value is retained (Chari et al., 2022). Especially when preserving product ownership, where manufacturers control product maintenance and recycling, the importance of product design is highlighted (Lopes de Sousa Jabbour et al., 2019). Therefore, organizations should comprehend circular product and service design procedures(De los Rios & Charnley, 2017; Sousa-Zomer et al., 2018) to develop sustainable solutions that satisfy human needs (Belhadi et al., 2022). To encourage circular design, organizations should initiate design requirements (e.g., for durability) (Fernandez de Arroyabe et al., 2021), aim to solve aesthetic issues with limited components (De los Rios & Charnley, 2017), develop design skills to integrate recycled materials (Chaudhuri et al., 2022), and include customers in the design process (Prieto-Sandoval et al., 2019). As a result, the *sustainable design* capability was defined as the following: *the ability to create sustainable products and services that satisfy human needs and desires.*

- **Efficient manufacturing** - Adopting sustainable and efficient practices within the manufacturing system was highlighted in multiple publications. It encapsulates activities ranging from acquiring and utilizing circular materials (Sumter et al., 2021; Khan et al., 2020; Chaudhuri et al., 2022) to understanding the process for reverse and re-manufacturing (De los Rios & Charnley, 2017). Moreover, initiatives such as dematerialization, narrowing resource usage, prioritizing resource efficiency (Lopes de Sousa Jabbour et al., 2019; Chari et al., 2022; Belhadi et al., 2022), and implementing renewable energy sources are also considered part of an efficient manufacturing system. The *efficient manufacturing* capability is defined as *the ability to comprehend and adopt sustainable production practices and increase resource efficiency in operations.*
- **Lifecycle management** - Management of the lifecycle comprises activities that focus on lifecycle extension and looping. Worn components may be replaced or repaired, energy may be recovered from non-recyclable waste, products may be reconditioned and sold, and components or a product may be used for a different function after improvement or modification (Belhadi et al., 2022). By considering the complete cradle-to-cradle process and understanding resources as future resources, the lifecycle perspective allows for identifying impacts and opportunities (Santa-Maria et al., 2021). Furthermore, lifecycle management may require designing and coordinating take-back systems (Lopes de Sousa Jabbour et al., 2019). The *lifecycle management* capability is defined as *the ability to manage the product's lifecycle by activities such as maintenance, repairing, repurposing, recycling, and recovering.*

Marketing and market analysis

- **Customer management** - In the circular economy, organizations provide offerings that align with customer needs (Sousa-Zomer et al., 2018) hence the relevance of customer management. Customer management is believed to anticipate the customer expectations and perception of value (De los Rios & Charnley, 2017; Khan et al., 2020; Santa-Maria et al., 2021), manage customer engagement throughout the lifecycle (Sumter et al., 2021; Sousa-Zomer et al., 2018), and understand specific customer needs according to different market segments (Sousa-Zomer et al., 2018). The *customer management* capability is defined as *the ability to manage the relationship with and understand the expectations of the customer.*
- **Market monitoring** - Monitoring market and sustainability trends (Khan et al., 2020) by collecting information on customer behavior (Elf et al., 2022) and being able to observe the dynamics in the market (Kusumowardani et al., 2022) were found to influence an organizations' ability to recognize market opportunities within the circular economy. Apart from market opportunities, organizations should closely monitor consumption patterns (Elf et al., 2022; Fernandez de Arroyabe et al., 2021) and environmental and social threats and opportunities (Santa-Maria et al., 2021). Organizations may appoint a distant dedicated team to search for and sense new opportunities in the market (Kuhlmann et al., 2022). The *market monitoring* capability was therefore defined as *the ability to monitor new trends, stakeholders' information, competitors' actions, and consumption patterns.*
- **Communication** - Communication is important in the circular economy transition as it facilitates changing existing narratives and building credibility. It is suggested to actively reshape the narrative of used products; for example, instead of using phrases such as 'second-hand', adopt terms with more positive connotations, such as 'pre-loved' (Sandberg & Hultberg, 2021). Part of this communication is the creation of narratives and engaging visions that can be utilized to generate stakeholder support (Sumter et al., 2021). To secure trust and engagement of stakeholders, fact-based and transparent communication is required (Santa-Maria et al., 2021; Wade et al., 2022). Moreover, appropriate communication channels are required to convey core values (Bertassini et al., 2021). The *communication* capability is therefore defined as *the ability to design communication channels and communicate credible and transparent circular economy narratives.*

- **Marketing** - Organizations must develop green and sound marketing strategies to effectively communicate value in the circular economy (Prieto-Sandoval et al., 2019; Chaudhuri et al., 2022). Organizations can use eco-labeling and zero-waste certifications to open new markets and develop green marketing. Through marketing, organizations should communicate how customer problems are solved sustainably (Han et al., 2022) and address new customers (Wade et al., 2022). These activities contribute to a sound marketing strategy and exposes credibility and legitimacy which builds customer trust (Han et al., 2022). In addition, market segmentation is an essential instrument as clients may be diverse (Prieto-Sandoval et al., 2019). The *marketing* capability is therefore defined as *the ability to develop and execute sound marketing strategies, build relationships, and communicate value.*

Logistics and Distribution

- **Logistics process management** - Understanding and managing logistic processes (De los Rios & Charnley, 2017) and collaborating with organizations on logistic operations (Prieto-Sandoval et al., 2019) are key activities for achieving a well-functioning circular supply chain. Examples of collaborations are partnering with retailers to support remarketing and reverse logistics (De los Rios & Charnley, 2017) and sharing real-time information with stakeholders. Organizations should focus on developing a resilient supply chain as such chain can respond to market uncertainty, changing customer demands, and disruptive events (Chari et al., 2022) and create an integrated supply chain management system (Sousa-Zomer et al., 2018). The *logistic process management* capability is *the ability to develop and manage processes for (reverse) logistics and (re)manufacturing.*
- **Green supply chain management** - Green supply chain management focuses on the sustainability of the supply chain as this is an important part of the circular ecosystem. It encapsulates practices such as ensuring that suppliers commit to meeting the standards and policies (Sousa-Zomer et al., 2018), strategically selecting suppliers aligned with the organizational vision (Elf et al., 2022), and engaging in green warehousing activities (Jayarathna et al., 2022). Furthermore, organizations may develop supplier incentives and certification programs (Belhadi et al., 2022) to support adopting sustainable practices. The *green supply chain management* capability is *the ability to develop and manage sustainable practices within the supply chain.*

4.7 Chapter Conclusion

This chapter presents the procedure and results of a systematic literature review that contributes by the identification of capabilities relevant to implementing circular strategies and synthesize them into an initial model. First, a systematic search is performed to map related literature reviews and highlight the specific contribution of the current review. Second, the methodology for reviewing the literature is presented, and the findings are elaborated. Third, the processes adopted for developing the initial model and synthesizing the capabilities are discussed. As a result, an overview of the initial model is presented with a discussion of the corresponding elements. To conclude, this systematic literature review yielded an initial model that serves as input for the Delphi study, further elaborated in the next chapter.

Chapter 5

Delphi Study

A Delphi study was deployed to advance the initial capability model that resulted from the systematic literature review. A literature study is only considered sufficient for serving as a theoretical starting point for model development; hence a further exploratory research method is required (de Bruin et al., 2005; Becker et al., 2009). The steps of a classical Delphi study by Skinner et al. (2015) are adopted in this study. First, the expert panel comprising the appropriate disciplines was composed according to the guidelines of Okoli & Pawlowski (2004). Then questionnaires were prepared and distributed to the expert panel. Accordingly, the responses were analyzed to understand whether a consensus was reached or an additional iteration was required. A maximum of three rounds was planned as this is generally sufficient (Rowe & Wright, 2001). Figure 5.1 provides an overview of the process.

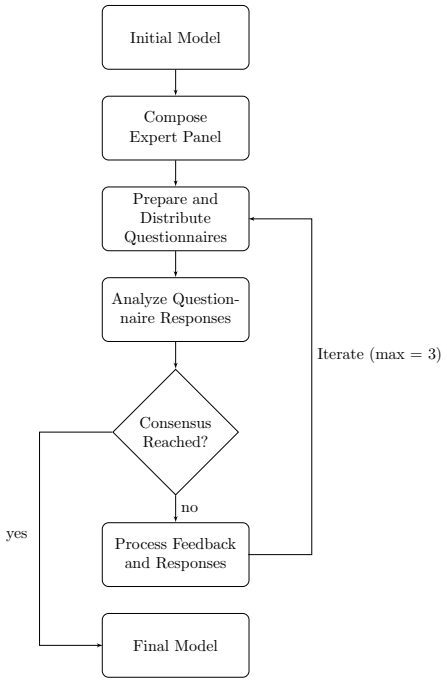


Figure 5.1: Protocol for Delphi Study

By conducting the Delphi study, it is aimed to advance the model threefold: (1) achieve consensus on the definition of the model's elements; (2) achieve consensus on the allocation of the elements in the model; and (3) identify missing elements. Satisfying these goals contributes to the face validity of the model as the experts assess whether appropriate representations of the

constructs are adopted (de Bruin et al., 2005). The remainder of this chapter elaborates on the composition of the expert panel, how the Delphi study was conducted, and the results.

5.1 Composition of the Expert Panel

A Delphi study entails identifying and selecting a panel of experts from whom information on a specific issue is elicited via the iterative completion of questionnaires (de Bruin et al., 2005). The ideal size of a Delphi panel is subject to variance as it depends on the research scope and available resources (Powell, 2003). Okoli & Pawlowski (2004) suggest a general panel size of 10 and 18 experts. Moreover, it is argued that a heterogeneous panel, characterized by experts from diverging backgrounds, is beneficial for performance (Murphy et al., 1998).

A knowledge resource nomination worksheet that denotes the appropriate disciplines for this study was prepared to arrive at a heterogeneous panel. Such a worksheet facilitates nominating relevant disciplines, organizations, and practitioners (Okoli & Pawlowski, 2004; Skinner et al., 2015). As the circular economy capability model is not limited to a specific organization or industry, the relevant stakeholders for model development are academia, practitioners, and policymakers (de Bruin et al., 2005). In terms of organizations, there was aimed for consultancy firms, universities, governmental bodies, European Union, and industry.

Participants were approached based on their roles and expertise and selected through purposive sampling, which is the selection of a participant based on individual attributes (Etikan, 2016). Academia involved in publications relating to circular economy, circularity, or sustainability were considered experts. Consultants and government officials were considered when they had experience with projects related to the circular economy. For the industry, organizations that implemented circular principles were approached. Out of 23 approached experts, 11 chose to be involved. An overview of the participating experts and their fields of expertise is displayed in Table 5.1. A more detailed description of the experts is reported in Appendix B.1.

Table 5.1: Expert Panel Delphi Study

	Expertise	Organization	Categorization
Expert 1	Sustainability and Responsible Governance	PwC	Consultancy
Expert 2	Sustainability and Responsible Governance	PwC	Consultancy
Expert 3	Waste Management	PreZero	Industry
Expert 4	Sustainable and Circular Business Transformation	Sustainable Transformers	Consultancy
Expert 5	Competitiveness, Innovation, and Sustainability	IDEA Consult	Consultancy
Expert 6	Corporate Social Responsibility and Procurement	RS sustainability	Consultancy
Expert 7	Circular Economy and Environment	TNO	Research/Consultancy
Expert 8	Sustainability, Environment, and Health	RIVM	Government
Expert 9	Sustainability Assessment and Sustainable Energy	TU/e	Research
Expert 10	Sustainability, Circular Economy, and Environment	Erasmus Brussels	Research
Expert 11	Circular Economy and Waste Management	RWS	Government

5.2 Structure of the Delphi Study

Due to the magnitude of the model in terms of elements, it was decided to adopt a questionnaire-based Delphi study. This way, the domain experts could independently determine when and where they completed the questionnaires. The primary research tool was Google Forms, for developing the questionnaires. Experts could vote 'stay, 'change', and 'go' for the questions and were asked to concisely elaborate on their decision if they opted for a 'change' or 'go' decision. A threshold of 80% in unanimity was adopted to accept elements of the capability model. In other words, 9 out of 11 experts had to vote 'stay' for an element to reach a consensus on element acceptance.

A common validity threat for the Delphi study is that it is perceived to impose agreements and restrict participants from elaborating on their decision (Hasson et al., 2000). Therefore, open

comments were solicited to provide a concise elaboration for each decision. Each elaboration was examined and answered to inform panelists on whether it triggered a change in the model (Martinek-Jaguszewska & Rogowski, 2022).

Cronbach's Alpha was applied to quantify the internal consistency between the expert responses. A score of 0 for Cronbach's alpha indicates that expert evaluations are entirely unrelated, whereas values close to 1 suggest a significant association between the evaluations. Alpha values of 0.7 to 0.8 are considered satisfactory for group comparisons (Tavakol & Dennick, 2011).

5.3 Results of Round 1

In the first round (Cronbach's alpha = 0.76), experts completed a questionnaire that presented all dimensions, categories, and capabilities. The questionnaire was structured in four sections related to the model's dimensions and a fifth section where experts were solicited to comment on the model as a whole. For each section related to a dimension, the experts had to review the corresponding categories and capabilities. More specifically, questions were asked for the capabilities to validate the synthesized name, definition, and allocated position. An example of the questionnaire layout can be found in Appendix B.2.1.

The results showed that experts agreed on acceptance for all the dimensions and 8 out of 12 categories. Experts reached a consensus for acceptance for 17 of the 34 capabilities and provided suggestions to improve the model through open comments. These suggestions were carefully reviewed and answered (Appendix B.2.3) resulting in a revamped version of the model (Appendix B.2.4). The findings and changes in the model's elements are discussed in the sections below.

5.3.1 Strategy

Experts reached a consensus for acceptance within the *strategy* dimension for two of three categories. Based on the voting results and interpretations of the open comments, it was decided to restructure the *strategy* dimension from two to four categories. Here, the reasoning behind the changes is briefly discussed, and the modifications are visualized in Figure 5.2.

Governance support & regulation was rejected as a category as experts believed it misrepresented the underlying capabilities. To elaborate, experts indicated that the *ecosystem orchestration* capability would fit better under a category related to the development of partnerships; hence the capabilities were relocated and new categories were created. *Regulatory compliance* was transferred to the *Finance & control* category and *ecosystem orchestration* was relocated to the *ecosystem* category.

Although the *operational strategy* category was accepted, there were some remarks. Experts argued that the combination of *organizational restructuring* and *strategy development* in this category is confusing as the former is part of the implementation of a strategy, and the latter focuses on developing a circular strategy. Therefore, an *implementation* and a *corporate* category were created emphasizing a distinction.

The experts widely acknowledged the relevance of *strategic collaboration & partnerships* despite the perceived overlap between *collaboration* and *partnership management*. As the *collaboration* capability focuses on the actual execution of partnerships, it was decided to move the capability to the *business operations* dimension.

5.3.2 Management & People

Experts accepted two out of three categories in the *management & people* dimension. From the voting results and the suggestions from the open comments, it was decided to reformulate the dimension into *people* and relocate the elements related to project management and processes. An overview of the modifications is displayed in Figure 5.3. Below, the rationale for the modifications is briefly discussed.

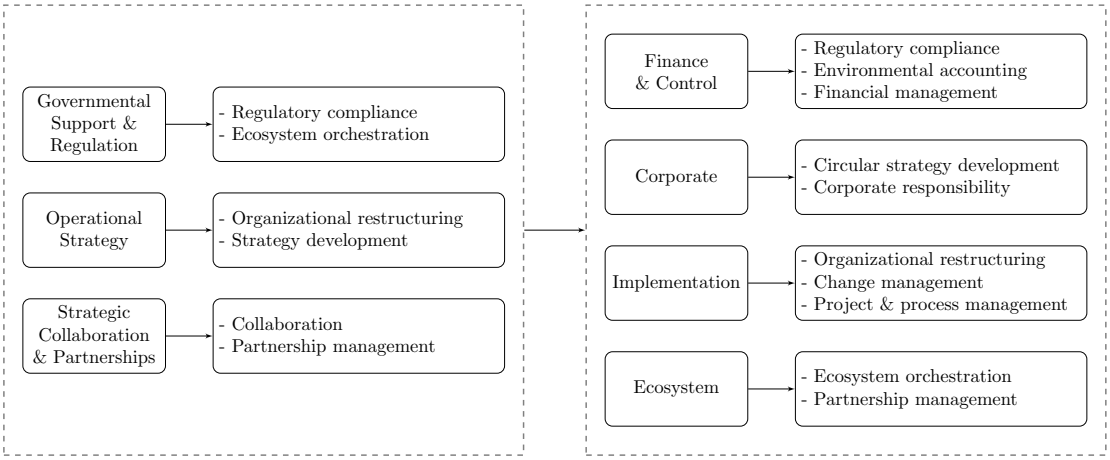


Figure 5.2: Changes to Strategy Dimension in Delphi Round 1

The *human resource management* category was accepted, while the underlying capabilities were subject to changes. The *training* capability incorporated elements that focus on training employees and further down the value chain. Experts indicated that these should be distinct; therefore, the definition of the *training* capability was modified. The training of people further down the value chain is covered by the *circular supply chain* capability discussed in Section 5.3.4. Concerning the *team compilation* capability, experts argued that this capability would fit better under the *culture & leadership* category.

For the *culture & leadership*, experts positively judged the category and the position of the assigned capabilities. However, the experts proposed suggestions for the definition and name of these capabilities. As sustainability is a broad term that can be applied within different settings, experts suggested providing a more specific term for the capability *sustainability culture*. The *leadership* capability aims to cover the organization's corporate responsibility and leadership that focuses on developing organizational commitment. The expert comments revealed that the capability is unclear and urges adaptation. Therefore, it was decided to split the capability into *leadership* and *corporate responsibility*, which was positioned under the *strategy* dimension.

Experts rejected the *project & process management* category, while most definitions and locations of the underlying capabilities were approved. Experts rejected the category based on the premise that it did not fit the *management & people* dimension. Therefore, the category and its capabilities were allocated to different dimensions. As a result, the *management & people* dimension became obsolete, hence the change to a *people* dimension.

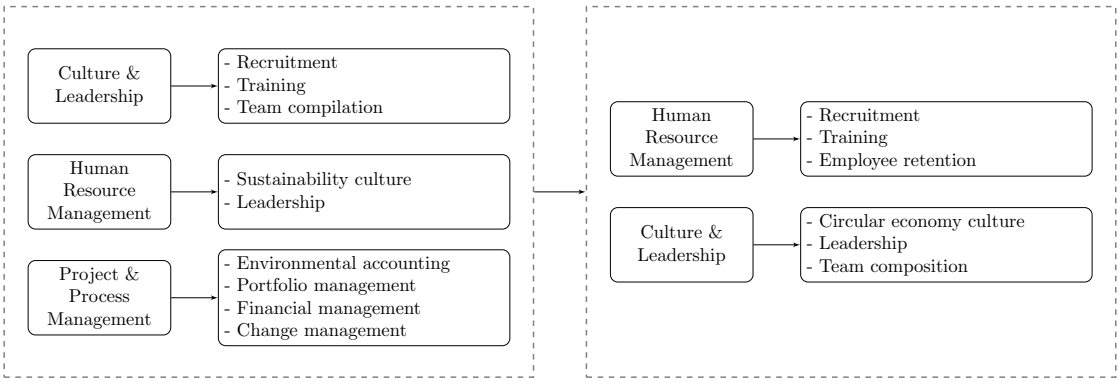


Figure 5.3: Changes to Management & People Dimension in Delphi Round 1

5.3.3 Business Development

Two of the three categories in the *business development* dimension were accepted. Based on the voting results and interpretation of open comments, it was decided to restructure the dimension into two categories. The inclusion of *market & customer* category under this dimension resulted from suggestions in the *business operations* dimension. An overview of the changes is shown in Figure 5.4. Below, the rationale for the modifications is briefly discussed.

The *business model design* category was accepted together with the underlying capabilities. Therefore, this category did not undergo any noteworthy changes.

The *research & development* category was rejected as experts indicated that this category would fit better under the *business operations* dimension. Focusing on the underlying capabilities, experts suggested two changes. First, merging *knowledge sharing*, *knowledge integration*, and *patenting* into the capability of *IP management* was proposed. Since *knowledge integration* and *patenting* were rejected, it was decided to follow up on this suggestion. Second, it was experienced as confusing that the *research and development* capability had a similar name as its corresponding category; hence it was suggested to rename the capability.

The *technology & digitalization* category was accepted, and experts resonated with the importance and relevance of the underlying capabilities. Nevertheless, some suggestions were made as the capabilities were believed to suit the *research & development* category. As a result, the *technology & digitalization* category became superfluous, and the underlying capabilities were repositioned under the *business operations* dimension.

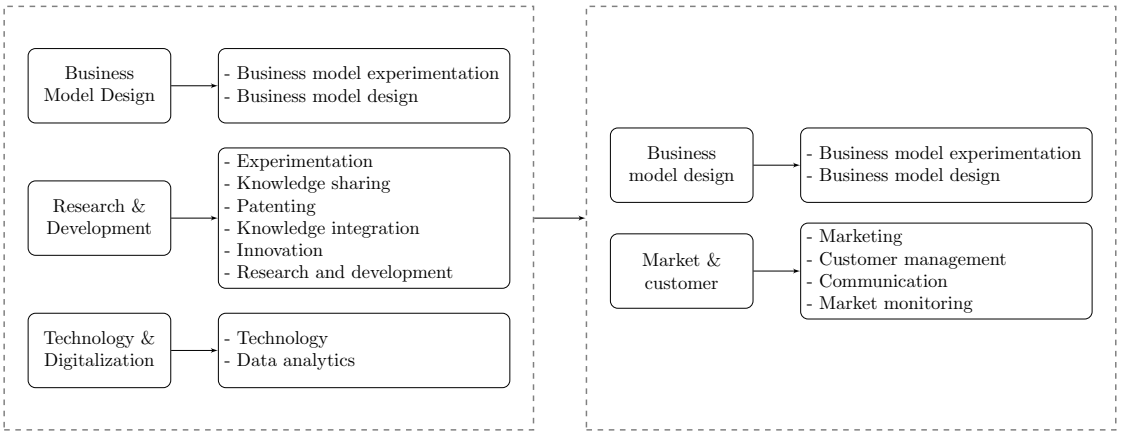


Figure 5.4: Changes to Business Development Dimension in Delphi Round 1

5.3.4 Business Operations

The *business operations* dimension comprised three categories, from which two were accepted. Guided by the voting results and the open comments, this dimension was restructured to two categories. The adoption of the *reseach & development* category under this dimension results from the expert suggestions in the *business development* dimension. An overview of the modifications is displayed in Figure 5.5. Below, the rationale for the modifications is briefly discussed.

The *circular design & manufacturing* processes category was accepted. Experts suggested changes to the definitions of the underlying capabilities; however, they agreed on the position of the capabilities.

The *marketing & market analysis* category was rejected, and it was suggested to alter the name and move to the *business development* dimension. The experts accepted the underlying capabilities except for the *market monitoring* capability definition. As a result, the definition of the former was reconsidered and adapted.

The *logistics & distribution* category was accepted as well as the position of the corresponding capabilities. However, the name and definition of the *green supply chain management* capability were considered ambiguous, leading to reconsidering the capability. Moreover, experts argued that the *logistics & distribution* category might overlap with practices related to the circular *design & manufacturing* category. Therefore, both categories' names were reconsidered and merged into a category named *logistics & manufacturing*.

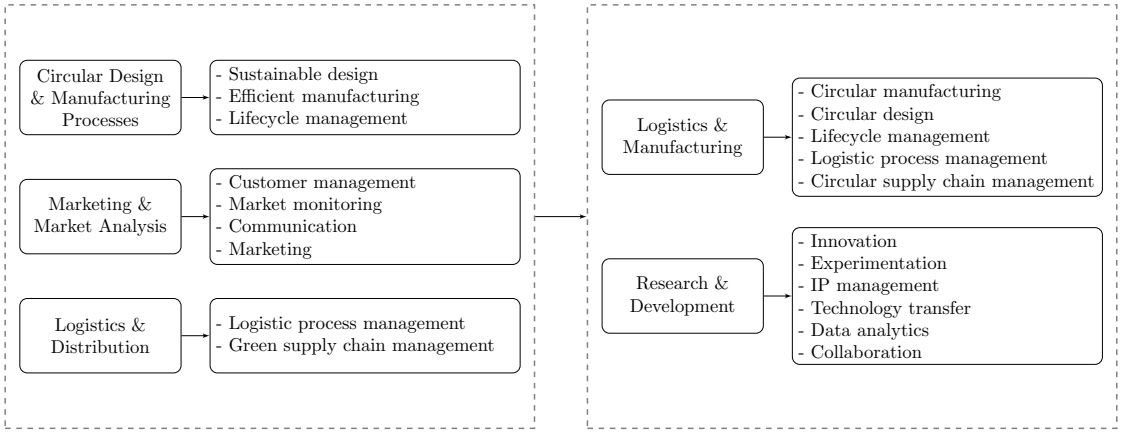


Figure 5.5: Changes to Business Operations Dimension in Delphi Round 1

5.4 Results of Round 2

Experts were solicited to judge the revised model in the second round (Cronbach's alpha = 0.85). The elements that were modified or for which no consensus on acceptance was reached were presented in the questionnaire. An example of the questionnaire layout can be found in Appendix B.3.1. From the expert panel, ten responses were received, implicating that eight experts needed to vote 'stay' to reach the threshold of 80% for acceptance.

The results demonstrated whether a consensus was reached for the elements susceptible to change in the previous iteration. Experts considered all categories relevant and appropriately assigned to its dimension. For the individual categories, experts agreed on acceptance for seven out of ten categories. Concerning the remaining capabilities, 16 out of 18 were accepted. Experts provided suggestions to improve the model through open comments, which were carefully reviewed and provided with a response (Appendix B.3.3) resulting in an revised arrangement of the model (Appendix B.3.4). Elements under the *people* and *business development* dimensions underwent minor modifications. The remainder of this section elaborates on the changes within the *strategy* and *business operations* dimensions.

5.4.1 Strategy

Although experts agreed on all underlying categories, some modifications were processed due to improvement suggestions and the relocation of individual capabilities. An overview of the modifications to the *strategy* dimension is displayed in Figure 5.6.

Experts perceived the *finance & control* category to fit the *strategy* dimension while discussing the allocation of the capabilities. First, it was argued that the category name did not reflect the *environmental accounting* capability. It was highlighted that *finance & control* does not involve *environmental accounting* in corporate jargon. Second, it was mentioned that *regulatory compliance* often conflicts with financial interests, raising the question of whether it should be allocated under the same category as *financial management*. In response to these remarks, it was

decided to reformulate the category name to *reporting & compliance* and transfer the *financial management* capability to the *corporate* category.

Experts agreed on acceptance for the *corporate*, *implementation*, and *ecosystem* categories. The open comments for these categories revealed suggestions for minor adaptations. It was suggested to rephrase *corporate responsibility* to *corporate sustainability* to align with the most recent terminology. After reviewing the definition, it was decided to adhere to the suggestion. For the *implementation* category, an expert suggested reformulating the category name as it was believed that a different name might represent underlying capabilities more appropriately. As a result, the category was reformulated to *organization*. For the *ecosystem* category, the term 'circular' was added to emphasize the type of ecosystem.

Finally, the importance of *environmental accounting* was emphasized by experts. An expert noted that the European Commission is working on regulations that give climate reporting the same legal weight as financial reporting. Alternatively, another expert highlighted that an *internal control* capability was lacking in the model. Internal control is considered the process of providing reasonable assurance regarding objectives related to operations, reporting, and compliance (PwC, 2013). As the relevance of the capability is supported by comments of individual experts, it was decided to adopt the *internal control* capability in the model.

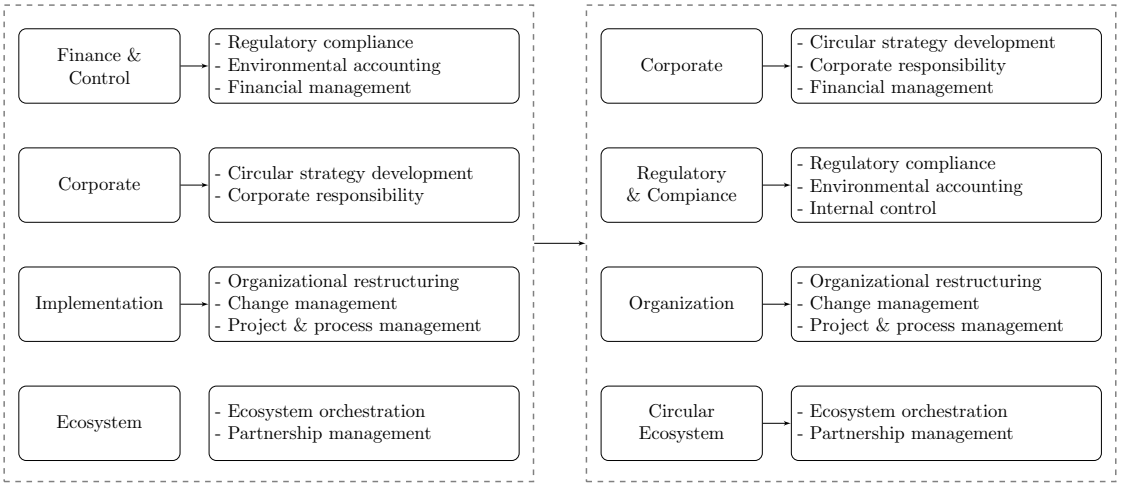


Figure 5.6: Changes to Strategy Dimension in Delphi Round 2

5.4.2 Business Operations

Voting on allocating the two categories within this dimension yielded acceptance for both. Instead, expert suggestions provided the rationale for changes in the allocated capabilities. Figure 5.6 gives an overview of the alterations.

Within the *business operations* dimension, a consensus on acceptance was reached for the *logistics & manufacturing* category. For the *research & development* category, experts rejected the *collaboration* capability and provided suggestions for improvement. Experts disagreed on the acceptance of the *collaboration* capability. The solicited comments demonstrated that the presence of the *partnership management* capability in the model renders the capability redundant. Therefore, it was decided to merge these capabilities in the *strategy* dimension.

Furthermore, experts suggested modifications for the formulation of the *innovation* capability. While reformulating the capability, it strongly overlapped with the *technology transfer* capability. As a result, it was decided to merge the *technology transfer* capability with the *innovation* capability.

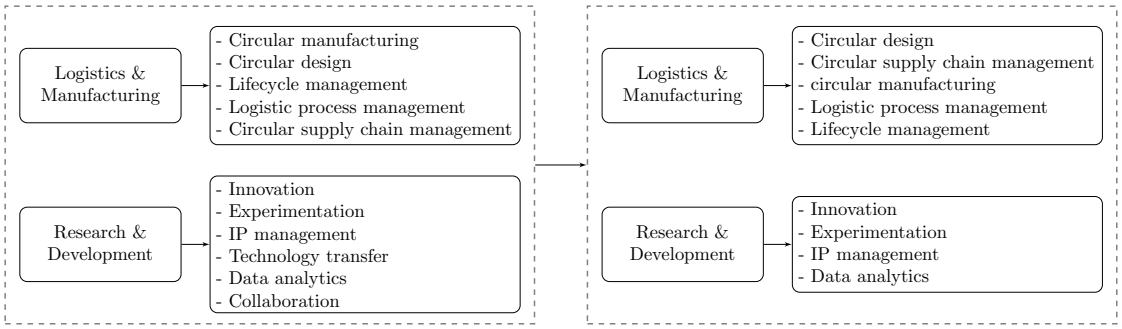


Figure 5.7: Changes to Business Operations Dimension in Delphi Round 2

5.5 Results of Round 3

A more confirmative approach was adopted in the third and final Delphi round. As the second round yielded a consensus on most of the model's elements and minor modifications were applied, it was decided to provide the experts with the previous round's results, a detailed overview of the changes, and the revised model. Accordingly, the experts were solicited by email to judge whether they agreed with the proposed model or had any further remarks. A confirmation was requested if they agreed, and a virtual meeting was scheduled if they had additional comments. In response, non of the experts indicated disagreement with the model, and no requests for changes were admitted.

5.6 Chapter Conclusion

The Delphi study has contributed to developing an empirically validated capability model. After three iterations, a consensus was reached by the expert panel on the elements of the capability model. Within these iterations, the structure, the capabilities, and their corresponding definitions were subject to modifications. Based on expert recommendations, two new capabilities were adopted in the model: *employee retention* and *internal control*. Furthermore, due to omittance, mergers, and additions, the number of capabilities in the model was optimized to 32. In terms of categories, experts supported the process of generating a more intuitive allocation of capabilities to overarching categories. The dimensions went through a minor transition by modifying the *Management & People* into the *People* dimension and allocating the management-related capabilities under the *Strategy* dimension. Experts proposed future improvement directions for the model, which have been included in Chapter 8. To conclude, the Delphi process yielded the final circular economy capability model that is further elaborated in Chapter 6.

Chapter 6

Proposed Capability Model

This chapter discusses the proposed artifact: the circular economy capability model. The model presents a comprehensive set of capabilities for implementing circular strategies. The model was developed by a systematic literature review that identified capabilities contributing to implementing circular strategies and, then, a three-round Delphi study with an expert panel of consultants, policymakers, practitioners, and academia that improved and affirmed the validity of the elements. Figure 6.1 visualizes the model by displaying the four dimensions at the center, encircled by 10 categories corresponding to the same-colored dimensions. An extended overview with a link to the web version is available in Appendix C. First, this chapter discusses the model's individual elements and, accordingly, elaborates on the practical use of the model.

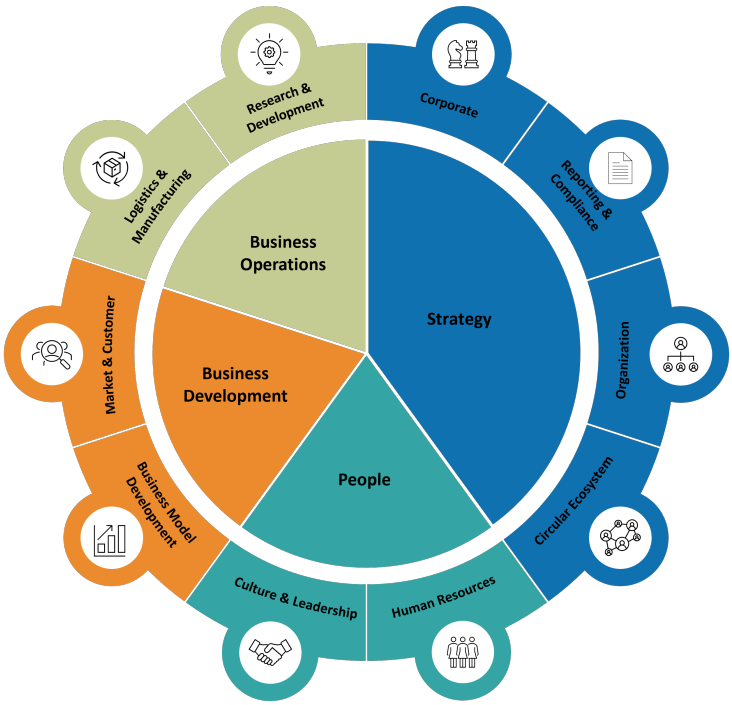


Figure 6.1: Circular Economy Capability Model

6.1 Elements of the Capability Model

The proposed model consists of four dimensions, 10 categories, and 32 capabilities accompanied by a corresponding definition. This section discusses the model's content according to the dimensions.

6.1.1 Strategy

The *strategy* dimension comprises four categories: *corporate*, *reporting & compliance*, *organization*, and *circular ecosystem*. The *corporate* category concentrates on developing a sound strategy, exhibiting social responsibility, and managing financial assets. The *reporting & compliance* category encompasses elements that relate to understanding and acting upon policies and regulations, developing appropriate indicators for assessing an organization's impact, and providing accurate information. The *organization* category is devoted to managing an organization's resources, managing change within the value chain, and managing projects and processes. Last, the *circular ecosystem* category focuses on the governance of the ecosystem and the establishment of partnerships. The capabilities allocated to these categories are displayed in Table 6.1.

Table 6.1: Capabilities Allocated to the Strategy Dimension

Corporate	
Circular strategy development	the ability to develop and communicate a strategy for the circular transition
Corporate sustainability	the ability to take appropriate ownership of organizational activities and to engage in environmental and social issues
Financial management	the ability to strategically plan investments, assess costs and financial risks
Reporting and Compliance	
Regulatory compliance	the ability to comprehend, anticipate, and comply to the regulatory landscape
Environmental accounting	the ability to develop, assess, and evaluate indicators that measure the impact of organizations' actions on humans, the environment, and resources
Internal control	the ability to assure the reliability, accurateness, and timeliness of provided environmental, financial, and legal information (PwC, 2013)
Organization	
Organizational restructuring	the ability to evaluate, prioritize, and adapt organizational resources and competencies
Change management	the ability to form a coalition of change agents and implement the planned changes
Project and process management	the ability to manage and define project and process management procedures
Circular Ecosystem	
Ecosystem orchestration	the ability to create, govern and improve circular ecosystems
Partnership management	the ability to explore, assess, develop and sustain strategic partnerships and organize collaborative practices

6.1.2 People

The *people* dimension constitutes two categories: *human resources* and *culture & leadership*. The *human resources* category considers the processes involved with the recruitment, training, and retention of employees. The *culture & leadership* category shows elements related to the organization's culture, the commitment of leadership, and the configuration of teams. Table 6.2 displays the capabilities allocated to these categories.

Table 6.2: Capabilities Allocated to the People Dimension

Human resources	
Recruitment	the ability to recruit personnel that aligns with the environmental and core values of the organization and possesses relevant skills
Training	the ability to provide employees with beneficial training and development programs to enhance skills and prepare for future positions (Hanaysha, 2016)
Employee retention	the ability to create and foster an environment that encourages employees to remain employed by having policies and practices in place that address their diverse needs (Kossivi et al., 2016)
Culture & leadership	
Circular culture	the ability to create a culture that encourages, engages, and influences employees and stakeholders to implement the circular economy vision
Leadership	the ability to ensure top management sponsorship and inspire employees to commit towards circular objectives
Team composition	the ability to configure relevant member attributes in a group that interacts interdependently to achieve a common objective (Somech & Drach-Zahavy, 2013)

6.1.3 Business Development

The *business development* dimension includes two categories: *circular business model* and *market & customer*. The *circular business model* category portrays the processes involved with the experimentation and development of business models aligned with circular principles. The *market & customer* category exhibits elements connected to understanding and managing customer expectations and keeping track of market trends and developments. Table 6.3 displays the capabilities allocated to these categories.

6.1.4 Business Operations

The *business operations* dimension contains two categories: *logistics & manufacturing* and *research & development*. The *logistics & manufacturing* category describes the operations involved with designing, manufacturing, and distributing a circular product or service and managing accountability along the lifecycle. The *research & development* category reveals elements connected to improving and innovating products and services, managing and sharing knowledge, and learning by utilizing technologies. Table 6.4 displays the capabilities allocated to these categories.

Table 6.3: Capabilities Allocated to the Business Development Dimension

Circular business model	
Business model experimentation	the ability to explore the most viable strategy to bring the product or service offering to the market
Business model development	the ability to design and implement circular business models
Market & customer	
Marketing	the ability to develop and execute sound marketing strategies, build relationships, and communicate value
Customer management	the ability to educate, manage the relationship with, and understand the expectations of the customer
Communication	the ability to design communication channels and communicate credible and transparent circular economy narratives
Market monitoring	the ability to monitor new trends, competitors' actions, and consumption patterns

Table 6.4: Capabilities Allocated to the Business Operations Dimension

Logistics & manufacturing	
Circular design	the ability to design products and services that incoporate circular principles and satisfy human needs and desires
Circular supply chain management	the ability to integrate circular accounting and monitoring in the management of the supply chain
Circular manufacturing	the ability to comprehend and integrate circular principles in manufacturing processes
Logistic process management	the ability to develop and manage processes for (reverse) logistics and (re)manufacturing
Lifecycle management	the ability to ensure accountability and manage the social and environmental impact throughout the product's lifecycle
Research & development	
Innovation	the ability to develop, integrate, and improve products, services, processes, and technologies
Experimentation	the ability to execute experiments and pilots to validate, learn, and adapt
IP management	the ability to manage processes related to the development, maintenance, distribution, and protection of IP assets
Data analytics	the ability to diagnose, discover patterns, and predict and prescribe relevant consequences based on data

6.2 Application of the Model

The proposed circular economy capability model provides a resource for those interested in an organization's transition toward the circular economy. The foreseen use of the model is twofold: descriptive through delivering a set of capabilities for the circular economy and prescriptive by presenting a capability base from which improvement objectives may be derived.

Zooming in on the descriptive use, inspecting the model supports identifying unfamiliar, overlooked, and unanticipated capability areas. Alternatively, comparing an organization's capability base with the model yields insights into understaffed capability areas and facilitates consequential discussions.

For the model to be of anticipated prescriptive use, a deep understanding of the organization's situation and the ecosystem in which it operates is a prerequisite. By presenting a holistic overview of capabilities, it must be emphasized that each capability's relevance level is situation-dependent.

Whether a capability is relevant to a specific organization must be carefully considered, and therefore, a sound understanding concerning the organization's role and responsibilities within its ecosystem is required. The prescriptive use of the model is seen as a subsequent step after identifying the exemplary composition of an organization's capability base. This way, the model demonstrates the desired capability base from which a potential path for improvement can be deduced (Frank, 2007).

The model distinguishes itself from previously developed circular economy models by presenting an empirically validated, comprehensive set of capabilities that are not tied to a particular industry. By taking an exhaustive approach toward the capabilities, the model aims to provide utility for various organizations considering implementing circular strategies and, thus, differs from its related work.

6.2.1 Best Practices for Using the Model

Based on the input generated during the capability model's development process, best practices were recognized and suggested to promote the efficacious use of the model.

- *Assess assumptions with domain specialists*: for the model to be of the predicted use, it is vital to understand the organization's position within its circular ecosystem. As one may struggle to gain an accurate understanding, assessing assumptions with domain specialists is recommended. With an understanding of an organization's position, the capability model can be tailored to illuminate the required capability base in a specific scenario.
- *Involve stakeholders in the assessment*: when assessing an organization's capability base, different ideas may exist on the relevance and presence of individual capabilities. It is recommended to assess an organization's capability base in the presence of the stakeholders to converge to an agreement and a shared understanding of a capability's state, relevance, and prioritization.
- *Use quantitative and qualitative methods for capability assessment*: the difficulty of assessing a capability depends on different aspects. It is recommended to apply qualitative (e.g., observations, interviews) and quantitative (e.g., company records, surveys) methods to assess the state of an individual capability. Relying on one of the methods might not be adequate for accurately judging the state of an organization's capability base.

6.3 Chapter Conclusion

This chapter presents the proposed circular economy capability model resulting from the design and development process. The model delivers a comprehensive overview of capabilities for implementing circular strategies. The model's content is discussed by highlighting the four dimensions and specifying the related elements.

Furthermore, this chapter zooms in on the use of the model. The model is projected to support organizations in both a descriptive and prescriptive manner. Descriptive by assisting in assessing an organization's capability base, and prescriptive by assisting in developing a path for improving an organization's ability to implement circular strategies. For prescriptive use, however, prerequisite knowledge regarding the circular ecosystem is demanded. Last, best practices for the efficacious use of the capability model were suggested.

The subsequent chapter will address the demonstration and evaluation of the circular economy capability model to understand to what degree it satisfies the objectives.

Chapter 7

Evaluation

Following a systematic design science research approach, a model that presents a set of relevant capabilities for implementing circular strategies was developed. An essential requirement of design science research is evaluating the developed artifact (Hevner et al., 2004). As discussed in the research design (Chapter 3), a summative ex-post evaluation strategy was adopted with characteristics of a naturalistic and artificial evaluation approach (Venable et al., 2016). For the evaluation of the capability model, two focus groups were conducted to understand whether the predefined solution objectives were achieved. This chapter elaborates on the focus groups' process and results, summarizes the findings, highlights improvement directions, and discusses the implications.

7.1 Criteria for Evaluation

Four criteria were defined for evaluation using the artifact evaluation taxonomy of Prat et al. (2015) and the criteria for reference model evaluation from Frank (2007): *completeness*, *appropriateness*, *understandability*, and *usefulness*. The process for identifying the criteria is reported in Chapter 3. These criteria were established to assess the extent to which the predefined solution objectives are satisfied. An overview of the criteria, aligned with the solution objectives, is presented in Table 7.1.

Table 7.1: Evaluation Criteria and Solution Objectives

(SO1) The model should present a set of capabilities that support the implementation of circular strategies
Completeness - the degree to which the model's structure contains all necessary elements (Prat et al., 2015) Appropriateness - the degree to which the model stresses an appropriate level of detail (Frank, 2007)
(SO2) The model should organize the capabilities in an understandable and comprehensive manner
Understandability - the degree to which the model can be comprehended, both at a global level and at the detailed level of the elements (Prat et al., 2015)
(SO3) The model should enable organizations to assess their capability base
Usefulness - the degree to which the model positively impacts the assessment of an organization's capability base (Prat et al., 2015)
(SO4) The model should support organizations in improving their ability to implement circular strategies
Usefulness - the degree to which the model positively impacts an organization's ability to improve circular strategies (Prat et al., 2015)

7.2 Participants of the Focus Groups

It was determined to conduct two focus groups in line with the previously defined (Chapter 3) target audiences. The first focus group was composed of potential end-users from consultancies and governmental bodies, while the second group included managers and executives from the industry. This section discusses the selection process, and briefly elaborates on the organizations that participated.

7.2.1 Selection Process

It was decided to aim for between four and six participants for the composition of both groups. Tremblay et al. (2010) investigated the use of focus groups in design science research and discovered a lower limit of four participants. Furthermore, they debated that a focus group with more than six participants is questionable as the subject matter is typically more complex than traditional focus groups. Consequently, a group size of between four and six participants was deemed desirable.

Purposive sampling, the selection of participants based on their characteristics, was used to select the participants (Etikan, 2016). For the first focus group, candidates were chosen by their experience with circular economy implementation. Candidates were eligible when they occupied a senior advisory role for circular economy-related activities. For the second group, managers and executives at companies that adopted circular strategies were approached. Candidates involved in the decision-making process for implementing circular principles were considered eligible. In the group with consultants and advisors, four of the five participants that agreed to participate were present. Of the four participants that agreed to participate in the group with managers and executives, three were present. An overview of the participants and their roles is presented in Table 7.2. In the remainder of this section, the organizations that participated in the focus groups and their relation with the circular economy is briefly discussed.

7.2.2 Involved Organizations

This section provides background information on the organizations that participated in the focus groups. Especially for the focus group with managers & executives, there was specifically aimed for organizations that implemented circular principles.

Focus Group 1

Participants from the consultants & advisors focus group represented four distinct organizations. First, *Tauw*, a leading consultancy and engineering firm that supports developing a strategic approach and offers solutions for sub-questions in the field of circular economy (Tauw, 2022). Second, *OK! Platform*, an advisory firm that helps organizations resolve internal issues and arrive at a sustainable value proposition of which the circular economy is an important aspect (OK!-Platform, 2022). Third, *Ministry of Infrastructure and Water Management*, who ensures a safe, liveable, and accessible Netherlands and has a division that advises on circular economy implementation and policies (Ministerie van Infrastructuur en Waterstaat, 2022). Last, *De Graaf & Co.*, who encourages and guides organizations to transition towards a circular economy, with a focus on knowledge transfer and communication (De Graaf & Co, 2022).

Focus Group 2

The participants within the managers & executives group originated from three different organizations that engage with the circular economy. *Waterschap Brabantse Delta* aims to limit climate change. They do this by reducing CO_2 emissions, saving energy, generating sustainable energy, reusing raw materials, and purchasing sustainably (Waterschap Brabantse Delta, 2022). *Decathlon* takes responsibility for reducing its CO_2 emissions in line with the recommendations of the scientific world. They are convinced that adopting a scientifically recognized trajectory is the best way to do this. When developing a circular economy model, considerations are focused on

their product ranges (raw materials, eco-design), the response to new consumption patterns (repair, second-hand, rental), and end-of-life product management (Decathlon, 2022). *InSus* wants to develop a leading position in the circular production of building materials and thus stimulate sustainability and circularity in the sector. Because the available raw materials on earth are finite, they want to transform linear production into circular production and, at the same time, drastically reduce the burden on the ecosystem (InSus, 2022).

Table 7.2: Participants of the Focus Groups

	Focus Group 1: Background	Organization
P1	Advisor for circular economy and sustainability implementation. Advises companies and governments and facilitates the interaction between both parties.	Tauw
P2	Advisor on value-retention, sustainability and the circular economy. Co-developer of the master circular economy at the HAN University of Applied Sciences	OK! Platform
P3	International circular economy advisor. Focused on the execution of sustainable policies and implementing the circular economy in practice.	Ministry of Infrastructure and Water Management
P4	Advisor for the Circulaire Maakindustrie and project manager at Holland Circular Hotspot. Focused on international partnerships to facilitate and design circular value chains.	De Graaf & Co.
	Focus Group 2: Background	
P5	Innovation manager - Responsible for the recovery of natural resources in wastewater and circular procurement	Waterschap Brabantse Delta
P6	Lead of Dutch circular team - Responsible for the development of circular business models	Decathlon
P7	Founder - Responsible for the circular strategy of circular insulation business	InSus

7.3 Structure of the Focus Groups

Both focus groups were conducted virtually and lasted approximately one hour. For determining the structure of the focus groups, the steps of Tremblay et al. (2010) were followed, leading to a structure as denoted in Table 7.3. This section briefly elaborates on the performed steps.

First, there was time reserved for a welcoming speech and for the participants to introduce themselves and elaborate on their circular economy activities and responsibilities. Then, the research was introduced by elaborating on the research goal and the definitions of the applied concepts.

Second, participants were familiarized with the issue that the model aims to tackle before presenting the developed capability model. The scenario "Pioneering circularity in the healthcare industry: Royal Philips" by Ellen MacArthur Foundation (2020) was presented. This scenario concentrates on Philips embedding circular principles into the company's practices. Participants were requested to think of capabilities that were relevant to the presented scenario. This process yielded a brief discussion and a list of capabilities. Accordingly, the developed capability model was presented with a reflection on the presence of the earlier-mentioned capabilities.

Third, participants were provided access to a web version of the capability model and time for inspecting and assessing the model. The web version contained an overview of the model and a table of contents that referred to each capability's definition and background information. Participants were requested to assess the model while keeping their circular-related activities in mind.

Fourth, discussions were held for each criterion to elicit the model's performance. During these discussions, the group could converge to one shared opinion, or multiple opinions could persist. Eventually, the participants were asked to complete a questionnaire to quantify the model's performance on the criteria. The next section elaborates on the results of the focus groups.

Table 7.3: Structure of Focus Groups

(1)	*Introduction and background* ($\pm 5min$)
	During the introduction, participants were asked to introduce themselves and elaborate on the relevance of the circular economy for their role. Then, the research goal was elaborated, and the definitions of circular strategies and capabilities were aligned.
(2)	*Use Scenario* ($\pm 10min$)
	A scenario of a company that implemented circular strategies was presented to the participants. Subsequently, participants were solicited to think of capabilities relevant to implementing circular strategies in the prescribed scenario. After a discussion, the developed model was displayed and elaborated.
(3)	*Participant Interaction* ($\pm 15min$)
	Participants were provided a link to a dedicated web version of the model and were granted time to inspect the model and assess the elements.
(4)	*Discussion on Criteria* ($\pm 30min$)
	Discussions were held for each evaluation criterion. The sessions were concluded by soliciting the participants to complete a questionnaire to quantify the results.

7.4 Results of the Focus Groups

In this section, the results from the focus groups are discussed. Participants elaborated in depth on each criterion and completed a questionnaire allowing a quantitative representation. This section discusses the results from the focus groups, followed by an overview of the questionnaire's results. Accordingly, a summary is provided and the findings are discussed in light of the current advancement of literature. Detailed transcripts of the focus groups are reported in Appendix D.1.

7.4.1 Completeness

The completeness criterion reflects the extent to which the model contains all necessary elements (Prat et al., 2015) and is one of two criteria for assessing the first solution objective.

Consultants and Advisors

The participants converged to a shared judgment indicating that the model appears complete; however, it is was recognized that it is generally unattainable to be fully complete. Participants argued that when developing such a model, it is generally impossible to be fully complete.

P1: *"It looks reasonably complete; it looks like most is covered."*

P2: *"The model contains a lot of information."*

P3: *"When you are developing a model like this, you have to realize that you will never be fully complete."*

To conclude, the model is considered an effort to describe a complete set of capabilities for implementing circular strategies. Although the participants did not identify missing capabilities, it is generally believed that full completeness is impossible.

Managers and Executives

Participants judged that the model seemed to be complete from a pragmatic perspective. Given the circular economy's holistic characteristics, it was considered challenging to assess the completeness of the model. Furthermore, participants reasoned that the model comprised capabilities that intersected with the capabilities of 'linear' organizations.

P5: *"The model looks very complete in the time I looked at it. From an operational perspective of a business, I think it is very complete. However, from a more holistic perspective, I am unsure whether everything is covered. It depends where you define the boundaries of responsibility of an organization."*

P6: *"Overall, the model is very complete for the day-to-day business. However, in the circular economy, the ecosystem is very important, and I notice that many companies are not prepared for that. It has to be in the core of the organization that you want to be part of that ecosystem. And this determines whether you can cope with the circular developments within your area of interest. This is something that the model misses for me."*

P7: *"I think the model is very complete. I agree that when having a circular business, every element needs attention and should be considered. However, I think the model contains many elements that are also relevant for traditional companies that do not engage in circularity."*

Participants stressed that the capability model appeared to be complete. However, ensuring completeness from a holistic circular value-chain perspective is challenging. Furthermore, one participant highlighted that the model overlooks an element demonstrating an organization's intention to be part of the circular ecosystem. The model, however, reflects ecosystem thinking in the *ecosystem orchestration* capability.

7.4.2 Appropriateness

Appropriateness is relevant as it is considered that reference models *"should stress an appropriate level of abstraction in detail—with respect to the purpose, a model is supposed to fulfill"* (Frank, 2007, p. 130). Appropriateness is the second criterion that is utilized for the evaluation of the first solution objective.

Consultants and Advisors

The discussion on the appropriateness criteria yielded various insights. First, the depth in which the capabilities are elaborated raised discussions. Participants remarked that the model does not support determining and quantifying the organizational impact that is imposed.

P2: *"For me, it is unknown whether the aspects in the model allow you to understand your current impact and whether you can calculate it."*

Alternatively, participants argued that the current model does not depict the dependencies between the capabilities. It was argued that understanding these when engaging in circular principles is crucial. Although these dependencies are outside the scope of current research, these comments were considered relevant to the appropriateness criterion.

P2: *"The model shows the elements in silo's. Understanding the interdependencies between the elements when developing a new business model is essential."*

P4: *"Circular design is developed together with the business model. So these are dependent elements."*

To conclude, it was found that the elements were considered relevant for the circular economy. However, it was reckoned that the descriptions of the capabilities do not elaborate on the specific implementation of an individual capability. Moreover, participants stressed the importance of underlying relations between capabilities. It should be noted that guidelines on capability implementation and dependencies between capabilities are beyond the current research's scope.

Managers and Executives

Participants had a common understanding regarding the appropriateness criteria of the model. It was argued that the model misses in-depth explanations and concrete steps for the execution of the capabilities. Moreover, participants found that the model appeared to cover capabilities appropriate for both 'linear' and 'circular' organizations. A stronger emphasis on the difference between 'linear' and 'circular' organizations within these capabilities was considered desirable.

P6: *"I miss additional in-depth explanation on the capabilities: what does the capability contribute to the circularity of a company? Since some capabilities are also relevant for traditional businesses, it must be emphasized how the capability should be differently executed to be more circular."*

P7: *"I would like to see a more in-depth explanation of the capabilities. I think the overview is very helpful; however, a more in-depth explanation would definitely contribute. You need a different mindset on the capabilities when you approach it with a strong circular purpose."*

The participants converged to a shared opinion that the model misses a more profound level that elaborates extensively on the content of the capability and emphasizes how it contributes to circularity. The current status of representation was considered abstract to a certain extent. The discussion section further reflects on the abstractness of the model and intersection of 'linear' and 'circular' capabilities.

7.4.3 Understandability

The understandability criterion relates to the degree to which the model can be comprehended and understood, both the information and the structure (Prat et al., 2015). The criterion relates to the second solution objective for the developed model.

Consultants and Advisors

Participants settled on the premise that the model overview was straightforward and intuitive. It was argued that the dimensions and categories allowed for prompt navigation toward the corresponding capabilities.

P4: *"The structure and categories are clear and intuitive with the components of a company. For example, someone could recognize, I am responsible for human resources, so the underlying capabilities are relevant for me."*

P3: *"I find the dimensions and categories familiar and recognizable. It shows four dimensions and whenever you zoom in, you understand the aspects that you should consider."*

Alternatively, it was recognized that the model's content raised questions for the participants. It was questioned whether organizations would be able to understand and distribute the responsibilities of all capabilities in the model. Moreover, participants derived some unforeseen assumptions from the model.

P4: *"With circular ecosystem, for example, I am not sure whether someone within an organization directly raises their hands and recognizes that it is a responsibility for his or her department."*

P4: *"There are many elements in the model that suggest equal importance of the capabilities. They are all relevant, but one capability is more relevant than another."*

Participants agreed that the model was intuitive and that the dimensions and categories could be linked to different organizational departments. However, participants derived unanticipated assumptions from the model, suggesting that there might be a gap between the information the model conveys and what it attempted to convey. Dependencies between capabilities and priority levels are not included in the scope of this research.

Managers and Executives

Participants were united in their opinion when discussing the understandability criterion. It was agreed that the model was understandable and that the elements with corresponding definitions were clear. The structure of the model did not raise questions with the participants.

P5: *"Model is understandable. When I am reading the model, it is easy to understand, and the texts are clear for me."*

P7: *"Yes, the model is very understandable and clear."*

Consequently, it was apprehended that the participants shared a positive perception of the understandability of the model.

7.4.4 Usefulness

The usefulness criterion relates to the extent to which the model is useful for two scenarios: first, for assessing an organization's capability base and, second, for deriving a path for improving an organization's ability to implement circular strategies. By evaluating the usefulness criterion, it is aimed to examine whether the third and fourth solution objectives have been satisfied.

Consultants and Advisors

Participants were requested to comment on the applicability of the model. First, they commented on the model's use for assessing their current capability base. The participants recognized use for assessing the capability base of organizations. It was argued that the model could identify unanticipated capabilities and investigate whether a company occupies a capability base ready for improvement. Furthermore, it was mentioned that startups could use such a model as a guide to get a sense of future development directions.

P3: *"The model's usefulness for me would be to consider and think about the capabilities and determine whether you thought of them and whether you think they are relevant for a certain type of company.*

P3: *"I find the dimensions and categories familiar and recognizable. It shows four dimensions, and whenever you zoom in, you understand the aspects that you should consider. Then organizations can determine whether they already possess the capability or not. In this way, you support firms and public organizations to consider their steps within the circular economy carefully. They could ask themselves: am I ready for the next step, or should I improve some capabilities first?"*

P1: *"The model seems to focus on larger companies as there are many capabilities, different categories, and different departments. Hence, I assume that it is not focused on, for example, a startup. However, it could be beneficial for a startup to trigger them to consider unanticipated elements."*

Second, the participants considered the usefulness of supporting organizational improvement. Participants identified limited use for improving an organization's implementation of circular strategies. It was argued that understanding what capabilities are relevant is a challenge that must be tackled before improvement strategies can be designed. In other words, not all capabilities were considered suitable for every organization.

P1: *"It is very case-specific which capabilities are relevant and translating the capabilities from the model to a subset of capabilities that is relevant for an individual case remains a challenge."*

P3: *"There will always be things that people do not need. It might be too much for one organization, and for the other, there might even be a lack of capabilities. This depends on many factors such as product, market, organization, etc."*

To summarize, participants foresee the use of the model mainly for assessing an organization's capability base and identifying unanticipated capability areas. For supporting the development of improvement strategies, participants see limited use as there must be carefully considered whether capabilities are relevant for a given organization and situation.

Managers and Executives

The participants were asked to express their opinion on the model's usefulness. First, they elaborated on the use of the model to assess their current capability base. It was found that the model has limited use for assessing their current capability base. One participant argued that an overview of pertinent capabilities was present in their human resources department. In contrast, one participant argued that the model helps by providing an overview but expressed hesitance since the model was thought to be mapping capabilities relevant to any generic organization.

P6: *"For Decathlon, the HR department monitors the capabilities in the teams and determines which capabilities are desired in teams. Therefore, a capability overview is more or less present. However, it would be interesting if you could provide more in-depth details and determine which actions to take. For example, that recruitment knows who to recruit.*

P7: *"The model helps with providing an overview; however, I think that when we would not be applying circular principles, the value for me would be similar as it maps many generally relevant capabilities."*

Participants pointed out that the model provides little use for developing improvement strategies. It was argued that concrete in-depth descriptions and action points should be derived from the capabilities to support the development of improvement paths. Alternatively, one participant found that the model demonstrated a focus on enterprises with a product or a service; hence, it was not considered helpful.

P7: *"The model, without further details does not help me for the determination of improvement strategies. I can analyze the model and think by myself about how we currently fill the capabilities. However, I am very curious about a layer that goes more in-depth on the activities. This determines for me whether it is useful."*

P5: *"In the public domain, some capabilities are relevant. However, for me personally, as it looks to be focused on a product or a service, it is not that useful for me."*

To conclude, the participants foresee a limitation in the model's usefulness in its current state. It was stressed multiple times that more concrete steps for the execution of these capabilities and a precise elaboration on why a specific capability is relevant and how it may influence their circular performance are desirable.

7.4.5 Questionnaire Results

At the end of the focus group, participants were asked to complete a questionnaire to quantify the criteria individually. The questionnaire (Appendix D.2) consisted of 11 questions that could be answered with a five-point Likert scale ranging from *strongly disagree* to *strongly agree* (Likert, 1932). The descriptive statistics of the questionnaire are provided in Table 7.4, and comparative bar charts for the different focus groups are presented in Figure 7.1.

Table 7.4: Descriptive Statistics of Evaluation Criteria

	Consultants & Advisors				Managers & Executives			
Criterion	$\bar{x}$	s	min	max	$\bar{x}$	s	min	max
Completeness	3.38	0.74	2.00	4.00	3.50	0.84	2.00	4.00
Appropriateness	3.58	0.67	3.00	5.00	2.44	1.24	1.00	5.00
Understandability	3.50	0.67	2.00	4.00	4.44	0.73	3.00	5.00
Usefulness	3.33	0.89	2.00	5.00	2.56	0.53	2.00	3.00

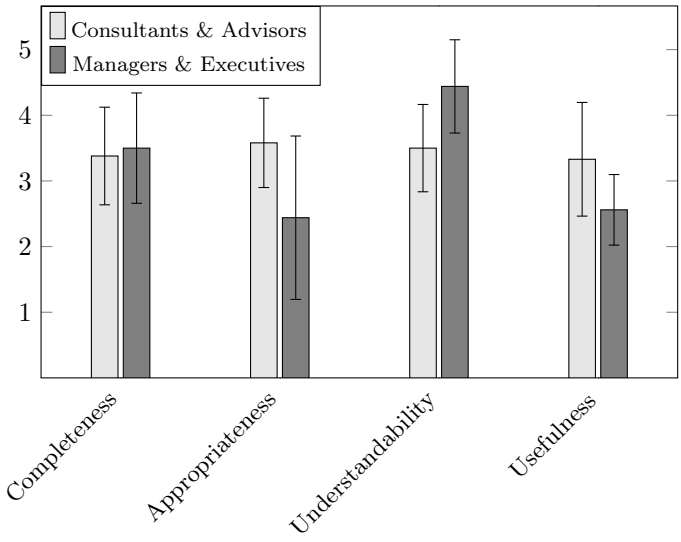


Figure 7.1: Questionnaire Results for Criteria

Figure 7.1 shows that the participants of the different focus groups had a similar rating for the completeness of the model. For the other criteria, greater differences are visible. In line with the perceived participant attitude in the discussions, managers and executives consider the capability model less appropriate and useful than the consultants and advisors. These results, however, should be carefully interpreted due to the relatively small focus group sizes.

7.4.6 Reflection on Solution Objectives

This section elaborates on the conclusive statements for the solution objectives deduced from the focus groups' results. The first solution objective describes that the model should present a set of capabilities that support implementing circular strategies. It was concluded that the model presents a comprehensive view of capabilities; however, since true completeness is improbable, the objective is considered partly satisfied. The second objective relates to the understandability of the model. It was concluded that the model provides an intuitive representation of its elements; hence, the objective was considered satisfied. Objectives three and four concern the usefulness of the model. It was concluded that the model partly satisfies the third objective as participants did not converge to a shared understanding. The fourth objective was concluded as unsatisfactory since little use for improving an organization's ability to improve circular strategies was recognized. Below in Table 7.5, the solution objectives are mapped against the conclusive statements.

Table 7.5: Evaluation of Solution Objectives

SO1: The model should present a set of capabilities that support the implementation of circular strategies
◐ It is concluded that the model provides an integral representation of relevant capabilities, and full completeness is considered improbable; hence, the objective is regarded as partly satisfied.
SO2: The model should organize the capabilities in an understandable and comprehensive manner
● It is concluded that the model provides a clear and intuitive representation of the identified capabilities; hence, the objective is regarded as satisfied.
SO3: The model should enable organizations to assess their capability base

Continued on next page

Table 7.5: Evaluation of Solution Objectives (Continued)

◐	It is concluded that the anticipated end-users had diverging perspectives on the achievement of this objective; hence, the objective is regarded as partly satisfactory.
SO4: The model should support organizations in their ability to improve circular strategies	
○	It is concluded that the anticipated end-users perceived limited support; hence the objective is not met. A more profound layer is necessary.

7.5 Summary of Focus Groups

The focus groups yielded insight into the perspectives of the anticipated end-users of the model on four criteria: completeness, appropriateness, understandability, and usefulness. This section provides a summary of the participant's perspective on the criteria.

Regarding completeness, participants argued that the set of capabilities appears complete as it covers elements related to different organizational departments. Nevertheless, both groups argued that absolute completeness is not achievable due to the holistic characteristics of the circular economy. The group with the consultants and advisors found that dependencies between the elements were missing aspects of the model. The elements were perceived to be placed in silos, as there is no interaction between the capabilities. The participants emphasized that the model misses these relationships as they are believed to be crucial in the circular economy.

Considering the appropriateness of the model, a difference in stance between the groups was identified. Both groups argued that the model misses a profound layer for understanding how the capabilities should be acquired or executed. Especially the group with managers and executives emphasized the lack of an in-depth and profound layer for the capabilities. The group consisting of consultants and advisors had a more positive attitude toward the appropriateness of the model.

When assessing understandability, the majority of participants in both groups mentioned the model as clear, understandable, and intuitive. Clear since participants thought to comprehend the texts and the underlying meaning of the capability. Understandable and intuitive regarding the overview and allocation of capabilities to specific categories and dimensions.

The last criterion was the usefulness of the model. When assessing usefulness, the participants reflected on two use scenarios of the model. The first scenario considers the model as a tool to support the assessment and evaluation of the existing capability base of an organization. For this purpose, the group with consultants and advisors recognized utility. In contrast, the group with managers and executives indicated that limited utility is supplied for this scenario. The second scenario encompasses the development of improvement strategies from the capability model. For this scenario, limited utility from the capability model is anticipated by both groups. The consultants and advisors reasoned that the uniqueness of each organization represents the main barrier to such use. Managers and executives argued that an additional profound layer for each capability is required to derive improvement strategies.

To conclude, four criteria have been evaluated by participants from consulting bodies and industries. First, the model was assessed on its completeness. Participants perceived the model as generally complete, while it was explicitly commented that full completeness is considered improbable. Second, the appropriateness of the model was examined. Participants found the model lacking a profound layer that elaborates on the implementation strategy for each capability. Third, the understandability of the model was evaluated. The majority of the participants described the model as *"intuitive"* and *"clear"*; hence it was considered understandable. Fourth, the usefulness for assessing an organization's capability base and developing strategies for improvement was considered. Participants from consulting bodies found a use for the model when assessing capability bases. For developing improvement strategies, limited use was recognized. Participants from the industry noticed limited use for assessing their capability base and little to no use for developing improvement strategies but for facilitating dialogue. Therefore, the circular economy capability model provides utility when assessing an organization's capability base and by facilitating dialogue when implementing or improving circular strategies.

7.6 Discussion

This study demonstrates the development of a circular economy capability model that provides a valuable instrument for organizations transitioning toward the circular economy. The findings indicated that the model provides an exhaustive and intuitively organized set of capabilities for implementing circular strategies. The model enables the assessment of an organization's capability base and facilitates dialogue on the capability base's state. This section reflects on the findings of the evaluation and suggests avenues for future research.

Contrary to prior capability research in the circular economy domain, the circular economy capability model is generically focused. Previous research often served specific industries such as the agri-food (Kusumowardani et al., 2022) and manufacturing (Uhrenholt et al., 2022) industry or specific areas such as industry 4.0 (Belhadi et al., 2022), digital (Chaudhuri et al., 2022) and managerial (Bertassini et al., 2021) capabilities. Instead, this research identified, combined, and synthesized the segregated knowledge into a holistic, empirically validated model.

The findings from the focus groups suggest that managers perceived the model to contain capabilities that apply to traditional linear organizations. A plausible explanation is that there is an intersection in capabilities between linear and circular organizations. Both types of organizations may need particular capabilities for an effective course of business. As the goal of the model was to offer a meticulous overview, capabilities subject to this intersection are deliberately included.

Results from the evaluation contradict the support of the model for improving circular strategies. This is noteworthy as reference models deliver prescriptive use by providing a blueprint for a strikingly good design of an organizational context (Frank, 2007). It might suggest that the model requires tailoring to a specific organizational setting before being of prescriptive use. This way, the model would be closer to establishing a 'strikingly good' design of an organization's capability base. Moreover, the level of abstraction that characterizes a reference model seemed to hamper the perceived potential of the model's application for improving circular strategies.

By performing the evaluation separately with the groups of anticipated end-users, the data contribute to a clearer understanding of a group's preference. The responses suggest that the group with consultants & advisors were more comfortable deriving the capability model's usefulness than managers & executives. Instead, managers & executives reiterated the need for an in-depth articulation of each model element which is beyond the scope of this study. The reason could be that consultants & advisors are more familiarized with capability models due to their widespread presence in the consulting domain (de Bruin et al., 2005). In that case, consultants & advisors might be the most suitable audience for the proposed capability model in its current state.

The evaluation of the capability model indicates that practitioners may benefit from a maturity model. Maturity models are regarded as tools that facilitate comparison, identify opportunities for improvement, and guide organizational development by depicting an anticipated implementation path (Lasrado et al., 2015). The participants' reasoning behind suggestions for a profound layer aligns with the features that a maturity model offers. Therefore, developing a maturity model upon the capability model's foundation is a promising path for future research.

Findings from the evaluation suggest that capabilities have strong dependencies, which are highly relevant when implementing circular strategies. To illustrate, focus group participants pointed out that, in some cases, legislation discourages them from implementing circular strategies. In such a case, an organization's lobbying strategy (part of *ecosystem orchestration*) is dependent on the organization's comprehension of the regulatory landscape (part of *regulatory compliance*). Visualizing these dependencies may enhance the understanding of the dynamics within an organization's capability base and combats the perception of capabilities operating in isolated 'silos'. As such, investigating the dependencies between the capabilities may be an interesting direction for future research.

To summarize, this section discusses the position of the developed model compared to its related work, reflects on the findings contrary to the anticipated outcomes, and suggests areas for future research. By developing a comprehensive, empirically validated circular economy capability model, the proposed artifact distinguishes itself from prior works. Presented capabilities may intersect with capabilities that are pertinent for an effective course of business for linear organizations,

illustrating the model's exhaustiveness. It is suggested that tailoring the model to a specific scenario may be required before fully unlocking its prescriptive potential. Moreover, It is reasoned that consultants & advisors are the most appropriate audience for the model in its current state. Last, avenues for future research were identified: developing a maturity model using the proposed capability model as foundation, and investigating the dependencies between capabilities which may contribute to an understanding of the dynamics within an organization's capability base.

7.7 Chapter Conclusion

This chapter elaborates on the evaluation procedure of the proposed circular economy capability model. For the evaluation, two focus groups were conducted with the anticipated end-users. The first group consisted of consultants & advisors and the second group of managers & executives. This way, four criteria have been evaluated by participants from consulting bodies and industries: completeness, appropriateness, understandability, and usefulness.

With these evaluation sessions, it was concluded that the model is considered as reasonably complete, while it is generally understood that full completeness is improbable. In terms of appropriateness, a more profound layer was considered missing for the implementation of capabilities. Concerning understandability, the model is regarded as understandable and intuitive. For the usefulness, use of the model was recognized when assessing capability bases while limited use was identified for developing improvement strategies. As a result, it was concluded that the solution objectives were partly satisfied.

Accordingly, the discussion chapter reflects on the findings and suggests implications of the results. Moreover, it identifies apparent paths for improvement. The next chapter addresses the overall conclusion of this research and elaborates on the implications, limitations, and directions for future research.

Chapter 8

Conclusion

A seismic shift from a linear to a circular economy is essential to reduce ecological pressure and enhance the security of primary raw material supplies (Neves & Marques, 2022). Organizations must implement circular strategies to realize this shift toward the circular economy (Castro et al., 2022). The objective of this research is to develop a circular economy capability model to support organizations with the implementation of circular strategies.

The outcome of this research proposes a circular economy capability model that provides a valuable instrument for organizations transitioning toward the circular economy. The model demonstrates a comprehensive and intuitively organized set of capabilities for implementing circular strategies. As a result, the model enables the assessment of an organization's capability base and facilitates dialogue on the capability base's state.

A systematic literature review was conducted to provide insight into the capabilities that are essential and pertinent for implementing circular strategies. From the findings of this review, an initial model was synthesized that was further enhanced and extended through a three-round Delphi study with 11 domain experts from consultancies, governmental bodies, industry, and universities. This process yielded the proposed circular economy capability model.

Accordingly, focus groups were organized with the anticipated end-users to evaluate whether the solution objectives were satisfied and whether the model provided the anticipated benefits. Results show that the model has limited use for supporting the improvement of circular strategies; instead, the model provides use for assessing an organization's capability base and facilitating discussion on the state of the capability base. Consequently, the research objective is concluded as partly satisfied.

Implementing circular strategies will make organizations more sustainable and resilient in the future. Organizations are coerced to report and justify the ecological expense of their activities. It requires ingenuity and a shift in focus to long-term interests to fulfill this transition satisfactorily. Thus, top management should no longer wait and act upon the circular potential of their organization.

8.1 Theoretical Implications

This research extends the existing body of literature with the development of a circular economy capability model and offers multiple noteworthy advancements.

First, it impacts the circular economy research domain by responding to an identified literature gap indicating a scarcity of empirically validated tools mapping capabilities for implementing circular strategies. In doing so, it provided an exhaustive up-to-date systematic literature review of capabilities for implementing circular strategies. Additionally, this work empirically advanced and evaluated the model. From the limited available tools that aim to present a comprehensive overview of relevant capabilities, to the best of the author's knowledge, none applied empirical techniques for model advancement or evaluation.

Second, the study contributes to maturity model research domain by providing the foremost element of a maturity model: a reference model (Salah et al., 2014). The proposed circular economy capability model could serve as foundation for developing a maturity model.

As articulated in the discussion, the outcomes of this study go beyond prior studies. Previous studies proposing a circular economy model or tool focused on specific capability areas (Belhadi et al., 2022; Ingemarsdotter et al., 2019) or industries (Kusumowardani et al., 2022; Uhrenholt et al., 2022). In contrast, studies that presented an overview of capabilities (Khan et al., 2020; Seles et al., 2022) did not construct an actionable model nor did they apply empirical validation techniques. By identifying, integrating, and arranging the segregated knowledge in an empirically validated model, this research extends the body of literature.

To conclude, current study offers multiple implications to the existing body of literature. First, the study contributes by presenting an up-to-date systematic literature review. Second, it presents a circular economy capability model subject to an empirical iterative improvement method for advancement. Third, it presents the results of two confirmatory focus groups with the anticipated end-users to determine whether the predefined solution objectives were satisfied. Fourth, the designed model represents the foundation for maturity model development.

8.2 Practical Implications

This section elaborates on the practical implications of the circular economy capability model. The model allows for assessing and mapping an organization's capability base. The capability model provides an overview of capabilities relevant to organizations that aim to integrate circular practices. Results show that the model is a comprehensive and an intuitive tool that supports determining whether the capabilities to engage in circular practices are present. It supports identifying unanticipated capability areas and can be used as a reference point when debating the relevance of capabilities for an organization.

Furthermore, the model facilitates the discussion on the circular transition. Projected end-users argued that the structure of the model is intuitive with the components of an organization; hence, it facilitates discussion on roles and responsibilities. Building on the assessment functionality, the model supports internal discussion for organizations on their state and whether advancement is required before engaging in certain circular practices.

To conclude, the model provides two main implications for practice. First, it can be used to assess and map an organization's capability base. Second, it supports discussion regarding the distribution of responsibilities and an organization's readiness for advancing in circular practices.

8.3 Limitations

Several limitations of the current study were recognized and discussed in this section. First, the limitations of the proposed capability model are debated, and then the relevant limitations to the development process.

As the identification of capabilities was limited to the findings of the systematic literature review, it is unattainable to be truly exhaustive when determining capabilities. As a result, the proposed model is limited to a comprehensive but not complete set of capabilities.

Contrary to the aim of this research, the model does not adequately deliver the anticipated prescriptive utility to its end-users. The capability model, in its current setup, provides limited utility for the development of improvement strategies.

Limitations concerning the development process are fourfold. First, the research scope was bounded to developing the foremost component of a maturity model: a reference model.

Second, the constant comparison technique is utilized to develop an initial model. The author used inductive reasoning to synthesize the initial capability model by applying the constant comparison technique. Through the application of this technique, reproduction may be difficult, and there is a potential for personal bias.

Third, limitations regarding the Delphi study were identified. As the proposed model is extensive, the expert panel was confronted with time-intensive questionnaires, which may have encouraged hasty decisions. Furthermore, it is unclear whether the convergence of group judgments increases the accurateness of the decisions (Powell, 2003).

Fourth, the capability model was evaluated with constraints in time and size, representing a limitation. As the aimed number of participants was not reached in one of the focus groups, the data may lack input covering alternative perspectives. Furthermore, participants had limited time to review the model, which restrained identifying additional shortcomings and improvement areas.

As such, this research is subject to several limitations. To start, the scope of this research is limited to developing the foremost component of a maturity model and the presented set of identified capabilities is as exhaustive as the advancement of current literature. The proposed capability model does not provide the anticipated prescriptive utility. Furthermore, the adopted techniques for developing the model were susceptible to personal bias, and the methods were bound in terms of time and availability of experts and participants. These bounds may have impeded the identification of shortcomings and improvement areas.

8.4 Suggestions for Future Research

This section embellishes suggestions for future research and further development of the proposed capability model. The identified avenues for future research are threefold: extending the model with a maturity element, investigating and visualizing the dependencies between the capabilities, and designing a tool that guides when tailoring the model to a specific organization.

The first suggestion is to use the proposed capability model as a foundation for developing a maturity element to the model. During the focus groups, the main advocated reason for the limited utility by managers and executives was a deficiency of a profound layer that elaborates on the different stages of a capability. Moreover, there was argued that a description of the capabilities in a 'linear' state and a 'circular' state would be highly desirable. These suggestions are aligned with the inherent characteristics of a maturity model. Consequently, adding a maturity element to the proposed capability model is recommended as a future research suggestion.

The second suggestion is to investigate the dependencies between the different capabilities. Domain experts stressed that recognizing the importance of dependencies between capabilities is crucial to prevent undesirable silos. An illustrative example where dependencies between capabilities exist is with the *ecosystem orchestration* and *regulatory compliance*. In some cases, the *regulatory compliance* capability is strongly related to the *ecosystem orchestration* capability. To exemplify, outdated regulations may hamper an organization's transition to the circular economy when they discourage second-hand use. In such cases, the lobbying element within *ecosystem orchestration* must be closely aligned with the *regulatory compliance* capability to facilitate an adequate transition. As these dependencies were outside the scope of this study, it is suggested to explore the possibilities of mapping them.

The third suggestion is to design a tool that guides practitioners when tailoring the proposed capability model to a specific organization. From the focus groups, it became clear that managers and executives value actionable elements that tailor the current model to their organization. Since the current study proposes a model developed from a general perspective and thus did not facilitate this feature, this might be an avenue for future research to explore.

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Appendix A

Systematic Literature Review

A.1 Priorly Conducted Reviews

Table A.1: Priorly Conducted Reviews in the Circular Economy and Capability Domains

	Publication	Databases
1	Geissdoerfer et al. (2020)	Scopus
2	Merli et al. (2018)	Scopus; Web of Science
3	Sassanelli et al. (2019)	Scopus; Science Direct
4	Pieroni et al. (2019)	Scopus; Web of Science
5	Lieder & Rashid (2016)	Scopus; Web of Science
6	Chauhan et al. (2022)	Scopus; Web of Science; Google Scholar
7	Rosa et al. (2020)	Scopus; Web of Science
8	Amui et al. (2017)	Scopus; Web of Science
9	Rialti et al. (2019)	Web of Science
10	Conz & Magnani (2020)	Scopus; Web of Science

A.2 Capability Extraction Template

Table A.2: Capability Extraction Template

Capability ID	1.01
Citation of publication	Arekrans et al. (2022)
Capability	Develop managerial commitment and incentives for experimentation
Definition	"Clear senior management commitment to sustainability and incentives for experimentation"
Category	Normative management
Dimension	Exploration
Context	Role of radical innovation in circular strategy deployment

A.3 Primary Studies

Table A.3: Included Primary Studies

#	Reference	Title
1	Arekrans et al. (2022)	The role of radical innovation in circular strategy deployment
2	Awan et al. (2021)	Big data analytics capability and decision-making: The role of data-driven insight on circular economy performance
3	Bocken et al. (2018)	Experimenting with a circular business model: Lessons from eight cases
4	Chaudhuri et al. (2022)	Circular economy and digital capabilities of SMEs for providing value to customers: Combined resource-based view and ambidexterity perspective
5	De los Rios & Charnley (2017)	Skills and capabilities for a sustainable and circular economy: The changing role of design
6	Elf et al. (2022)	Advancing the circular economy through dynamic capabilities and extended customer engagement: Insights from small sustainable fashion enterprises in the UK
7	Fernandez de Arroyabe et al. (2021)	The development of CE business models in firms: The role of circular economy capabilities
8	Han et al. (2022)	How do companies launch circular service business models in different countries?
9	Hofmann & zu Knyphausen-Aufseß (2022)	Circular business model experimentation capabilities—A case study approach
10	Howard et al. (2022)	Going beyond waste reduction: Exploring tools and methods for circular economy adoption in small-medium enterprises
11	Jayarathna et al. (2022)	Exploring sustainable logistics practices toward a circular economy: A value creation perspective
12	Khan et al. (2020)	Microfoundations of dynamic capabilities: Insights from circular economy business cases
13	Köhler et al. (2022)	Towards a collaboration framework for circular economy: The role of dynamic capabilities and open innovation
14	Kristoffersen et al. (2020)	The smart circular economy: A digital-enabled circular strategies framework for manufacturing companies
15	Kristoffersen et al. (2021)	Towards a business analytics capability for the circular economy
16	Kuhlmann et al. (2022)	How incumbents realize disruptive circular innovation Overcoming the innovator's dilemma for a circular economy
17	Kusumowardani et al. (2022)	A circular capability framework to address food waste and losses in the agri-food supply chain: The antecedents, principles and outcomes of circular economy
18	Marín-Vinuesa et al. (2021)	Firms' capabilities management for waste patents in a circular economy
19	Parida, Burström et al. (2019)	Orchestrating industrial ecosystem in circular economy: A two-stage transformation model for large manufacturing companies

Continued on next page

Table A.3: Included Primary Studies (Continued)

#	Reference	Title
20	Prieto-Sandoval et al. (2019)	Key strategies, resources, and capabilities for implementing circular economy in industrial small and medium enterprises
21	Reim et al. (2021)	Circular business model implementation: A capability development case study from the manufacturing industry
22	Ritola et al. (2022)	Learning-based dynamic capabilities in closed-loop supply chains: an expert study
23	Sandberg & Hultberg (2021)	Dynamic capabilities for the scaling of circular business model initiatives in the fashion industry
24	Santa-Maria et al. (2021)	How do incumbent firms innovate their business models for the circular economy? Identifying micro-foundations of dynamic capabilities
25	Sousa-Zomer et al. (2018)	Exploring the challenges for circular business implementation in manufacturing companies: An empirical investigation of a pay-per-use service provider
26	Sumter et al. (2021)	Key Competencies for Design in a Circular Economy: Exploring Gaps in Design Knowledge and Skills for a Circular Economy
27	Wade et al. (2022)	Capabilities for circularity: Overcoming challenges to turn waste into a resource

Appendix B

Results Delphi Study

B.1 Expert Panel

Table B.1: Expert Panel Delphi Study

	Expertise	Organization	Categorization
Expert 1	Sustainability and Responsible Governance	PwC	Consultancy
Expert 2	Sustainability and Responsible Governance	PwC	Consultancy
Expert 3	Waste Management	PreZero	Industry
Expert 4	Sustainable and Circular Business Transformation	Sustainable Transformers	Consultancy
Expert 5	Competitiveness, Innovation, and Sustainability	IDEA Consult	Consultancy
Expert 6	Corporate Social Responsibility and Procurement	RS sustainability	Consultancy
Expert 7	Circular Economy and Environment	TNO	Research/Consultancy
Expert 8	Sustainability, Environment, and Health	RIVM	Government
Expert 9	Sustainability Assessment and Sustainable Energy	TU/e	Research
Expert 10	Sustainability, Circular Economy, Sustainability, Environment and Climate	Erasmus Brussels	Research
Expert 11	Circular Economy and Waste Management	RWS	Government

Expert 1 is working in the sustainability & responsible governance team of PwC. She engaged in a broad spectrum of sustainability services, including advisory on the topics of circular economy, supply chain integrity, responsible investing, and sustainability reporting.

Expert 2 is working in the environmental, social & governance (ESG) team of PwC. She engaged in advisory and assurance services, including circular economy, emission reductions, and sustainability reporting.

Expert 3 is manager at PreZero (former SUEZ) since 2019 and a specialist in waste management. He has experience in advising organizations to arrange more sustainable and circular waste streams.

Expert 4 has been active in the field of sustainability since 1998 and has a professional background in IT consulting, delivery management, and organizational change in various industries. Now he uses his knowledge for the sustainable transition of organizations with Sustainable Transformers.

Expert 5 is an innovation, competitiveness, and sustainability consultant at IDEA consult. He worked on a wide array of services and expertise in the field of national and international research and innovation policy. This varies from research assignments to the involvement and support of strategic policy development processes in research and innovation.

Expert 6 has supported organizations within the circular economy domain since 2018. He consults on sustainable (public) procurement and policy. Preparing and executing EU tenders with a focus on circular and responsible textiles/workwear.

Expert 7 is cluster lead and senior business developer circular economy & environment at TNO. He has a Ph.D. in organometallic chemistry and a master in Economics and a wide experience in petrochemical and sustainable chemical industry. His main focus within TNO is on circularity of plastics and on sustainable chemical Industry.

Expert 8 is a researcher of circular economy & sustainability at RIVM National Institute for Public Health and the Environment. His focus is on sustainability in the healthcare sector and green public procurement, supported by analytical tools such as Life Cycle Assessment and Material Flow Analysis.

Expert 9 is a Professor at Eindhoven University of Technology (TU/e). His expertise includes technology and sustainability assessments for the energy transition and the circular economy. His research deals with assessing and implementing sustainable technologies and is at the intersection of industrial ecology, feasibility studies, and innovation sciences.

Expert 10 is a lecturer in Circular economy business modeling and circular consumer behavior. He is responsible for developing and managing the circular economy postgraduate program at Erasmus Brussels University of Applied Sciences and Arts.

Expert 11 is a scientific advisor at the Dutch Ministry of Infrastructure and Water Management (Rijkswaterstaat). He advises on circular economy and waste management projects and is specialized in water quality.

B.2 Results Delphi Round 1

This section provides goes in detail regarding the formation of the questionnaire, the voting results of the domain experts, and their suggestions for improvement for the first Delphi round.

B.2.1 Examples of Questionnaire

This subsection contains sample questions of the distributed questionnaire. Figure B.1 illustrates the questions focusing on the individual capability while Figure B.2 presents the questions that concerned the dimensions and categories.

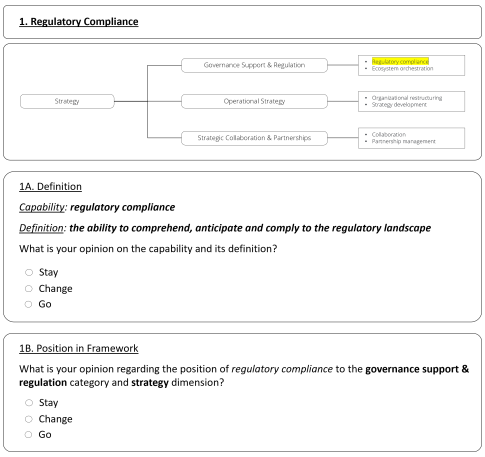

Figure B.1: Questions on Regulatory Compliance Capability

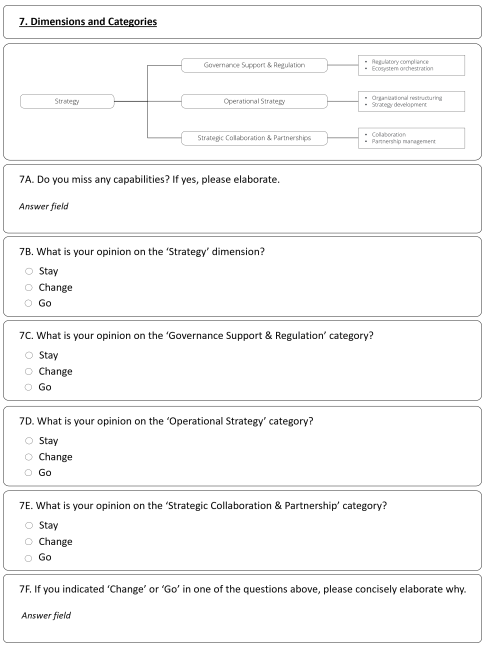

Figure B.2: Questions on Strategy Dimension and Categories

B.2.2 Voting Results

Expert Voting on Dimensions and Categories: Results Round 1

The voting results for the model's dimensions (in bold) and categories are shown below. Experts were solicited to indicate their opinion for the model dimensions and categories.

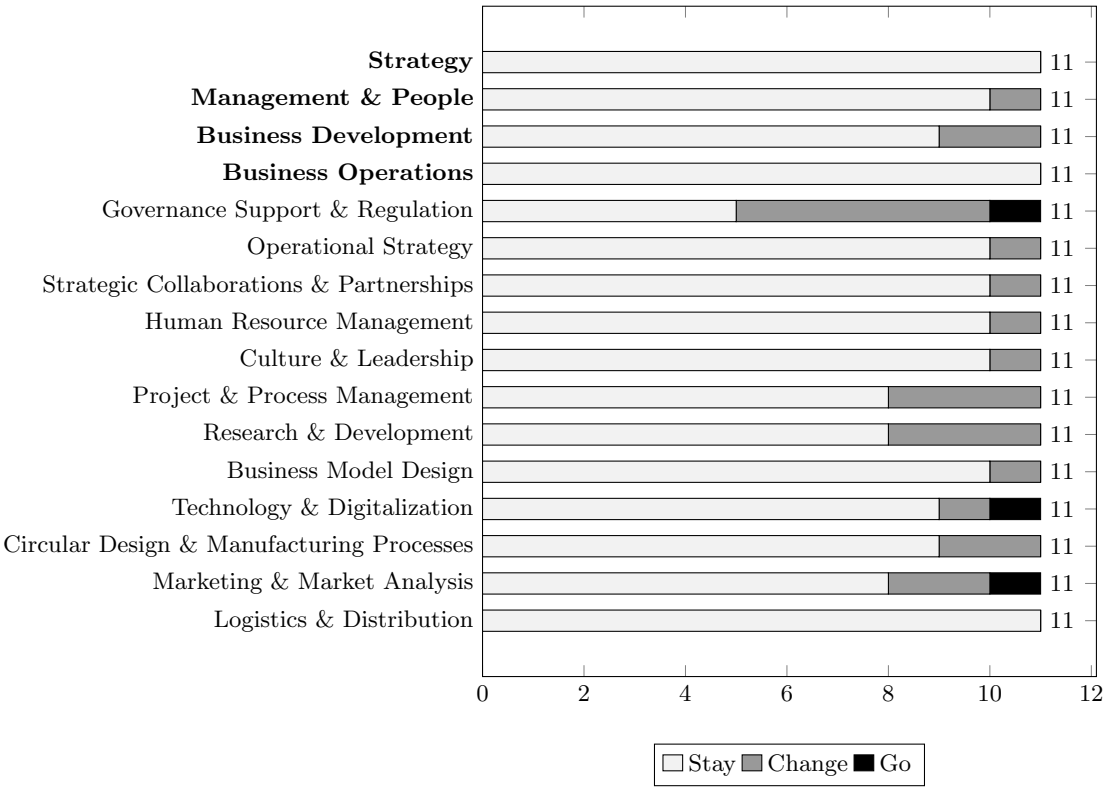

Figure B.3: Voting Results Delphi Round 1: Dimensions and Categories

Expert Voting on Capabilities: Results Round 1

The table below displays the voting results of the first Delphi round. Experts were solicited to indicate their opinion on the definition and the allocation of each capability.

Table B.2: Expert Voting on Capabilities: Results Round 1

Capability	Definition of Cap.			Allocation of Cap.		
	Stay	Change	Go	Stay	Change	Go
Regulatory compliance	11	0	0	7	4	0
Ecosystem orchestration	8	3	0	4	6	1
Organizational restructuring	11	0	0	8	3	0
Strategy development	7	4	0	11	0	0
Collaboration	8	3	0	6	5	0
Partnership management	9	1	1	10	0	1
Recruitment	9	2	0	10	1	0
Training	8	3	0	11	0	0
Team compilation	9	2	0	8	3	0
Sustainability culture	8	3	0	10	1	0
Leadership	6	5	0	11	0	0
Environmental accounting	10	0	1	5	5	1
Portfolio management	10	1	0	10	1	0
Financial management	10	1	0	9	2	0
Change management	10	1	0	9	2	0
Experimentation	8	3	0	10	1	0
Knowledge sharing	9	2	0	10	1	0
Patenting	6	3	2	8	1	2
Knowledge integration	3	7	0	8	3	0
Innovation	9	2	0	9	2	0
Research and development	7	3	1	10	1	0
Business model experimentation	9	2	0	10	1	0
Business model development	9	2	0	11	0	0
Technology	8	3	0	8	3	0
Data analytics	8	3	0	9	2	0
Sustainable design	5	6	0	10	1	0
Efficient manufacturing	7	4	0	11	0	0
Lifecycle management	8	3	0	11	0	0
Customer management	9	2	0	9	2	0
Market monitoring	8	3	0	9	2	0
Communication	11	0	0	9	1	1
Marketing	11	0	0	9	2	0
Logistic process management	11	0	0	11	0	0
Green supply chain management	7	4	0	9	0	2

B.2.3 Suggested Changes

Here the expert's suggested changes for the elements of the model's elements are documented. Table B.3 contains five types of suggested changes separated by a dashed line: (1) suggested changes that relate to the name of the elements, (2) suggested changes that relate to the definition of the elements, (3) suggested changes that relate to the location of the elements, (4) changes that relate to merging elements, (5) new model elements.

Table B.3: Suggested Changes Delphi Round 1

Experts	Suggested change	Rationale	Answer
1,5,8	Change the name of sustainability culture	Experts perceived the name as ambiguous	Accept: the name was changed to 'circular economy culture'
1,10	Change the name of portfolio management	To avoid misinterpretation, changing the name of the capability was suggested	Accept: the name was changed to 'project and process management'
1,2,5,9	Change the name of research and development	Experts perceived a capability with a similar name to its category as confusing	Accept: the name was changed to 'technology transfer' based on an expert suggestion
9,10	Change the name of sustainable design	Experts suggested including 'circular' in the name	Accept: the name was changed to 'circular design'
4	Change the name of operational strategy category	Experts found the category name to be ambiguous	Accept: the category was renamed to 'corporate'
1,2,4,7,9,10	Change the name and definition of technology	Experts considered the technology capability too broad and suggested removal as other capabilities capture the essence.	Accept: the capability was omitted
1,5,6	Change the name and definition of efficient manufacturing	Experts proposed changes to the name and definition to avoid misinterpretation and reduce ambiguity	Accept: the name was changed to 'circular manufacturing' and the definition updated
1,2,6	Change the name and definition of green supply chain management	Experts suggest changing 'green' to 'circular' and rewriting the definition more precisely	Accept: the name and definition were modified
5	Change the name of strategy development	An expert suggested making it more explicit to the circular economy	Accept: the name was modified
1,11	Change the definition of strategy development	Experts indicated that the 'strategic roadmap' is redundant and suggested removing this	Accept: the definition was modified
1,2,5,6	Change the definition of leadership	The definition includes corporate responsibility and encouraging employees, and developing commitment	Accept: the capability was splitted into leadership and corporate responsibility
1,5,9	Change the definition of recruitment	Experts suggest that an organization's core values follow from environmental values; hence it might be redundant	It was decided to keep the emphasis on both values in the definition
1,5	Change the definition of experimentation	Experts suggested changing 'implement' to 'execute'	Accept: the suggestion was adopted
1,5	Change the definition of data analytics	Experts suggested a different formulation structure	Accept: structure of the definition was modified
1,5,9	Change the definition of training	The definition was perceived to include aspects irrelevant to the overarching category	Accept: the definition was adapted

Continued on next page

Table B.3: Suggested Changes Delphi Round 1 (Continued)

Experts	Suggested change	Rationale	Answer
2,5,9	Change the definition of business model development	Experts suggested changing 'sustainable' for 'circular'	Accept: the definition was changed
5,6,8	Change the definition of sustainable design	Experts suggested adding more emphasis on environmental sustainability in the definition	Accept: an emphasis on environmental sustainability was added
2,5	Change the definition of lifecycle management	Experts suggested emphasizing the importance of accountability	Accept: an emphasis on accountability was added
1,2	Change the definition of market monitoring	The expert suggested removing 'stakeholders' information' as it was considered redundant	Accept: the definition was updated
5	Change the definition of innovation	The expert suggested reflecting on the definition and making it more explicit	Accept: the definition was updated with an emphasis on resource retention
2	Change the definition of customer management	The expert suggested emphasizing end-of-life management in the definition	It was decided to keep customer management
5	Change the definition of lifecycle management	The expert suggested emphasizing accountability throughout the lifecycle	Accept: the definition was adapted
3,4,5,10	Change the location of ecosystem orchestration	Experts suggested changing the location to strategic collaborations & partnerships	Accept: the capability was relocated
5,7,9	Change the location of collaboration	Experts perceived it as an operational activity that would fit better under a different dimension	Accept: the capability was relocated to business operations
2,7,6,10	Change the location of environmental accounting	Experts perceived it as highly important and relevant to the strategy dimension	Accept: the capability was relocated to the strategy dimension
4,7,10	Change the location of financial management	Considered a part of the strategy dimension	Accept: the capability was relocated
4,5	Change location of change management	Considered a part of strategic change, while another expert considers it part of the people dimension	It was decided to relocate the capability to the strategy dimension
2,7	Change the location of sustainable design	Expected under business development dimension or research and development category	It was decided to keep it under business operations but changed the category
9,10	Change the location of data analytics	Expected under the research and development category or business model design	It was decided to move the capability to research and development
4,7,10	Change the location of team compilation	Expected under the culture and leadership category	Accept: the capability was relocated
9,10	Change the location of technology	Expected under the research and development or business model design category	It was decided to move the capability to research and development category
4,7	Change the location of marketing & market analysis category	Experts suggested placing the category under the business development dimension	Accept: the category was transferred
2	Change the location of portfolio management	The expert suggested moving the capability to the strategy dimension	Accept: the capability was relocated
7	Change the location of market monitoring	The expert suggested moving the capability to the business development dimension	Accept: the category was relocated

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Table B.3: Suggested Changes Delphi Round 1 (Continued)

Experts	Suggested change	Rationale	Answer
7	Change the location of marketing	The expert suggested moving the capability to the business development dimension	Accept: the category was relocated
10	Change the location of lifecycle management	The expert suggested that capability would fit under the logistics category	Accept: the capability was relocated
1,10	Merge collaborations and ecosystem orchestration	Capabilities are perceived to overlap hence the suggestion to merge the capabilities	It was decided to relocate the collaborations capability
2,6	Merge collaborations and partnership management	Capabilities are perceived to overlap hence the suggestion to merge the capabilities	It was decided to relocate the collaborations capability
6,7,8,10	Merge knowledge sharing, knowledge integration, and patenting	Experts argued that these capabilities overlap and questioned the relevance of the patenting capability	Accept: capabilities were merged in the new framework
10	Merge innovation and experimentation	The expert considered experimentation as a part of innovation	It was decided to keep them separate as literature puts a strong emphasis on experimentation as an individual capability
7	Add capability	The expert found that employee retention capability was missing	Accept: the capability was included
4	Add capability	The expert found that ethics capability was missing	The new capability corporate responsibility is considered to reflect ethics
10	Add capability	The expert found that quality management capability was missing	Quality management is considered to be covered by circular manufacturing

B.2.4 Model after Delphi Round 1

In this section, an overview of the capability model after the first Delphi iteration is presented. Figure B.4 portrays the capabilities of the model structured according to the allocation to overarching categories and dimensions.

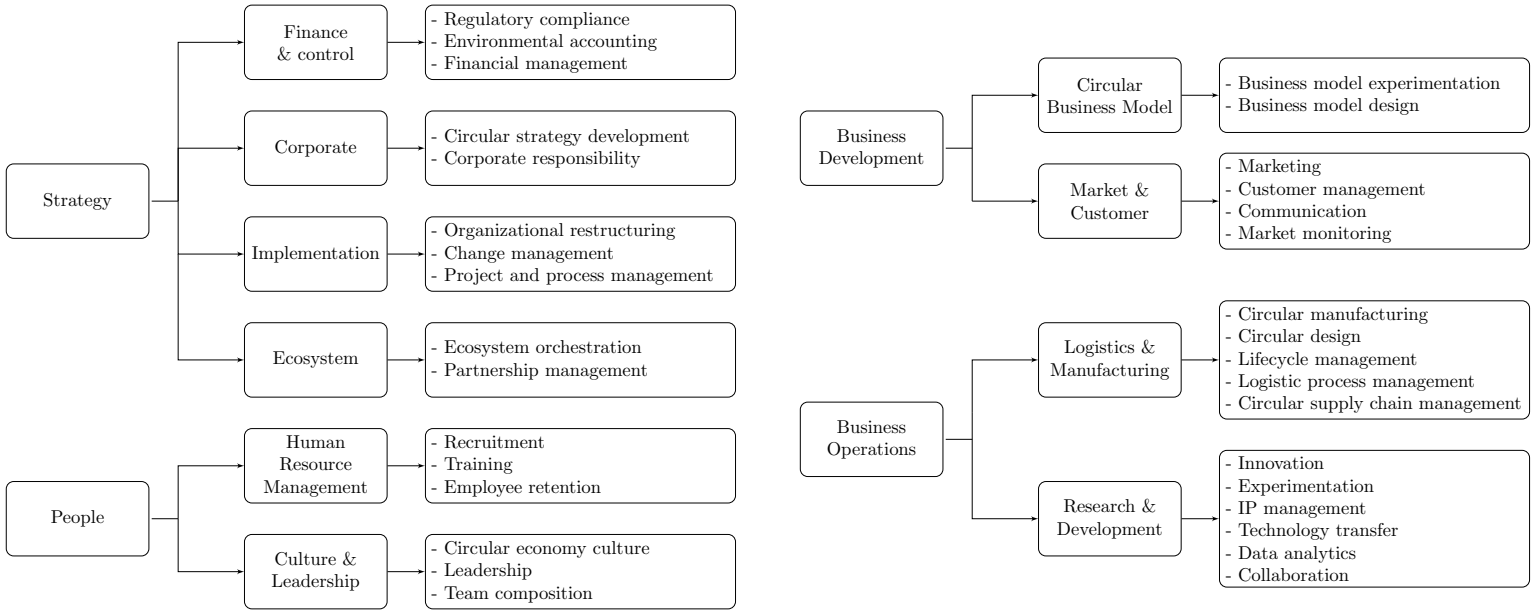

Figure B.4: Circular Economy Capability Model after Delphi Round 1

B.3 Results Delphi Round 2

This section provides goes in detail regarding the formation of the questionnaire, the voting results of the domain experts, and their suggestions for improvement for the second Delphi round.

B.3.1 Example of Questionnaire

This subsection provides a sample question of the distributed questionnaire. Figure B.5 illustrates questions concerning the implementation category. First, the expert opinion concerning the allocation of the category is solicited. Then, the underlying capabilities that underwent modifications and their allocation to category were assessed. Finally, there was room to elaborate and ventilate the rationale behind the assessment.

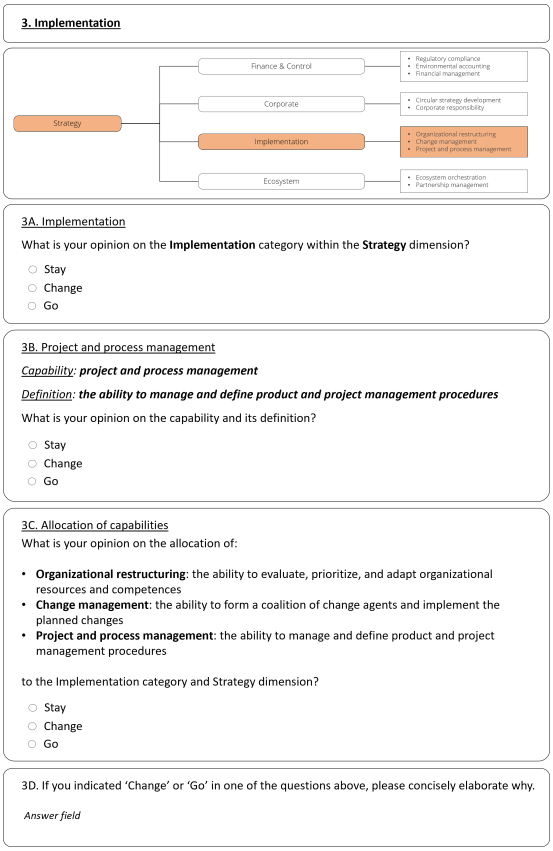

Figure B.5: Questions on Implementation Category

B.3.2 Voting Results

In this section, the voting results of the second Delphi round are illustrated. Figure B.6 provides an overview of the voting results on the categories. Experts were solicited to indicate their opinion on the position of the category within the model. Additionally, Figure B.7 depicts the voting results on the allocation of capabilities to the categories. Experts were solicited to indicate their opinion on the allocation of underlying capabilities to the category. Finally, Figure B.8 presents the voting results on the capabilities. Here, experts were solicited to indicate their opinion for each capability

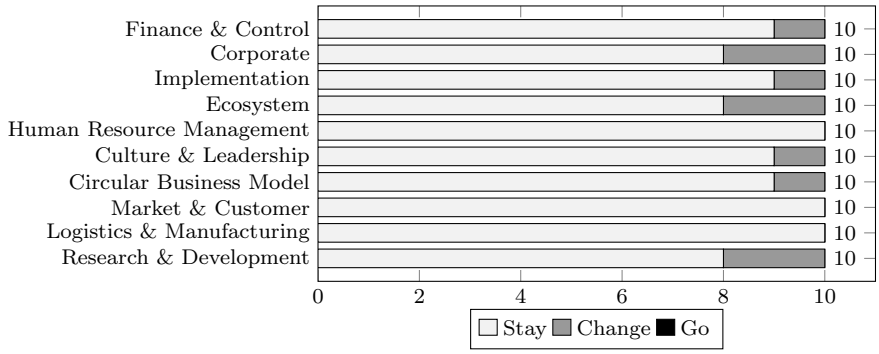

Figure B.6: Voting Results Delphi Round 2: Categories

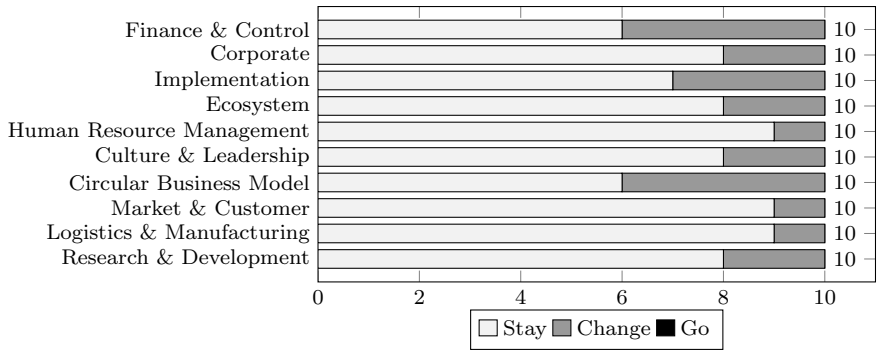

Figure B.7: Voting Results Delphi Round 2: Categories - Allocation

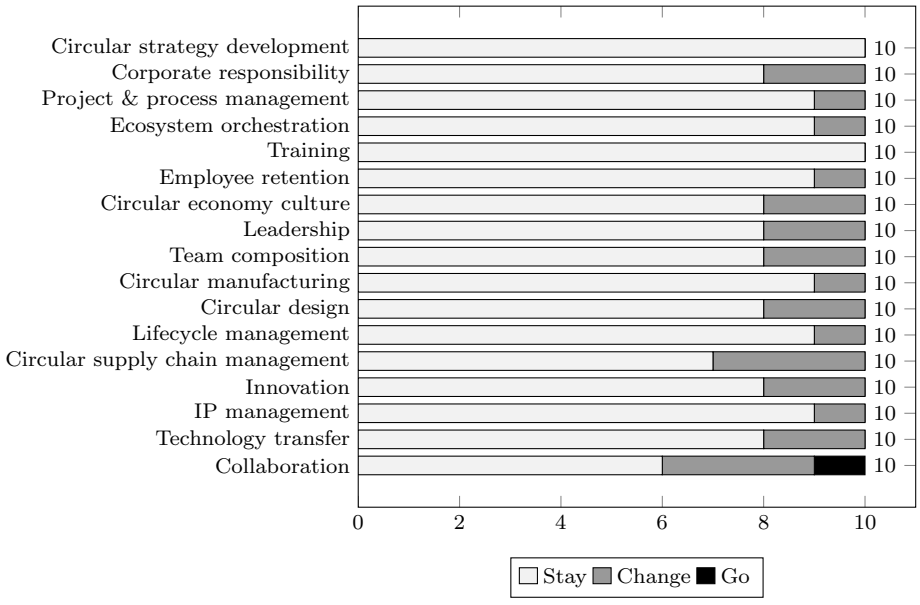

Figure B.8: Voting Results Delphi Round 2: Capabilities

B.3.3 Suggested Changes

Here the expert's suggested changes for the elements of the model's elements are documented. Table B.4 contains five types of suggested changes separated by a dashed line: (1) suggested changes that relate to the name of the elements, (2) suggested changes that relate to the alloca-

tion of capabilities, (3) suggestions for additional capabilities, (4) changes that relate to merging elements, (5) suggested changes that relate to the definition of the capabilities.

Table B.4: Suggested Changes Delphi Round 2

Experts	Suggested change	Rationale	Answer
5,3,1	Change finance & control category	The environmental accounting dimension should be better reflected in the title 'finance & control' because in corporate jargon finance & control does not typically involve environmental accounting. One expert proposed to give climate reporting its own dimension.	Accept: the name of the category is updated to reporting & compliance and the financial management capability is relocated to the corporate category
1	Change name of Implementation category	Expert suggests 'implementation' does not really cover the underlying terms and proposes 'organizational design and development'	Accept: the name of the category was changed to Organization
8	Change name of ecosystem category	Expert suggests to change the category to ecosystem development	The name of the category was adapted to 'circular ecosystem'
1	Rename corporate category	The assigned capabilities are focused on sustainability while it is considered that the 'corporate' term does not necessarily reflect this.	As the allocation of corporate to the strategy dimension reached a consensus for approval, it was decided to keep the category in its current form
2	Change name of corporate responsibility	It was remarked that 'corporate sustainability' is more in line with the most recent insights and concepts	Accept: after researching the suggested term it was decided to adopt the formulation
1	Change name of business model development	Expert suggests to change the name to circular business model development	As there was reached a consensus on acceptance for this capability, it was decided to remain it as stated
8	Change order of categories in startegy dimension	Expert suggests to locate corporate category as the first one	The categories are arranged in no particular order. Therefore, the request was satisfied
7	Relocate partnership management to market & Customer category	Expert suggests to place partnership management under the market & customer category	As partnership management is considered relevant to the strategy dimension and experts reached a consensus, it was decided to keep the capability in its current position.
2	Change order of capabilities in logistics & manufacturing category	Expert suggests to change the order of the elements, as there is a certain chronology to it: circular design, circular supply chain management, circular manufacturing, logistics process management and then lifecycle management	The categories are arranged in no particular order. Therefore, the request was satisfied
1,8	Change location of research & development category	Experts argue that R&D does not necessarily fit under business operations but also under business development/organizational development	R&D indeed might fit under different dimensions. However, since a consensus was reached, it was decided to keep the category in the business development dimension
4	Change location of culture & leadership category	Expert argues that the category should be allocated to the strategy dimension as it is considered to be too near to HRM	As there was reached a consensus on the allocation of the culture & leadership category to the people dimension, it was decided to keep the category in its current position

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Table B.4: Suggested Changes Delphi Round 2 (Continued)

Experts	Suggested change	Rationale	Answer
4	Change position of regulatory compliance	Regulatory compliance is considered to conflict with finance interests hence it was suggested to change the allocation	As it was decided to relocate financial management, this suggested change is resolved
7	Change position of project & process management capability	It was suggested to move project & process management to the business operations dimension as this was believed to provide a better fit	As there was reached a consensus on the allocation of the capability, it was decided to adhere to the current location
7	Change position of partnership management	Expert suggested that the capability would fit also under business development as this capability comprises several activities that are relevant for this dimension. However, some of the activities do fit under the curently assigned dimension	It is acknowledged that the activities that this capability comprises can be allocated to diverse dimensions. Due to current consensus, it was decided, however, to remain the capability in the allocated position
10	Change position of circular economy culture	It is argued that circular economy culture is part of the implementation category as such culture is not solely the responsibility of HR	Circular economy culture indeed cannot be solely allocated to HRM. However, current capability is positioned under the culture & leadership category which differs from HRM
10	Change location of team composition	It is argued that team composition is normally a clear 'business operations' activity and is not part of the HR-activities, but interpretation may vary.	As interpretation varies and a consensus on the capability was reached, it was decided to keep the capability in its current position
5	Change position of circular design	It was suggested to switch the capability to the top place of the category	The categories are arranged in no particular order. Therefore, the request was satisfied
2	Add capability to implementation category	Expert suggests adding upskilling of the work force to this category	Upskilling the workforce is believed to be covered by the training capability within the people dimension
5	Add resource management under ecosystem category	Expert suggests considering adding resource management to this category	The management of resources is considered to be covered by the organizational restructuring capability
5	Add 'people' under corporate category	People in the corporation category is missing as they drive the company forward with the company (or organisation) in return having the responsibility to care for its employees and give a sense of responsibility and urgency	It was decided to keep the capabilities related to staffing, people and leadership in the people dimension.
2	Add new capability internal control	Expert misses "something along the lines of internal control"	Accept: internal control as additional capability has been adopted in the framework
7	Merge circular supply change management and lifecycle management	Expert suggested to combine the capabilities and integrate accounting in circular supply chain management	As the relevance of both individual capabilities was acknowledged by an expert majority, it was decided to keep both capabilities in the framework

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Table B.4: Suggested Changes Delphi Round 2 (Continued)

Experts	Suggested change	Rationale	Answer
8	Remove IP management	The capability is considered to be an obstacle for the circular economy transition	The relevance of the IP management capability is acknowledged by the other experts. Therefore, it was decided to keep the capability in the framework
1	Change definition of circular manufacturing	It was suggested to change the definition to "manufacturing processes based on circular economy principles"	As there was reached a consensus on the definition of the capability, it was decided to adhere to current formulation
5	Change definition of circular design	It was proposed to swap "create" with "design" in the definition.	Accept: the suggested change was adopted
1	Change definition of lifecycle management	It was suggested to change the definition to "management of the social and environmental impacts of a product or process throughout it's lifecycle"	Accept: the definition has been broadened according to the suggestion
7,9	Change definiton of circular supply chain management	It was suggested to adapt the definition to "the ability to integrate circular accounting and monitoring in the management of the supply chain"	Accept: the suggested change was adopted
1	Change definiton of circular supply chain management	Suggested to change the definition to "management of the social and environmental impacts of a product or process throughout it's lifecycle"	Accept: the definition has been changed inspired by the received suggestions
1	Change definition of innovation	The definition was considered to cover innovation in general and, therefore, it was suggested to adopt a formulation that is more focused on circular innovation	Accept: based on two expert comments the definition of the innovation capability was adjusted
5	Change definition of innovation	It was suggested to incorporate the development of new products in the definition	Accept: based on two expert comments the definition of the innovation capability was adjusted
7	Change definition of technology transfer	It was suggested to remove "conduct research on resources and other industries and" as this is not considered to fit the capability	Accept: the technology transfer capability was merged with innovation
1,10,9,4	Change definition of collaboration	Experts argued that capability is not a part of R&D catagory. Two experts considered the capability redundant and two experts suggested relocation	Accept: it was decided to merge the capability
5	Change definition of business model experimentation	Expert argues that identification of circular economy practices should also be included in definition. Experimentation preceeds the strategy and the strategy fits more into the development phase.	Identification of circular economy practices is considered to be covered by the experimentation capability in the research and development category.
1	Change definition of corporate responsibility	The 'engage in ... issues' is considered to be out of scope for this capability	Engaging in social and environmental issues is considered part of this capability which is supported by the definition of corporate sustainability

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Table B.4: Suggested Changes Delphi Round 2 (Continued)

Experts	Suggested change	Rationale	Answer
1	Change definition of project & process management capability	Expert suggested to revise the definition as it was argued that an alternative formulation may represent the capability more appropriately	Accept: the definition had a minor update to improve alignment with the name
8	Change definition of ecosystem orchestration	It is not clear how a 'circular industrial ecosystem' differs from a circular ecosystem and therefore reconsidering the definition is suggested	Accept: circular ecosystems is in line with the content of the capability. Hence the suggestion was adopted
5	Change definition of employee retention	Expert argued that current definition mentions general employability and, thus, it should be reformulated	As this definition was based on literature (Kossivi et al. (2016)) and a consensus was reached on the definition. It was decided to keep the definition unchanged
1	Change definition of circular economy culture	Expert suggested a change for the definition: "the ability to create a culture that encourages, engages, and influences employees and stakeholders to engrain the circular economy vision into all they do?"	Accept: a minor adaptation was applied to the definition to improve readability
1	Change definition of leadership	It was considered unclear for what top management sponsorship is required. Moreover, it was suggested to change "commit towards circular objectives" to "to put circular objectives first in all they do"	Enabling top management sponsorship refers to managerial commitment in making sure that the executed projects are aligned with company goals.
2	Change definition of team composition	The definition was considered to lack a concrete part on diversity and inclusion	As this definition was based on literature (Somech & Drach-Zahavy, 2013) and a consensus is reached on the definition. It was decided to keep the definition unchanged

B.3.4 Model after Delphi Round 2

In this section, an overview of the capability model after the second Delphi iteration is presented. Figure B.9 portrays the capabilities of the model structured according to the allocation to overarching categories and dimensions.

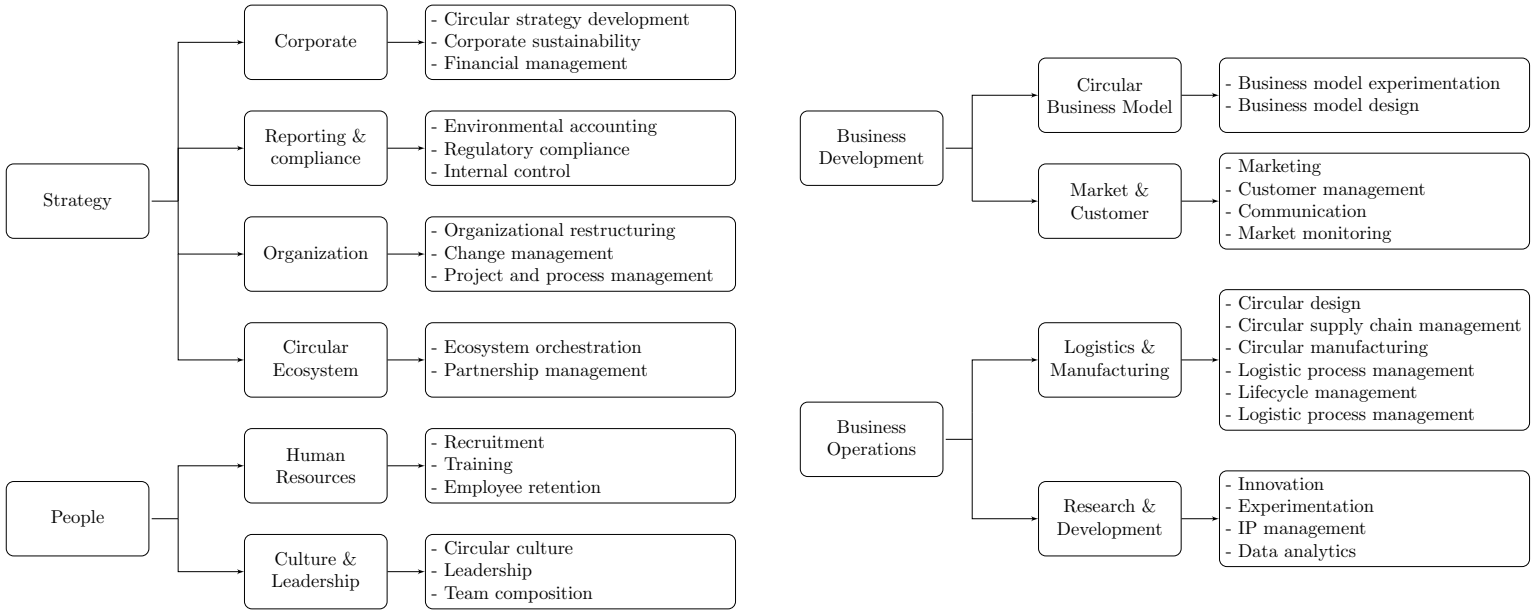

Figure B.9: Circular Economy Capability Model after Delphi Round 2

Appendix C

Circular Economy Capability Model

The proposed capability model is illustrated in Figure C.1. Furthermore, an extended description for the capabilities is included in this appendix. For the *strategy* dimension, the categories and capabilities are denoted in Table C.1. The categories and capabilities for the *people* dimension are reported in Table C.2, for the *business development* dimension in Table C.3, and, finally, for the *business operations* dimension in Table C.4. An online version of the capability model is accessible at `https://cecm.gitbook.io/`.

Research & Development
- Innovation
- Experimentation
- IP management
- Data analytics

Logistics & Manufacturing
- Circular design
- Circular supply chain management
- Circular manufacturing
- Logistic process management
- Lifecycle management

Market & Customer
- Marketing
- Customer management
- Communication
- Market monitoring

Business Model Development
- Business model experimentation
- Business model development

Culture & Leadership
- Circular culture
- Leadership
- Team composition

Corporate
- Circular strategy development
- Corporate sustainability
- Financial management

Reporting & Compliance
- Environmental accounting
- Regulatory compliance
- Internal control

Organization
- Organizational restructuring
- Change management
- Project and process management

Circular Ecosystem
- Ecosystem orchestration
- Partnership management

Human Resources
- Recruitment
- Training
- Employee retention

Figure C.1: Circular Economy Capability Model

Table C.1: Capabilities relating to the Strategy dimension

Category	Capability	Defintion	Background
Corporate	Circular strategy development	the ability to develop and communicate a strategy for the circular transition	The development of a circular strategy is recognized as a fundamental activity in the circular transition. Activities related to the formalization and execution of such strategy include integrating sustainability into the organization's core, acquiring knowledge regarding strategy development (Chari et al., 2022), and prioritizing resources (Santa-Maria et al., 2021). To fully integrate circular economy goals, organizations should develop a sustainable strategy aligned with the organizational culture (Bertassini et al., 2021). Strategy development also includes considering growth strategies, which are essential (Sandberg & Hultberg, 2021). Moreover, developing, adapting, and articulating a clear and ambitious vision are recognized as practices that guide organizations (Santa-Maria et al., 2021; Elf et al., 2022) and represent a catalyst for organizational change (Elf et al., 2022). This process involves motivating employees with a vision of how the organization should appear in a circular state and integrating the perspective of stakeholders (Bertassini et al., 2021). Adopting a proactive sustainable strategy and vision is believed to fuel innovation (Khan et al., 2020).
	Corporate sustainability	the ability to take appropriate ownership of organizational activities and to engage in environmental and social issues	By exercising corporate sustainability, an organization takes ownership and responsibility with appropriate significance, engages in social and environmental issues (Sandberg & Hultberg, 2021), and considers the responsibilities regarding environmental sustainability (Kusumowardani et al., 2022). Such behavior is aimed at sustainable feedstock consumption and economic prosperity distribution (Belhadi et al., 2022).
	Financial management	the ability to strategically plan investments, assess costs and financial risks	Financial management comprises investment planning, capital budgeting, and cost comprehension. Investment planning and capital budgeting are essential for engaging in newly identified circular opportunities (Khan et al., 2020). Investments in eco-innovation, renewable energy sources, and research and development are enablers of the circular transition and facilitate new product development (Wade et al., 2022). On the other hand, cost efficiency contributes to the success probability of circular businesses (Chari et al., 2022). Calculating and measuring the financial impact of products and services is critical to comprehend the costs along the product or service's lifecycle (Sousa-Zomer et al., 2018). Understanding costs allows for risk assessment which is especially relevant for business models that incorporate leasing or renting activities as the financial risk is passed from the consumer to the producer (Sousa-Zomer et al., 2018).
Reporting & compliance	Environmental accounting	the ability to develop, assess, and evaluate indicators that measure the impact of organizations' actions on human, environment, and resources	Environmental accounting encapsulates the measurement and assessment of organizational sustainability performance (Jayarathna et al., 2022; Sumter et al., 2021) definition of goals and metrics (Arekrans et al., 2022) development of new costing models and criteria that are aligned with the circular economy (Kristoffersen et al., 2021) and the assessment and evaluation of the impact on human, environment, and resources (Belhadi et al., 2022). Measuring and assessing sustainability improves corporate image and contributes to corporate sustainability (Jayarathna et al., 2022).

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Table C.1: Capabilities relating to the Strategy dimension (Continued)

Category	Capability	Defintion	Background
	Regulatory compliance	the ability to develop, assess, and evaluate indicators that measure the impact of organizations' actions on human, environment, and resources	Comprehending and complying with regulations and policies is believed to benefit businesses in the circular economy. Extended producer responsibility, eco-label requirements, and carbon taxation are examples of environmentally focused policies that may encourage industry-wide partnerships and sustainable innovation in businesses (Santa-Maria et al., 2021). Complying with environmental policies and certificates enhances the company's reputation and helps it remain viable (Jayarathna et al., 2022). Moreover, comprehension of the regulatory landscape is required to meet the legal requirements for novel and innovative payment and asset ownership constructions (Sousa-Zomer et al., 2018).
	Internal control	The ability to assure the reliability, accurateness, and timeliness of provided environmental, financial, and legal information (PwC, 2013)	This capability was included based on expert recommendations. Expert comments revealed that reporting environmental performance is becoming as important to shareholders and auditors as financial performance. Assuring reliability of provided information is crucial for listed organizations and organizations that aim for transparency in their business operations and communications. Moreover, accurate and timely provision of data may support decision making, which may benefit the transition toward the circular economy.
Organization	Organizational restructuring	the ability to evaluate, prioritize, and adapt organizational resources and competences	Organizational restructuring is essential in pursuing the circular economy (Khan et al., 2021). This includes the integration, planning, and modification of organizational structures. Examples of the restructuring of assets are the abandonment of a subsidiary, acquisition of a firm, addition of a new facility (Khan et al., 2020), and development of business units and formal procedures (Bertassini et al., 2021). In some cases, changing the governance structure (e.g., restructuring the board of directors) is required to foster collaboration (Khan et al., 2020).
	Change management	the ability to form a coalition of change agents and implement the planned changes	Management of change is considered relevant as the alteration of existing routines (Bertassini et al., 2021), adoption of acknowledged best practices, and implementation of new working methods are facilitators of the circular transition (Khan et al., 2020). Examples of best practices that can be implemented are the reduction of packaging (Khan et al., 2020), the introduction of a zero-waste program (Sousa-Zomer et al., 2018), and the implementation of sustainability guiding frameworks (Khan et al., 2020; Santa-Maria et al., 2021). As a result, organizations must adhere to innovations and promote change when transitioning to the circular economy (Sehnem et al., 2022). Organizations should thus develop a change management proficiency (Santa-Maria et al., 2021) and form coalitions of change agents who implement the planned changes (Bertassini et al., 2021).
	Project and process management	the ability to manage and define project and process management procedures	The development and management of circular economy projects is an essential competence as it supports the development of appropriate products and services (Fernandez de Arroyabe et al., 2021; Prieto-Sandoval et al., 2019). Part of this competence is the definition of project procedures (Sousa-Zomer et al., 2018) and the management of the corresponding processes (Chari et al., 2022). The AFNOR XP X30-901 certification, for example, is a managerial tool that facilitates dialogue across organizations and stakeholders to recognize the production and consumption through a shared language and definitions, allowing for planning, executing, evaluating, and improving circular projects (Fernandez de Arroyabe et al., 2021).

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Table C.1: Capabilities relating to the Strategy dimension (Continued)

Category	Capability	Defintion	Background
Circular ecosystem	Ecosystem orechstration	the ability to create, govern and improve circular ecosystems	Orchestration of the circular ecosystem is considered relevant when aiming for policy changes, developing business sector objectives, and aligning incentives and investments. When aiming for policy change, more pressure on policymakers can be exercised when collaborative networks or partnerships within the ecosystem are formalized and represent the voice of an industry rather than an individual organization (Sandberg & Hultberg, 2021). Moreover, the transition to the circular economy forces organizations to adapt their business models and strategies while also persuading their ecosystem partners to accompany them in the circular economy transition (Parida, Burström et al., 2019). In this way, business sector objectives can be clearly defined (Howard et al., 2022) and rules for circular ecosystem established (Parida, Burström et al., 2019). Consequently, routines to orchestrate collaboration with partners in the ecosystem to design logistic processes are considered part of a mature ecosystem (Reim et al., 2021).
	Partnership management	the ability to explore, assess, develop and sustain strategic partnerships and organize collaborative practices	Management of partnerships and collaborating are essential activities for the circular transition. Partnerships may be required for the acquisition of specialized competences (Bertassini et al., 2021), funding for research and development (Fernandez de Arroyabe et al., 2021; Sousa-Zomer et al., 2018), or influencing the adoption of sustainable practices (Sousa-Zomer et al., 2018). Activities that come with the management of partnerships are the identification of a shared agenda with critical stakeholders (Arekrans et al., 2022), the identification of mutually beneficial relationships (Parida, Burström et al., 2019), and the reevaluation of relationships with existing partners (Arekrans et al., 2022). Recommended practices are assessing the inclusion of new partners based on a risk and benefit analysis (Parida, Burström et al., 2019) and balancing multiple goals that might be in conflict (Bertassini et al., 2021). Moreover, openness toward external collaborations (Sandberg & Hultberg, 2021) and geographical proximity to stakeholders (Prieto-Sandoval et al., 2019) are considered enablers of sustainable partnerships. Furthermore, organizations should collaborate across the value network to accelerate the shift to the circular economy (Sumter et al., 2021). The rationale for this necessity is that the circular transition demands communication and coordination among the network of stakeholders (Bertassini et al., 2021). Organizations can develop synergistic solutions such as shared infrastructures and reverse logistic processes (Han et al., 2022). Other examples of industrial symbiosis are the cascading use of resources (Fernandez de Arroyabe et al., 2021), research and development collaboration (Marín-Vinuesa et al., 2021), and co-investment (Kristoffersen et al., 2021; Wade et al., 2022). Collaboration contributes to the stakeholders' involvement in the circular economy (Khan et al., 2020; Jayarathna et al., 2022). Conditions for successful collaborations are a low threshold for participation (Sandberg & Hultberg, 2021) and relational interdependences to reduce the prospect of conflicts (Parida, Burström et al., 2019).

Table C.2: Capabilities relating to the People dimension

Category	Capability	Defintion	Background
Human resources	Recruitment	the ability to recruit personnel that aligns with the environmental and core values of the organization and possesses relevant skills	Adequate recruitment and talent selection support the transition to the circular economy (Khan et al., 2020; Kristoffersen et al., 2021). In the recruitment process, organizations should aim to adapt the employee structure by using organizations' core values for selecting candidates with a compatible mindset and environmental values (Prieto-Sandoval et al., 2019; Bertassini et al., 2021). Organizations should anticipate changes in their workforce as the circular transition may create new job opportunities (Howard et al., 2022) or declare jobs obsolete (Prieto-Sandoval et al., 2019). Moreover, organizations should account for the compilation of multidisciplinary teams to foster the implementation of circular practices and hire accordingly (Elf et al., 2022).
	Training	the ability to provide employees with beneficial training and development programs to enhance skills and prepare for future positions (Hanaysha, 2016)	Training is identified as a fundamental practice for the circular transition. Training on sustainability topics is believed to create employee empowerment to propose improvements that might lead to bottom-up innovations (Prieto-Sandoval et al., 2019; Khan et al., 2020; Santa-Maria et al., 2021). Moreover, training facilitates the transformation of obsolete jobs into new employment (Prieto-Sandoval et al., 2019).
	Employee retention	The ability to create and foster an environment that encourages employees to remain employed by having policies and practices in place that address their diverse needs (Kossivi et al., 2016)	This capability was included based on expert recommendations. Employee retention is considered a facilitator within the circular transition as an organization is strongly dependent on the quality of its workforce. By creating an environment in which an employee is motivated to remain employed, the continuity of the organizational processes is secured. Moreover, due to current tightness in the labor market it is viewed as critical to have appropriate policies in place that foster employee retention.
Culture & leadership	Circular culture	the ability to create a culture that encourages, engages, and influences employees and stakeholders to implement the circular economy vision	A circular culture boosts the implementation of the circular economy from inside an organization (Prieto-Sandoval et al., 2019). The concept is based on a green organizational culture that promotes an environmental ideology for economic, social, and environmental development and is believed to generate employee and stakeholder engagement, facilitate knowledge integration and diffusion, and avoid premature satisfaction (Bertassini et al., 2021). Practices relevant to developing a sustainability culture are: prioritizing customer value creation, nurturing mutual trust and respect, and encouraging employees to pursue the circular economy vision and goals (Bertassini et al., 2021). Thus, to support the transition toward the circular economy, it is vital to generate employee awareness and build a work environment that stimulates economic, social, and environmental performance (Bertassini et al., 2021).
	Leadership	the ability to ensure top management sponsorship and inspire employees to commit towards circular objectives	Leadership is focused on the commitment, involvement, and support of leaders within the organization for circular strategies (Santa-Maria et al., 2021; Chari et al., 2022). Environmental leadership is expected to ensure top management sponsorship (Chaudhuri et al., 2022) and inspire employees to commit to sustainable and ecological objectives (Belhadi et al., 2022).

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Table C.2: Capabilities relating to the People dimension (Continued)

Category	Capability	Defintion	Background
	Team composition	the ability to configure relevant member attributes in a group that interacts interdependently to achieve a common objective (Somech & Drach-Zahavy, 2013)	The composition of multidisciplinary teams and allocating adequate resources to support them reinforces the circular transition in considerable ways. Sustainability-oriented innovation can be promoted by forming decentralized innovation teams (Santa-Maria et al., 2021) with relevant skills and knowledge regarding business model innovation, product design, and the development of circular strategies (Bertassini et al., 2021; Santa-Maria et al., 2021).

Table C.3: Capabilities relating to the Business Development dimension

Category	Capability	Defintion	Background
Circular business model	Business model experimentation	the ability to explore the most viable strategy to bring the product or service offering to the market	Organizations engaging in the circular economy may need to adapt their existing business model as they acknowledge that the current business model is no longer viable (Arekrans et al., 2022). In other words, business model evolution (Wade et al., 2022), business model improvement (Prieto-Sandoval et al., 2019), or business model innovation (Elf et al., 2022) may be necessary, which demands the recognition of alternative business model configurations. Business model experimentation is identified as a relevant proficiency to arrive at an alternative business model configuration. Practices for business model experimentation are: the value proposition experiment, where insights are collected and tests are executed to explore whether offerings exist; the value deliver experiment, where, from a customer perspective, is determined how the business is brought to the market; the value creation experiment where the needs of stakeholders that take the offering to the market are identified; and the value capture experiment where business cases should be analyzed for the involved stakeholders (Bocken et al., 2018).
	Circular business model development	the ability to design and implement circular business models	Organizations must modify their strategies and business models to respond adequately to the circular economy's potential and persuade their ecosystem partners to do the same (Parida, Burström et al., 2019). Redesigning business models is fundamental to the circular transition (Khan et al., 2020). Organizations should aim to leverage strategic value and market opportunities (Kristoffersen et al., 2021). Example practices for designing a circular business proposition are the definition of pricing models for different customer segments and the definition of sales processes and channels (Sousa-Zomer et al., 2018). Organizations should aim for a mix of products and services to satisfy customer needs jointly (Sousa-Zomer et al., 2018).

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Table C.3: Capabilities relating to the Business Development dimension (Continued)

Category	Capability	Defintion	Background
Market & customer	Marketing	the ability to develop and execute sound marketing strategies, build relationships, and communicate value	Organizations must develop green and sound marketing strategies to effectively communicate value in the circular economy (Prieto-Sandoval et al., 2019; Chaudhuri et al., 2022). Organizations can use eco-labeling and zero-waste certifications to open new markets and develop green marketing. Through marketing, organizations should communicate how customer problems are solved sustainably (Han et al., 2022) and address new customers (Wade et al., 2022). These activities contribute to a sound marketing strategy and exposes credibility and legitimacy which builds customer trust (Han et al., 2022). In addition, market segmentation is an essential instrument as clients may be diverse (Prieto-Sandoval et al., 2019).
	Customer management	the ability to educate, manage the relationship with, and understand the expectations of the customer	In the circular economy, organizations provide offerings that align with customer needs (Sousa-Zomer et al., 2018) hence the relevance of customer management. Customer management is believed to anticipate the customer expectations and perception of value (De los Rios & Charnley, 2017; Khan et al., 2020; Santa-Maria et al., 2021), manage customer engagement throughout the lifecycle (Sumter et al., 2021; Sousa-Zomer et al., 2018), and understand specific customer needs according to different market segments (Sousa-Zomer et al., 2018). The *customer management* capability is defined as *the ability to manage the relationship with and understand the expectations of the customer*.
	Communication	the ability to design communication channels and communicate credible and transparent circular economy narratives	Communication is important in the circular economy transition as it facilitates changing existing narratives and building credibility. It is suggested to actively reshape the narrative of used products; for example, instead of using phrases such as 'second-hand', adopt terms with more positive connotations, such as 'pre-loved' (Sandberg & Hultberg, 2021). Part of this communication is the creation of narratives and engaging visions that can be utilized to generate stakeholder support (Sumter et al., 2021). To secure trust and engagement of stakeholders, fact-based and transparent communication is required (Santa-Maria et al., 2021; Wade et al., 2022). Moreover, appropriate communication channels are required to convey core values (Bertassini et al., 2021).
	Market monitoring	the ability to monitor new trends, competitors' actions, and consumption patterns	Monitoring market and sustainability trends (Khan et al., 2020) by collecting information on customer behavior (Elf et al., 2022) and being able to observe the dynamics in the market (Kusumowardani et al., 2022) were found to influence an organizations' ability to recognize market opportunities within the circular economy. Apart from market opportunities, organizations should closely monitor consumption patterns (Elf et al., 2022; Fernandez de Arroyabe et al., 2021) and environmental and social threats and opportunities (Santa-Maria et al., 2021). Organizations may appoint a distant dedicated team to search for and sense new opportunities in the market (Kuhlmann et al., 2022).

Table C.4: Capabilities relating to the Business Operations dimension

Category	Capability	Defintion	Background
Logistics & manufacturing	Circular design	the ability to design products and services that incoporate circular principles and satisfy human needs and desires	As the transition toward the circular economy is accompanied by circular product and service development practices, design and creativity are fundamental for delivering a competitive offering (Chaudhuri et al., 2022). If the design is not aligned with the circular economy, solutions may not be suitable for repair, re-manufacturing, or reprocessing while value is retained (Chari et al., 2022). Especially when preserving product ownership, where manufacturers control product maintenance and recycling, the importance of product design is highlighted (Lopes de Sousa Jabbour et al., 2019). Therefore, organizations should comprehend circular product and service design procedures(De los Rios & Charnley, 2017; Sousa-Zomer et al., 2018) to develop sustainable solutions that satisfy human needs (Belhadi et al., 2022). To encourage circular design, organizations should initiate design requirements (e.g., for durability) (Fernandez de Arroyabe et al., 2021), aim to solve aesthetic issues with limited components (De los Rios & Charnley, 2017), develop design skills to integrate recycled materials (Chaudhuri et al., 2022), and include customers in the design process (Prieto-Sandoval et al., 2019).
	Circular supply chain management	the ability to integrate circular accounting and monitoring in the management of the supply chain	Circular supply chain management focuses on the sustainability of the supply chain as this is an important part of the circular ecosystem. It encapsulates practices such as ensuring that suppliers commit to meeting the standards and policies (Sousa-Zomer et al., 2018), strategically selecting suppliers aligned with the organizational vision (Elf et al., 2022), and engaging in green warehousing activities (Jayarathna et al., 2022). Furthermore, organizations may develop supplier incentives and certification programs (Belhadi et al., 2022) to support adopting sustainable practices.
	Circular manufacturing	the ability to comprehend and integrate circular principles in manufacturing processes	Adopting sustainable and efficient practices within the manufacturing system was highlighted in multiple publications. It encapsulates activities ranging from acquiring and utilizing circular materials (Sumter et al., 2021; Khan et al., 2020; Chaudhuri et al., 2022) to understand the process for reverse and re-manufacturing (De los Rios & Charnley, 2017). Moreover, initiatives such as dematerialization, narrowing resource usage, prioritizing resource efficiency (Lopes de Sousa Jabbour et al., 2019; Chari et al., 2022; Belhadi et al., 2022), and implementing renewable energy sources are also considered part of an efficient manufacturing system.
	Logistic process management	the ability to develop and manage processes for (reverse) logistics and (re)manufacturing	Understanding and managing logistic processes (De los Rios & Charnley, 2017) and collaborating with organizations on logistic operations (Prieto-Sandoval et al., 2019) are key activities for achieving a well-functioning circular supply chain. Examples of collaborations are partnering with retailers to support remarketing and reverse logistics (De los Rios & Charnley, 2017) and sharing real-time information with stakeholders. Organizations should focus on developing a resilient supply chain as such chain can respond to market uncertainty, changing customer demands, and disruptive events (Chari et al., 2022) and create an integrated supply chain management system (Sousa-Zomer et al., 2018).

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Table C.4: Capabilities relating to the Business Operations dimension (Continued)

Category	Capability	Defintion	Background
	lifecycle management	the ability to ensure accountability and manage the social and environmental impact throughout the product's lifecycle	Management of the lifecycle comprises activities that focus on lifecycle extension and looping. Worn components may be replaced or repaired, energy may be recovered from non-recyclable waste, products may be reconditioned and sold, and components or a product may be used for a different function after improvement or modification (Belhadi et al., 2022). By considering the complete cradle-to-cradle process and understanding resources as future resources, the lifecycle perspective allows for identifying impacts and opportunities (Santa-Maria et al., 2021). Furthermore, lifecycle management may require designing and coordinating take-back systems (Lopes de Sousa Jabbour et al., 2019).
Research & development	Innovation	the ability to develop, integrate, or improve circular products, services and processes	Innovation has the potential to guide organizations toward circularity (Wade et al., 2022) by initiating new routines, procedures, and practices (Marín-Vinuesa et al., 2021; Sehnem et al., 2022). The concept of circularity requests innovations that contribute to more efficient use of resources (Sehnem et al., 2022). Innovations related to circular principles, eco-design, and process design are required to enable the design and development of sustainable products and processes (Seles et al., 2022). The primary role of innovation within the circular economy transition can be considered as the support and generation of novel methods for producing goods and managing waste while retaining the value of resources. However, the shift from linear models to the circular economy enabled by innovation is a complicated topic, given the many actors, networks, relationships, and organizational structures involved (Sehnem et al., 2022). Conventional commercial and economic logic can embody a barrier to circular economy innovations' success (Sehnem et al., 2022). Applying tools such as a life cycle analysis or participating in conferences, seminars, trade shows, and brainstorming sessions (Khan et al., 2020) increases the likeliness of generating ideas and accomplishing innovation. Therefore, idea generation, relating to the organizational desire to innovate and transform circular practices, is an important aspect (Elf et al., 2022). In addition, other innovative activities are considered to commercialize, collect customer data, and manage maintenance and support (Sehnem et al., 2022). Furthermore, product (Chari et al., 2022) and technological (Kusumowardani et al., 2022) innovation enabled by stakeholder cooperation are important assets for the circular economy transition.
	Experimentation	the ability to execute experiments and pilots to validate, learn, and adapt	Experimentation supports organizations in moving toward circularity as it is widely recognized by researchers in sustainability fields as an essential practice for organizations aiming to reduce their environmental impact (Wade et al., 2022). Especially organizations that focus on circular business and product innovation benefit from experimentation (Wade et al., 2022). In general, experimentation decreases uncertainty and risk, validates assumptions, and facilitates organizational learning before scaling practices (Santa-Maria et al., 2021). Operational risk reduction may be achieved by investigating customers' behavior, identifying barriers, and responding appropriately before product launches (Sousa-Zomer et al., 2018). Organizations should, therefore, actively engage in experimentation (Elf et al., 2022) and develop experimentation plans to safeguard economic and financial business viability (Sousa-Zomer et al., 2018).

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Table C.4: Capabilities relating to the Business Operations dimension (Continued)

Category	Capability	Defintion	Background
	IP management	the ability to manage processes related to the development, maintenance, distribution, and protection of IP assets	Managing IP assets is considered crucial for circular organizations and requires a carefully created balance between knowledge sharing, knowledge integration and patenting. Knowledge and intellectual property exchange encourage complementary innovation and enable the broader ecosystem to achieve its circular goals (Parida, Burström et al., 2019). Knowledge sharing promotes cooperation in three ways: by offering a platform for communication, channeling knowledge, and promoting efficient governance (Köhler et al., 2022). Central agencies may examine and disseminate knowledge to benefit the ecosystem (e.g., forecasts for purchases are made using trend and sales data from various retailers) (Sandberg & Hultberg, 2021). The involvement in open innovation practices and pursuing competitive advantage must be carefully balanced regarding knowledge sharing (Köhler et al., 2022). Knowledge-sharing practices collect and provide circular economy-relevant knowledge (Fernandez de Arroyabe et al., 2021), establish non-hierarchical knowledge-sharing routines, and adopt open innovation-sharing mechanisms (Köhler et al., 2022). Integration of knowledge is crucial for executing the circular economy (Khan et al., 2020). Employing cognitive abilities to sense new opportunities (Wade et al., 2022), accumulated experiences, intellectual property, and know-how within the organization are positively associated with the circular transition (Santa-Maria et al., 2021). Knowledge may be integrated into enterprises by reconfiguring how resources, work, and other business practices are organized (Elf et al., 2022). Furthermore, it was found that organizations collaborated with research institutions to exploit their knowledge (Khan et al., 2020). Patenting intellectual property concerning sustainable practices is considered a relevant element within the circular economy as it may improve organizations' competitive advantage. Moreover, patenting may indicate circular economy performance as it demonstrates the investments in intangible assets that aim to close the material loop (Marín-Vinuesa et al., 2021). To promote patent development, organizations should collaborate with research and development institutes, exercise a strong persistence in patenting, and develop territorial linkage within their territory (Marín-Vinuesa et al., 2021).
	Data analytics	the ability to diagnose, discover patterns, and predict and prescribe relevant consequences based on data	Technological developments such as the internet of things, big data, and data analytics are important facilitators of the circular economy transition (Kristoffersen et al., 2020). More specifically, using technologies may support the design of a circular business model (Reim et al., 2021). Important aspects are the upgradation of technology (Khan et al., 2021), the assurance of connectivity, and the development of digital proficiency (Chari et al., 2022). Furthermore, the importance of traceability within the circular value chain is acknowledged by multiple studies (Ingemarsdotter et al., 2019; Prieto-Sandoval et al., 2019; Lopes de Sousa Jabbour et al., 2019; Kusumowardani et al., 2022). Traceability enables organizations to monitor, track, and control products' location, composition, and condition (Ingemarsdotter et al., 2019). The relevance of data analytics within the circular economy is widely recognized (Kristoffersen et al., 2020; Awan et al., 2021; Ingemarsdotter et al., 2019). Data analytics may support organizations with the optimization of operations using advanced algorithms (Ingemarsdotter et al., 2019) or assist with the execution of business intelligence analytics (Awan et al., 2021). Recommended practices for data analytics are to develop an understanding of the nuances of data analytics (Awan et al., 2021), automate data collection, develop data sharing infrastructures, and utilize feedback data for organizational learning (Kristoffersen et al., 2021).

Appendix D

Results Focus Groups

D.1 Focus Group Transcripts

Here the transcripts of the focus groups are reported. First, the transcripts of the focus group with consultants & advisors are documented and thereafter the transcripts of the group with managers & executives.

D.1.1 Transcript Focus Group: Consultants & Advisors

This section presents the translated transcripts from the focus group with consultants and advisors. The section is structured by the criteria that were discussed. The section is closed with the comments that did not directly relate to the criteria.

Completeness

P1: *"It looks reasonably complete; it looks like most is covered."*

P2: *"The model contains a lot of information."*

P3: *"When you are developing a model like this, you have to realize that you will never be fully complete."*

Appropriateness

P2: *"For me, it is unknown whether the aspects in the model allow you to understand your current impact and whether you can calculate it."*

P2: *"How do you create a completely new business model? This is something that I don't see in the model"*

P2: *"The model shows the elements in silo's. Understanding the interdependencies between the elements when developing a new business model is essential."*

P3: *"The change management capability is mostly relevant if the circular economy has not been implemented yet. When you changed parts of your organization, this capability is less important."*

P4: *"Circular design is developed together with the business model. So these are dependent elements."*

Understandability

P4: *"The structure and categories are clear and intuitive with the components of a company. For example, someone could recognize, I am responsible for human resources, so the underlying capabilities are relevant for me."*

P3: *"I find the dimensions and categories familiar and recognizable. It shows four dimensions and whenever you zoom in, you understand the aspects that you should consider."*

P4: *"With circular ecosystem, for example, I am not sure whether someone within an organization directly raises their hands and recognizes that it is a responsibility for his or her department."*

P4: *"There are many elements in the model that suggest equal importance of the capabilities. They are all relevant, but one capability is more relevant than another."*

Usefulness

P3: *"The model's usefulness for me would be to consider and think about the capabilities and determine whether you thought of them and whether you think they are relevant for a certain type of company.*

P3: *"I find the dimensions and categories familiar and recognizable. It shows four dimensions, and whenever you zoom in, you understand the aspects that you should consider. Then organizations can determine whether they already possess the capability or not. In this way, you support firms and public organizations to consider their steps within the circular economy carefully. They could ask themselves: am I ready for the next step, or should I improve some capabilities first?"*

P1: *"The model seems to focus on larger companies as there are many capabilities, different categories, and different departments. Hence, I assume that it is not focused on, for example, a startup. However, it could be beneficial for a startup to trigger them to consider unanticipated elements."*

P1: *"It is very case-specific which capabilities are relevant and translating the capabilities from the model to a subset of capabilities that is relevant for an individual case remains a challenge."*

P1: *"I was thinking: When I am an entrepreneur, then I think most people need an additional step of support. If you only run a company with two persons its easy to determine whether you have these capabilities. However, when you have a legal department, it might be hard to understand whether you possess these capabilities. And it might be unknown what the next step is."*

P3: *"There will always be things that people do not need. It might be too much for one organization, and for the other, there might even be a lack of capabilities. This depends on many factors such as product, market, organization, etc."*

P3: *"It shows the large steps which are useful."*

Other

P2: *"80% of Dutch firms are SME's. Together, they have a huge part within the transition. If you want to emphasize the relevant capabilities for them, it might require a different way of representation."*

P3: *"Can you couple the circular principles to the capabilities. For example, when you are focusing on reduce and reuse, which capabilities do you need for that? What would people within your organization be able to do to implement these principles. What do you need to get your place within an ecosystem clear?"*

P3: *"Considering that you have an existing firm that wants to change towards the circular economy, then you need a set of capabilities. These capabilities by themselves are not circular. You are a designer, business analyst, or financial expert. You are not suddenly 'circular financial expert'. When you describe it, it must have to do with circular product design for example. However, the function remains designer."*

P1: *"Some elements have different terminology than I would use or am used to. For example, I was looking for lobbying which I could not find. However, when I later on looked at ecosystem orchestration, it was there."*

D.1.2 Transcript Focus Group: Managers & Executives

This section presents the translated transcripts from the focus group with managers and executives. The section is structured by the criteria that were discussed. The section is closed with the comments that did not directly relate to the criteria.

Completeness

P5: *"The model looks very complete in the time I looked at it. From an operational perspective of a business, I think it is very complete. However, from a more holistic perspective, I am unsure whether everything is covered. It depends where you define the boundaries of responsibility of an organization."*

P6: *"Overall, the model is very complete for the day-to-day business. However, in the circular economy, the ecosystem is very important, and I notice that many companies are not prepared for that. It has to be in the core of the organization that you want to be part of that ecosystem. And this determines whether you can cope with the circular developments within your area of interest. This is something that the model misses for me."*

P7: *"I think the model is very complete. I agree that when having a circular business, every element needs attention and should be considered. However, I think the model contains many elements that are also relevant for traditional companies that do not engage in circularity."*

P7: *"The way I look at it is that you need all capabilities indeed at a circular business."*

Appropriateness

P6: *"I miss additional in-depth explanation on the capabilities: what does the capability contribute to the circularity of a company? Since some capabilities are also relevant for traditional businesses, it must be emphasized how the capability should be differently executed to be more circular."*

P7: *"I would like to see a more in-depth explanation of the capabilities. I think the overview is very helpful; however, a more in-depth explanation would definitely contribute. You need a different mindset on the capabilities when you approach it with a strong circular purpose."*

Understandability

P5: *"Model is understandable. When I am reading the model, it is easy to understand, and the texts are clear for me."*

P7: *"Yes, the model is very understandable and clear."*

Usefulness

P6: *"For Decathlon, the HR department monitors the capabilities in the teams and determines which capabilities are desired in teams. Therefore, a capability overview is more or less present. However, it would be interesting if you could provide more in-depth details and determine which actions to take. For example, that recruitment knows who to recruit.*

P7: *"The model helps with providing an overview; however, I think that when we would not be applying circular principles, the value for me would be similar as it maps many generally relevant capabilities."*

P7: *"The model, without further details does not help me for the determination of improvement strategies. I can analyze the model and think by myself about how we currently fill the capabilities. However, I am very curious about a layer that goes more in-depth on the activities. This determines for me whether it is useful."*

P5: *"In the public domain, some capabilities are relevant. However, for me personally, as it looks to be focused on a product or a service, it is not that useful for me."*

Other

P6: *"We see sometimes that outdated regulations hamper the transition toward the circular economy. For example, we recently had the case where safety regulations prevented the second-hand use of one of our articles even when the article was safe and in a good condition. Here, for us lobbying is required."*

D.2 Evaluation Questionnaire

Table D.1: Results of Evaluation Questionnaire

	Consultants & Advisors				Managers & Executives			
Completeness	$\bar{x}$	s	min	max	$\bar{x}$	s	min	max
The model misses relevant capabilities*	3.25	0.96	2.00	4.00	3.33	1.15	2.00	4.00
I would rate the completeness of the model	3.50	0.58	3.00	4.00	3.67	0.58	3.00	4.00
Appropriateness								
The elements in the model are highly relevant for the circular economy domain	3.75	0.50	3.00	4.00	1.53	1.53	2.00	5.00
The model elements provide sufficient detail to improve circular strategies	3.00	0.00	3.00	3.00	1.33	0.58	1.00	2.00
I would rate the appropriateness of the model	4.00	0.82	3.00	5.00	2.67	0.58	2.00	3.00
Understandability								
It is easy to understand the information in the model	3.25	0.96	2.00	4.00	4.67	0.58	4.00	5.00
The structure of the model is entirely clear	3.50	0.58	3.00	4.00	4.33	1.15	3.00	5.00
I would rate the understandability of the model	3.75	0.5	3.00	4.00	4.33	0.58	4.00	5.00
Usefulness								
The model helps to assess the capabilities of an organization	3.75	0.96	3.00	5.00	2.67	0.58	2.00	3.00
The model helps to develop improvement strategies for an organization	2.75	0.96	2.00	4.00	2.67	0.58	2.00	3.00
I would rate the usefulness of the model	3.50	0.58	3.00	4.00	2.33	0.58	2.00	3.00

* reverse scale is applied