

Barriers faced and dynamic capabilities needed for a circular transition – evidence from the manufacturing industry in the Netherlands.

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Abstract

The transition from a linear to a circular economy is key to realize a more sustainable tomorrow. SMEs are seen as the backbone of the economy and therefore play a prominent role in realizing this transition. However, until now only few SMEs have succeeded this circular transition. There are still many barriers faced during this transition and until now the current literature has not focused on which dynamic capabilities are needed to solve these CE-barriers. To address this knowledge gap, this study uses a multiple-case studies approach, where the barriers and dynamic capabilities during the different stages of the CE transition are explored. The findings indicate that especially business model innovation, circular design and collaboration in the value network are important dynamic capabilities. The results show that especially CE-specific barriers and dynamic capabilities have an influence on the success of the CE transition. Moreover, the results implicate that the stage of the transition matters in experiencing the different barriers and dynamic capabilities, something which has not been emphasized throughout the literature until now. This is important, because the stage of transition matters to understand the context when researching barriers and dynamic capabilities. In addition, this paper contributes to the theory that it is insightful to distinguish between CE-specific and general innovation barriers, as these were perceived and possessed differently by the case firms. It is valuable to know which dynamic capabilities need to be developed from scratch when engaging in a CE transition, apart from general dynamic capabilities needed for innovation and change.

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1. Introduction

New products made from re-used materials, refurbished products, products as a service: all examples of circular business models that are needed to change our linear economy to a circular one. Small and medium- sized enterprises (SMEs) are seen as the backbone of the economy and therefore play a very important role in steering the current linear economy towards a more circular one (Rizos et al., 2015). Until now, several SMEs have left their linear principles in the past and successfully transitioned to circular practices. An example of an SME that has embraced circular economy (hereafter referred to as CE) principles to the fullest is Ahrend, a manufacturer of office furniture. Sustainability (and therefore circular principles) is an integral part of their strategy and the CE ambitions and goals are closely connected to their vision (Ahrend, 2020). They focus on circular design, closing loops and collaborate within their value network (Ahrend, 2020). However, not many SMEs have followed the example set by Ahrend and up to now still many SMEs are engaged in the linear way of doing business.

The attention to the concept of a CE has grown enormously over the last years leading to the fact that policymakers have started with actively promoting CE practices (Reike et al., 2018). In Europe, many governments have implemented CE practices, policies and programs to stimulate diffusion of the CE philosophy (EUKN, 2015; Reike et al., 2018). Even though many businesses (hereafter also referred to as companies, organizations or firms) are provided with these supporting programs and policies to transition to a CE, implementation of CE practices still appears to be difficult for businesses and is more focused on recycling rather than re-use (Ghisellini, 2016). That is why this paper will research the success of the CE transition of SMEs. There are still many barriers businesses face during the process of the CE transition. De Jesus & Mendonça (2018) have developed a CE barriers framework and especially the availability of technical solutions and financial factors form hard barriers for CE expansion. However, De Jesus & Mendonça (2018) concluded that this framework does need additional empirical substantiation. Kirchherr et al. (2018), for example, aimed to provide this empirical data and identified barriers in the cultural, regulatory, market and technological context. The most pressing barriers identified took place in the cultural and market context. Cultural barriers were hesitant company culture, operating in a linear system and lacking customer awareness and interest. Market barriers were low virgin material prices and high upfront investment costs. Nonetheless, additional empirical evidence on CE barriers from a business perspective

is still of high need, especially because of contradicting current literature. For example, Kirchherr et al. (2018) found that technological barriers were not perceived relevant in their survey, which contradicts existing literature (e.g. Preston, 2012; Bicket et al., 2014; Shahbazi et al., 2016; Pheifer, 2017; De Jesus & Mendonça, 2018) and this difference should be further researched.

In order to become successful in the CE context and to overcome the aforementioned barriers, businesses need to possess certain capabilities. However, some businesses are too rooted in a linear economy approach and their strategies, structures, operations and supply chains are not able to exploit CE opportunities (Accenture, 2014). That is why businesses need to reconfigure these existing resources and capabilities and develop new, dynamic, capabilities that reorganize their strategies, structures, operations and supply chain in order to get rid of a linear way of doing business and capture CE value (Hart, 1995; Wu et al., 2013; Lacy & Rutqvist, 2015). However, dynamic capabilities in the CE context is still unexplored territory and additional empirical research is needed, especially when it comes to the maturity of these capabilities (Helfat & Peteraf, 2003; Khan et al., 2020). For example, no previous studies have taken into account which stage of the transition to CE operations the business is currently in and which dynamic capabilities are needed throughout the different stages of transition and how these change over time (Khan et al., 2020). Taking into account the stages of transition is important while researching the dynamic capabilities, while these may change throughout the transition (Helfat & Peteraf, 2003). It is therefore interesting to research the development of these capabilities over time to overcome the CE barriers perceived in the different stages throughout the CE transition, i.e. do the capabilities change according to intensity or does the nature of these capabilities change. According to Löwik's Circular Innovation Maturity Model, businesses will face five stages during their transition to more circular practices: unformed, basic, improving, engaged and advanced (Löwik, 2019).

The aim of this research is twofold. First of all, the aim is to clarify which barriers businesses face while transitioning to more circular practices. Second, the aim of this study is to develop an understanding of the dynamic capabilities businesses possess and adjust when they transition from linear to circular practices and how they use these capabilities to overcome the aforementioned barriers. To provide context, the stage of the transition the business is in will be taken into account while researching these dynamic capabilities. The five stages mentioned in the Circular Innovation Maturity Model initiated by Löwik (2019) will

serve as a framework for this. This will be researched among small- and medium sized enterprises (SMEs) in the manufacturing industry in the Netherlands. This leads to the following research question: “Which dynamic capabilities are needed to overcome the barriers faced while transitioning from linear to circular operations?”.

The findings of this study aim to make an important contribution to the field of barriers and the corresponding dynamic capabilities in the CE context by providing empirical data and to give insights in how these two concepts are linked to each other. In addition, the findings should provide new insights and understandings in how businesses need, adapt and use their dynamic capabilities according to the barriers faced and thereby advance the knowledge in this area of interest. From a business perspective, this study can provide guidelines to help businesses to critically reflect on their own capabilities and adjust these accordingly. In that way, this study can contribute to a wider diffusion of CE and help businesses take their CE practices to a higher level.

The structure of this paper is as follows: first, I will provide a theoretical framework to define the barriers faced while transitioning from linear to circular practices and to elaborate on the concept of dynamic capabilities. After that, the results will show which dynamic capabilities are needed to solve certain barrier s in order to discuss the theoretical implications and practical recommendations for managers that are facing a CE transition.

2. Theoretical Framework

In a CE, the economic system is provided with a cyclical flow model – instead of the traditional linear one – and emphasizes product, component and material reuse, remanufacturing, refurbishment, repair, cascading and upgrading (EMAF, 2013; Korhonen et al., 2018). Next to that, it also stimulates solar, wind, biomass and waste-derived energy utilization throughout the product value network and follows the cradle-to-cradle philosophy (Mihelcic et al., 2003; Braungart et al., 2007; Rashid et al., 2013). A widely used definition, based on a meta-analysis of 114 definitions, reads as follows: “A circular economy describes an economic system that is based on business models which replace the ‘end-of-life’ concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality,

economic prosperity and social equity, to the benefit of current and future generations.” (Kirchherr et al., 2017, p. 224-225). This definition will serve as the basis for this paper, but the focus is on the aforementioned micro level. In addition, the three main principles defined by the Ellen McArthur Foundation (2015) will be used. The first principle is known as preserve and enhance natural capital and will be achieved by controlling finite stocks and balancing renewable resources flows (e.g. using renewable energy instead of fossil fuels). The second principle, optimize resource yields, focuses on achieving the highest utility of circulating products, components and materials by for example extending the lifetime of products or by sharing or looping products. The third principle, foster system effectiveness, focuses on diminishing negative externalities related to resource use, such as water, air, soil and noise pollution; climate change; toxins; congestion and negative health effects. These principles for the basis for the ReSOLVE framework and have been translated into six business actions: regenerate, share, optimize, loop, virtualize and exchange, as shown in Table 1 (EMAF, 2015).

	Examples
Regenerate	<ul style="list-style-type: none"> - Shift to renewable energy and materials - Reclaim, retain, and restore health of ecosystems - Return recovered biological resources to the biosphere
Share	<ul style="list-style-type: none"> - Share assets (e.g. cars, rooms, appliances) - Reuse/secondhand - Prolong life through maintenance, design for durability, upgradability, etc.
Optimize	<ul style="list-style-type: none"> - Increase performance/efficiency of product - Remove waste in production and supply chain - Leverage big data, automation, remote sensing and steering
Loop	<ul style="list-style-type: none"> - Remanufacture products or components - Recycle materials - Digest anaerobically - Extract biochemicals from organic waste
Virtualize	<ul style="list-style-type: none"> - Books, music, travel, online shopping, autonomous vehicles etc.
Exchange	<ul style="list-style-type: none"> - Replace old with advanced non-renewable materials - Apply new technologies (e.g. 3D printing) - Choose new product/service (e.g. multimodal transport)

Table 1 ReSOLVE Framework, acquired from EMAF (2015)

2.1 Barriers

In their systematic literature review, De Jesus & Mendonça (2018) have categorized barriers for CE and distinguished between cultural, regulatory, market and technological barriers. Kirchherr et al. (2018) have used these categories in their studies as well and used the paper of De Jesus & Mendonça (2018) as a starting point for their research. In this paper, the theoretical framework will build on the categories of barriers used by De Jesus & Mendonça

(2018) and Kirchherr et al., (2017) and other literature will be added. The aforementioned categories are used as a base, but the organizational aspect is added to the cultural category, as organizational aspects such as rigid organizational structure are also covered in this category. These categories will be elaborated on below. Table 2 shows an overview of the categories and corresponding sub-categories of barriers identified.

Barrier category	Sub-category	Mentioned by
Cultural/Organizational Lacking awareness, skills and/or willingness to engage with CE (Kirchherr et al., 2018)	Rigid organizational structure	e.g. Preston, 2012; Rizos et al., 2015; Shahbazi et al., 2016; Mont et al., 2017; Pheifer, 2017; Ritzén & Sandström, 2017; De Jesus & Mendonça, 2018; Kirchherr et al., 2017; Ormazabal et al., 2018; Ranta et al., 2018; Bressanelli et al., 2019; Hart et al., 2019; Vermunt et al., 2019
	Hesitant company culture	
	Lacking availability of CE knowledge and skills	
	Operating in a linear system – strategy and CE does not align	
	Limited willingness to collaborate in the value network	
Regulatory Lacking policies in support of a CE transition (Kirchherr et al., 2018)	Lacking standards	e.g. Preston, 2012; Rizos et al., 2015; Mont et al., 2017; Pheifer, 2017; De Jesus & Mendonça, 2018; Kirchherr et al., 2017; Ranta et al., 2018; Bressanelli et al., 2019; Mura et al., 2020
	No (financial) incentives for circularity, while there is for linearity	
	Obstructing laws and regulations	
Market Lacking economic viability of circular business models (Kirchherr et al., 2018)	Low virgin material prices	e.g. Preston, 2012; Kok et al., 2013; Rizos et al., 2015; Mont et al., 2017; Pheifer, 2017; Ranta et al., 2017; Ritzén & Sandström, 2017; De Jesus & Mendonça, 2018; Kirchherr et al., 2017; Ormazabal et al., 2018; Bressanelli et al., 2019; Hart et al., 2019; Vermunt et al., 2019
	High upfront investment costs, but focus on short term results	
	Limited funding for circular business models	
	Lack of reverse logistics/reverse supply-chain	
Technological Lacking (proven) technologies to implement CE (Kirchherr et al., 2018)	Lacking ability to deliver high-quality circular products	e.g. Berchicci & Bodewes, 2005; Rizos et al., 2015; Mont et al., 2017; Pheifer, 2017; Ritzén & Sandström, 2017; De Jesus & Mendonça, 2018; Kirchherr et al., 2017; Ormazabal et al., 2018; Bressanelli et al., 2019

Table 2 Barriers to CE transition

Cultural/Organizational barriers

Cultural and organizational barriers refer to a lack of awareness, skills and/or willingness to engage with CE within and beyond organizational boundaries (Kirchherr et al., 2018). First of all, a *rigid organizational structure* with a strong hierarchy can prevent awareness and recognition of CE-opportunities as ideas coming from lower levels cannot get to the top of the organization easily (Pheifer, 2017). Next to that, Ritzén & Sandström (2017) and Hart et al.

(2019) mentioned that CE practices are too complex to be handled by one single department and that the organization should aim to integrate different functions within the company in order to facilitate a CE transition. A rigid organizational structure could hamper this. Ritzén & Sandström (2017) also identified in their case studies that a sustainability vision was not integrated throughout the organization which is a challenge for a CE transition because of the numerous dimensions and aspects and therefore the complexity of CE.

A *hesitant company culture* forms another barrier to a CE transition, though it is closely connected to a rigid organizational structure. A “silo mentality” of certain departments discourages information sharing across the company and organizational silos prevent smooth development and implementation of circular business models, which even happens in SMEs (Pheifer, 2017; Goldfein, 2019). In terms of SMEs, the manager is usually the owner of the company with a lot of power on the strategic decisions, making the SME managers’ attitude towards circularity a key factor in the CE transition of SMEs (Rizos et al., 2015). In addition, Ritzén & Sandström (2017) identified the large risk aversion and “the business logic of taking small safe steps” as the most prominent barrier when it comes to a disruptive transition to CE.

Previous research has shown that businesses still struggle with the *lacking availability of CE knowledge and skills* within their organization (e.g. Rizos et al., 2015). A clear understanding of what CE actually is and means is not common sense (e.g. Rizos et al., 2015; Pheifer, 2017; Ritzén & Sandström, 2017). For example, research from Pheifer (2017) showed that each interviewee explained CE differently and that multiple interviewees highlighted that they have a poor understanding of what a CE entails. But not only the lack of general knowledge is a challenge, the limited availability of expertise and technological knowledge when it comes to CE is also perceived as a major bottleneck (Shahbazi et al., 2016; Agyemang et al., 2019).

Many businesses are still *operating in a linear system*, leading to the fact that the strategy of the business does not align with CE goals. CE practices are usually not integrated in the strategy, mission, vision, goals and key performance indicators, leading to the fact that they are not perceived as key activities which hampers the implementation of these practices (Pheifer, 2017; Ritzén & Sandström, 2017).

Businesses making the transition to CE face *limited willingness to collaborate in the value network*. Partners within the supply chain can be very conservative (Kirchherr et al., 2018) and initializing a “green supply chain” is not that easy as it may seem, because of the

potential costs suppliers have to deal with (Rizos et al., 2015). Next to that, SMEs only have little influence on their suppliers' attitude towards green activities because of their small size and bargaining power (Zhu et al., 2008; Eltayeb & Zailani, 2009; Wooi & Zailani, 2010). In addition, the fact that the supply chain is usually managed internationally makes collaboration more difficult (Preston, 2012; Rizos et al., 2015).

Lastly, consumer habits only change slowly because of inadequate information spreading regarding CE and the possible consumer choices available (De Jesus & Mendonça, 2018). This leads to a *lacking consumer awareness and interest* in the CE concept. On the other hand, Kirchherr et al., (2018) mentioned that “consumers change their mind too quickly” which could interfere with the production of durable products, because these products last longer than the fashion trend. In addition, Pheifer (2017) mentioned that price is still the number one driver in the buying decision of consumers, which may lead to the fact that a very environmentally conscious individual acts as a very ignorant consumer who buys non-sustainable products (Alphonse et al., 2014). Next to that, there are still many misunderstandings about refurbishment, reuse and the product-as-a-service business model (Mont, 2017). For example, many consumers still believe that refurbished products are inferior to new products and most consumers still have a high preference over new products (Mont, 2017; Ranta et al., 2017).

Regulatory barriers

Current laws, rules and regulations are perceived as important constraints for CE implementation. Regulatory barriers therefore refer to lacking policies that support CE or existing policies that hamper a CE transition (Kirchherr et al., 2018). The first type of regulatory barrier is the currently *lacking standards*. These lacking standards could address CE processes, activities and materials and provide guidelines to define sustainability in SMEs (Bressanelli et al., 2019; Mura et al., 2020). Next to that, standards can help to diminish the *lacking consumer awareness and interest* barrier by providing product certifications or labelling systems, like those for energy and carbon (Preston, 2012). In that way, consumers might understand the value of the CE concept better and therefore a greater awareness of the concept will be created (Preston, 2012).

In the current regulatory system, many subsidies are in place, but these mostly apply to linear practices, instead of circular ones (Pheifer, 2017). This leads to the fact that there are *not enough (financial) incentives for circularity* imbedded in the current regulatory system,

while there is for linearity (Pheifer, 2017). For example, Pheifer (2017) mentioned that there is a great amount of financial support, such as tax reduction and subsidies, for large oil companies, whereas there are only few governmental financial incentives for circular business models. Some governments do try to discourage the use of fossil energy, but do not focus enough on encouraging the investment in sustainable energy sources (Pheifer, 2017). Next to that, the current regulations which are in place merely focus on recycling by means of certifications and awards, but do not focus on institutional support for reuse, which forms a major barrier for the CE (Ranta et al., 2018).

Instead of incentives for CE, many businesses face *obstructing laws and regulations* (e.g. Ranta et al., 2018). For example, how policies define what is waste, and what is not waste, highly influences the development of CE practices (De Jesus & Mendonça, 2018). Pheifer (2017) also mentioned that the current (waste) legislation and regulations are designed for linearity and that resources are too easily defined and allocated as waste, which makes the labelling to use this as a resource for reuse very difficult and an administrative burden. In the end, this discourages businesses to rethink their waste management policies because the costs are higher than the reward (Pheifer, 2017).

Market barriers

Market barriers refer to a lacking economic viability of circular business models, because of the high costs incurred and the limited funding possibilities (Kirchherr et al., 2018). The first market barrier is that businesses are faced with *low virgin material prices* which makes circular products much more expensive compared to fossil-fuel based plastics (Mont et al., 2017; Kirchherr et al., 2017). Since price is still most important for customers when it comes to their buying decisions, the low virgin material prices have a large impact on the expected number of sales for circular products. If virgin material prices would be higher, there could be more affordable circular products (Kirchherr et al., 2018).

Because of the aforementioned high degree of complexity when committing to a CE transition, a *high upfront investment* is needed with high market uncertainty, whereas most businesses *still focus on short term results* (Ritzén & Sandström, 2017; De Jesus & Mendonça, 2018; Hart et al., 2018; Kirchherr et al., 2017). A shift to CE is complex and is associated with high investment costs (Ritzén & Sandström, 2017). For example, businesses who transition to circular practices need to invest in retooling machines, relocating entire factories, building new distribution and logistics chains and have to retrain their staff (Preston, 2012).

Governments can play a role to diminish this financial barrier by providing funding for businesses who transition to CE practices and to provide clear and strong policy frameworks that encourage investment and experimentation (Preston, 2012; Kirchherr et al., 2017). Closely connected to this is that *limited funding for circular business models* is also perceived as a pressing barrier. Especially SMEs have difficulties in finding appropriate funding (apart from governmental subsidies) for the innovations needed for a CE transition (Geng et al., 2010; De Jesus & Mendonça, 2018). Furthermore, Ranta et al., (2017) mentioned that CE innovations and initiatives have such high costs that financial injections are needed to make these initiatives economically viable, resulting in the fact that financial support is key for a CE transition (Rizos et al., 2015). For certain types of circular business models, such as the product-as-a-service business model, funding is an even bigger issue (Pheifer, 2017). In this business model, costs need to be financed upfront and revenue will be delayed for months (Bresanelli et al., 2019). Businesses investing in these types of business models need a strong financial position or an external investor (Pheifer, 2017).

When using a product-as-a-service business model or when manufacturing other circular products, a *reverse logistics system and supply chain* should be in place. In the current linear system, many businesses lack networks and/or supply-chains that take care of disassembled products, components and materials (Mont et al., 2017). However, organizing this reverse supply-chain is difficult. Due to the geographical dispersion, reverse logistics resulting from CE business models would drastically increase transportation activities since all the products have to be send back to the producers or refurbishment sites (Bresannelli et al., 2019).

Technological barriers

Technological barriers can be identified as the lacking presence of proven technologies that enhance the implementation of CE (Kirchherr et al., 2018). These barriers do not only include the existence, but also technology gaps and the lack of well qualified staff to design and use these technologies (De Jesus & Mendonça, 2018). The main technological barrier identified is that delivering *high-quality circular products* is a big challenge. Current technologies and products are not designed for circularity and cannot be easily disassembled, repaired, refurbished and remanufactured (Berchicci & Bodewes, 2005; Pheifer, 2017). Businesses need highly qualified staff that can identify, adapt, assess and implement advanced circular technologies, but this is something most businesses currently lack (Rizos et al., 2015).

Moreover, many businesses are confronted with the fact that the current infrastructure does not support circular services (Mont et al, 2017) and is highly dependent on fossil fuels and “once-through manufacturing models” (Preston, 2012 p.14).

2.2 Dynamic capabilities

The development and application of dynamic capabilities by a firm is crucial to overcome the aforementioned barriers firms face while transitioning to CE practices (Wu et al., 2013). According to Bocken & Geradts (2019), dynamic capabilities “govern how a firm’s ordinary capabilities are developed, augmented and combined to sense opportunities and threats, seize opportunities and to reconfigure a firm’s assets to remain competitive (Harreld et al., 2007, Helfat & Peteraf, 2015; Teece, 2007). Teece & Pisano (1994) were first to describe the perspective of dynamic capabilities and emphasized two key aspects that had not been the main focus in previous perspectives. First, the dynamic aspect refers to the shifting environment, meaning that certain strategic responses are needed when timing is crucial, the pace of innovation is accelerating, and the future competition and markets are hard to determine (Teece & Pisano, 1994). Second, the capabilities aspect emphasizes the important role of strategic management to appropriately adapt, integrate and reconfigure internal- and external organizational skills, resources and competencies to meet the demands of the aforementioned shifting environment (Teece & Pisano, 1994). In addition, Eisenhardt & Martin (2000, p. 1107) have defined dynamic capabilities as: “the firm’s processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match and even create market change. Dynamic capabilities thus are the organizational and strategic routines by which firms achieve new resource configurations as markets emerge, collide, split, evolve, and die.” This definition is in line with the definition of Zollo & Winter (2002) criticizing the definition of Teece et al. (1997) which requires the presence of a rapidly changing environment for dynamic capabilities. Dynamic capabilities coordinate the resources, as mentioned by Eisenhardt & Martin (2000), through complex routines, meaning that competencies and tacit knowledge are essential to implement strategies to improve organizational effectiveness (Kabongo & Boiral, 2017).

2.3 Stages of CE transition

Dynamic capabilities evolve and change over time, just as competitive advantage or disadvantage shifts over time (Helfat & Peteraf, 2003). A dynamic capability can pass through multiple stages of transformation before it reaches maturity and faces decline (Helfat & Peteraf, 2003). This is also the case when a company is involved in a CE transition, where dynamic capabilities take various forms during the different stages of the CE transition.

As mentioned earlier, in Löwiks Circular Innovation Maturity Model, five stages are covered: unformed, basic, improving, engaged and advanced (Löwik, 2019). In the first stage the business has minimally developed circular innovation capabilities and circular principles are not part of the mission and vision. In the second stage there is some conscious and intentional development of circular capabilities, e.g. in the attention to materials use and re-use. In the third stage the business has recognized the potential of the CE and circular capabilities are developed with commitment from management. In the fourth stage the business has embraced and established circular innovation principles by for example implementing a new business model and circularity is embedded in the strategy. In the fifth and final stage the business continuously improves the circular innovation capabilities to take circularity to the next level.

2.4 Types of dynamic capabilities

As mentioned before, dynamic capabilities are important for businesses to overcome the barriers faced during a CE transition (Wu et al., 2013). Several dynamic capabilities, both CE-specific dynamic capabilities and more general dynamic capabilities, are needed to solve the aforementioned barriers. CE-specific dynamic capabilities are more focused on the operational level of the organization, whereas the general dynamic capabilities take place organization wide. The focus of this research will be on the circular dynamic capabilities but taking into account the role of general dynamic capabilities on the successful transition to circular practices. In order to determine dynamic capabilities that specifically belong to the successful transition to the CE, the aforementioned ReSOLVE framework will be used as a basis, since this framework gives clear directions to companies and economies concerning the actions needed to take circularity to a higher level (EMAF, 2015; McKinsey, 2016). An overview

of the dynamic capabilities, the addressed barrier, the important stage and the relation to the ReSOLVE framework (in case of CE-specific dynamic capabilities), is shown in Table 3.

Dynamic capability	Barrier addressed	Especially important in stage	Relation to ReSOLVE framework
CE-specific dynamic capabilities			
Business model innovation (CIM, CUM, COM)	- Operating in a linear system – strategy and CE does not align	3 – Improving	Share: e.g. share assets Loop: e.g. remanufacture products or components Exchange: e.g. choose new product/service Virtualize: e.g. online shopping
The ability to manage the residual materials flow	- Lack of reverse logistics/reverse supply-chain	3 – Improving 4 – Engaged	Share: e.g. recycle materials Loop: e.g. reuse/secondhand
System thinking	- Operating in a linear system – strategy and CE does not align - Limited willingness to collaborate in the value network	3 – Improving 4 – Engaged	Regenerate: e.g. reclaim, retain, and restore health of ecosystems
Disruptive technological innovation	- Lacking ability to deliver high-quality circular products	2 – Basic	Optimize: e.g. increase performance + efficiency of product Exchange: e.g. apply new technologies Regenerate: e.g. return recovered biological resources to the biosphere
Circular design of products	- Lacking ability to deliver high-quality circular products	3 – Improving	Share: e.g. reuse/secondhand Regenerate: e.g. return recovered biological resources to the biosphere Loop: e.g. remanufacture
Close the resource and material loops	- Lacking ability to deliver high-quality circular products	2 – Basic 3 - Improving	Regenerate: e.g. shift to renewable energy and materials Loop: e.g. recycle materials,
Collaboration in value network	- Lack of reverse logistics/reverse supply-chain - Limited willingness to collaborate in the value network	4 – Engaged	Regenerate: e.g. shift to renewable energy and materials Exchange: e.g. replace old with advanced non-renewable materials;
General dynamic capabilities			
Decentralization and local independence	- Rigid organizational structure	3 – Improving	
Knowledge creation and learning	- Hesitant company culture - Lacking availability of CE knowledge and skills	2 – Basic 3 – Improving	
Scanning the environment & Surveillance of	- Lacking consumer awareness and interest	1 – Unformed 2 – Basic	

markets and technologies		
Alliance and acquisition (acquiring funding)	- Limited funding for circular business models	2 – Basic
Lobbying	- Lacking standards - Low virgin material prices - No (financial) incentives for circularity, while there is for linearity - Obstructing laws and regulations	1 – Unformed 2 – Basic

Table 3 Dynamic capabilities

CE-specific dynamic capabilities

The first CE-specific dynamic capability identified is *business model innovation*. When businesses are transitioning to more circular practices, they may also need to adapt their business model, which usually takes place in the third stage of transition (KPMG, 2018; Prieto-Sandroval et al., 2019; Löwik, 2019). Whereas in linear business models the focus lies on adding value to specific concepts, such as a product, circular business models focus on maintaining value (EMAF, 2015). This is a different mental model, a changing paradigm and a shift in thinking that requires a change in the business model to be able to keep access to the product after use. The product-as-a-service (PAAS) business model might be a solution for this. There are several types of circular business models: Circular Input Models (CIM), Circular Use Models (CUM) and Circular Output Models (COM) (KPMG, 2018). CIM models focus on the input side of production (such as design, production process and materials used), CUM models focus on the use phase (such as the PAAS business model) and COM models focus on the output and added value of a product in the after-use phase (KPMG, 2018). When a business successfully adapts its business model for CE purposes, CE is entirely embedded in the strategy of the business. This dynamic capability can therefore diminish the barrier of *operating in a linear system – strategy and CE does not align*.

When using CUM business models and especially the PAAS business models, businesses should have *the ability to manage the residual materials flow* by having a right system in place for the *reverse logistics*. Reverse logistics entails all the logistics to take back products for remanufacturing or recovery of materials (KPMG, 2018). One approach is that businesses set up a logistics system for products to be returned after use to the producer easily (KPMG, 2018). It is important that the product will be returned to the original producer,

since they have detailed knowledge of the materials used and the mechanics needed for disassembly (EMAF, 2015; KPMG, 2018). Even if the company does not disassemble or remanufacture the products itself (because of the geographical dispersion in the value chain), they can still play a part in the reverse logistics system by facilitating that materials are returned to external actors in the new value network (KPMG, 2018). Setting up this reverse logistics system usually takes place in the improving and engaged stage of a CE transition, as this is where the business is developing and implementing their new business model. However, as the number of products coming back might grow over time, the intensity of the residual materials flow might increase over time, which makes this dynamic capability important throughout all stages.

The optimization of entire processes and systems – also known as *systems thinking* – rather than single components is becoming increasingly important for businesses. This is especially important in the third and fourth stage of transition, where the businesses is reconfiguring its principles in its strategy, system and culture (Löwik, 2019). Systems thinking is seen as a core principle of the CE where the links between businesses, people or plants as part of a complex systems are taken into consideration at all times (EMAF, 2015). More specifically, system-thinking requires studying “the flows of material and energy through industrialized systems, understanding the links, how they influence each other and the consequences, enabling closed-loop processes where waste serves as an input” (Adams et al., 2017, p.16). This means that businesses should organize their material and product flows in cycles and in such a way that no resources are wasted (Lehmann et al., 2014). In order to do so, businesses should develop close *collaborations* with scientists, governments, economists and other stakeholders in the system (Lehmann et al., 2014). If system thinking is implemented in the right way, the *strategy* of the company will completely *align the CE-goals* as all the connections are taken into account and optimized in a circular way.

The next dynamic capability specifically important in the CE context identified is *disruptive technological innovation*. In order to increase the performance and efficiency of the production and in order to reduce waste in the after-use phase of the product, disruptive technological innovation is needed (EMAF, 2015). Digital technologies, such as Internet of Things (IoT), big data, blockchain and RFID may help companies to track their resources and monitor utilization and waste capacity (WBCSD, 2017). In addition, physical technologies, such as 3D printing, robotics, energy storage and harvesting, modular design technology and

nanotechnology can help businesses to reduce production and material costs and thereby reduce the environmental footprint (WBCSD, 2017). Finally, biological technologies such as bioenergy, bio-based materials, biocatalysis, hydroponics and aeroponics can help businesses to diminish the use of fossil-based energy sources and enhance the extraction of biochemicals from waste (WBCSD, 2017; EMAF, 2015). Using these technologies can help companies to *deliver high-quality circular products* and thereby diminishes the occurrence of this barrier. Even though technological innovation is important throughout all stages of the transition, the development and implementation of these technologies is essential in the basic stage, where internal strategy and processes are geared towards efficiency improvement. However, this dynamic capability may take a different form in the final stages of the transition, where continuous improvement of these technologies is focused on, instead of development and implementation of these technologies. The use of renewable energy should also be considered throughout the production process and all the operations of the business. Using renewable energy and eliminating the use of fossil fuels is one of the main principles of the CE and ensures that the system is regenerative by design and therefore energy cannot be made from non-renewable resources (KPMG, 2018). By ensuring to solely making use of renewable energy sources, businesses integrate this principle of the CE in their strategy, which is a start to align their strategy and the CE principles better.

Closely related to the aforementioned dynamic capability, businesses should be able to enhance the *circular design of products* as a means to *produce high-quality circular products*. According to KPMG (2018), a circular product design rests on seven principles. First of all, products should be designed to last for a long period of time. Second, products should be designed to be used for a long period of time, so that customers are willing to use them longer at the highest utility. Third, designs should be standardized and compatible. Next to that, products should consist of standardized and compatible parts. Fourth, designs should take into account the ease of maintenance and repair in order to maintain the value of the product. Fifth, the design should aim to integrate upgradability and adaptability to enhance an easier change of products. Sixth, the design should take ease of disassembly into account, in order to separate parts and materials easily. Last, the design should integrate the use of materials that easily can be recycled in the after-use phase. The focus on circular design will most probably take place in the improving stage of the CE transition, as this is where management is committed to circular innovation principles and aims to extend product life

cycles (Löwik, 2019). But, similarly to the technological innovation, the circular design will be continuously improved in the final stages of the transition.

Another dynamic capability that is key in the CE transition is the ability to *close resource and material loops*, which will diminish the barrier of lacking ability to produce a high-quality circular product. Several strategies can help to close these loops (KPMG, 2018). First of all, businesses should focus on reducing the amount of materials used in products and the number of products in total. Second, businesses should repair and maintain products in a way that only the parts that need to be improved are replaced. Third, products need to be reused when possible or should be redistributed by the service providers. Fourth, the focus should be on refurbishing and reassembling products at the component level. Functioning, reusable parts will be disassembled and reused in new products. Last, the parts that cannot be used for reassembly or refurbishment need to be recycled and used for producing new parts. By using these five strategies, businesses can close their resource and material loops to the best of their ability, which will enable them to deliver high-quality circular products. Closing these resource and material loops usually starts in the basic stage, where there is a beginning attention to material use and re-use and becomes serious in the improving stage, where the circular principles are fully integrated (Löwik, 2019).

In order to successfully transition to circular practices, *collaboration in the value network* is needed. As mentioned before, limited willingness to collaborate in the value network was identified as one of the most pressing barriers for businesses while transitioning to CE. In addition, *the lack of a reverse logistics and reverse supply-chain* was also seen as a crucial barrier, and collaboration within the supply-chain is needed to solve this barrier. This is important since there should be processes in place to take back products in different phases of the product lifecycle and this can incentivize consumers to return their used product (Pheifer, 2017). But a shift to a fully circular supply chain is harder as it may seem. In a linear supply-chain, the relation with suppliers is usually of a competitive nature, based on cost reduction, whereas in a circular supply chain all the actors need to work together, since the added value is the joint process of assembling and disassembling (KPMG, 2018). That is why this dynamic capability is a CE-specific dynamic capability, as the nature of the collaboration is completely different compared to non-CE collaboration. The choice of green suppliers is even more important in a CE, since materials play an essential role. By making use of green suppliers with materials that come from, and safely flow into their respective nutrient cycles,

businesses can create an optimal value network that is designed to eliminate the concept of waste (Circular Design Guide, 2018). When shifting to a circular value chain, the solution is not always found in the same value network and cooperation with actors in an unrelated value network where you can use their waste stream as inputs or vice versa might provide the optimal circular value network (KPMG, 2018). Value and supply-chain collaboration takes place in the engaged stage of the CE transition, as this is when the business takes responsibility for the value network and actively minimizes upstream and downstream value network emissions (Löwik, 2019)

General dynamic capabilities

Firms that *decentralize* their organizational structure and have *high local independence* will face less *rigidity throughout the entire organization*, which is beneficial to a smoother CE transition (Teece et al., 1997). This especially has a major influence in the improving stage, where the company starts aligning CE with their principles, strategy and resources (Löwik, 2019).

Knowledge creation also plays an important role in the CE transition, whereby new ways of thinking are established within the firm and the gained knowledge is shared across the organization (Eisenhardt & Martin, 2000; Ellonen et al., 2011). In order to create new knowledge, businesses need to possess strong *learning routines*, throughout the entire transition to CE and beyond. In the first stages, these learning routines will be focused on getting familiar with CE, but as the knowledge develops, these learning routines will be intensified and more complicated, in order to take the CE knowledge and skills to the next level. Learning is a process of repetition and experimentation that enable tasks to be performed better and quicker and that enable new production opportunities to be identified (Teece et al., 1997). When strong learning routines are established, businesses are able to possess enough *CE knowledge and skills*, a prerequisite for a successful CE transition. When employees possess the right amount of CE knowledge and skills, they might understand the value of the CE concept better which will help pointing their noses in the same direction and have the right *company culture* in place to successfully transition to circular practices.

The ability of businesses to *scan the environment* to evaluate markets and competitors is an important dynamic capability to reconfigure and transform business activities ahead of competition (Teece et al., 1997). By means of this dynamic capability, businesses are able to understand customer needs and interests better and can tackle the *lacking consumer*

awareness and interest barrier better which will enhance a CE transition. The environmental scanning can therefore lead to the fact that businesses should *assess strategic alternatives* (Teece, 2007). However, Zollo & Winter (2002) argue that environmental scanning is usually more understood as a stimulus to initiate proposals that modify existing routines rather than a mechanism that directly shapes the development of dynamic capabilities. Similarly, Teece et al. (1997) and Eisenhardt & Martin (2000) stressed the importance of continuous *surveillance of markets and technologies* and the willingness to *adopt best practice* initiatives, by making use of for example benchmarking. These examples of dynamic capabilities are especially important in the first two (unformed and basic) stages of a CE transition, as this is when the organization becomes familiar with CE and starts to assess alternatives to their linear practices. However, the continuous surveillance of markets and technologies will be a capability important throughout the entire transition to CE and beyond.

In order to strengthen and renew the firm's resource base, external resource acquisition is essential. *Alliance and acquisition routines* bring new resources into the firm from external sources (Eisenhardt & Martin, 2000; Zollo & Winter, 2002). This mostly takes place in the third and fourth stage of the transition, since this is when the organization extends its own boundaries towards stakeholders and takes responsibility for the value network (Löwik, 2019). However, *finding appropriate funding* is an important activity in the earlier stages of the transition and might form a prerequisite for a successful CE transition. Businesses can combine multiple forms of capital (impact investors, venture capital or private equity) and different forms of loans (lease, factoring & supply chain finance or structured finance) to acquire the right amount of funding (KPMG, 2018). This can minimize the risks for the banks if the company is not able to pay for the bank loan via cash flows (KPMG, 2018). In addition, contracts can help to solve legal ownership issues, which often restrict the finance ability of circular business models (KPMG, 2018). Negotiation routines can form an important way to form new alliances and to acquire new resources (Kuuluvainen, 2012). In addition, Teece et al (1997) have emphasized the importance of external coordination and integration of external activities and technologies. This also includes *lobbying*, to have an impact on the current *restricting legislation* and public opinion businesses face throughout the entire CE transition (Oliver & Holzinger, 2008). Restricting legislation and financial incentives especially play a role in the beginning of the transition (stage 1 and 2), when CE is still perceived as a new way of

doing business and businesses have to find a way to work around current legislation and the lack of financial incentives.

3. Methodology

3.1 Case selection

To address the aforementioned research question, a multiple-case studies approach is adopted for the following reasons. First of all, the mainstream empirical research on dynamic capabilities is either largescale surveys or single-case studies (Albort-Morant et al., 2018). The complexity of the dynamic capability construct makes a multiple-case study method a good approach, because it is hard to analyze through quantitative measures (Khan et al., 2020).

According to Eisenhardt (1989) 4-10 cases is considered to be the ideal number of cases chosen. This research includes interviews with employees from five different SMEs within the Dutch manufacturing industry. These companies range from companies that might have CE as part of their core business to companies that are just at the beginning of a CE transition. Three of these companies already include circularity in their day-to-day business and the other two are interested in the CE but do not specifically focus on CE. The five companies included in this research are shown in Table 4.

Case Company	Number of Employees	Core business	Relation to CE
A	260	Specialized in infrastructure and recycling. Next to that, they produce several raw materials, building materials and biofuels	Making recycled raw materials from plastic
B	13	Specialized in the service of remanufacturing products	Remanufacture products as a service
C	100	Supplier of (circular) facades for buildings	Manufacture circular facades (leasing) and making use of smart technology to keep track of the performance

D	180	Manufacturer of unique customized bikes for people with a disability	Researching circular business models and making use of an energy neutral building
E	250	Manufacturer of mobile sanitary systems, refrigerators, cooking appliances and toilet additives	Researching circular business models

Table 4 Case firms

The first three of these companies already focused on CE and mentioned circularity or CE on their website. These cases were chosen because they all operated in the Dutch manufacturing industry, but all in different ways. They used (or intended to use) different types of circular business models such as circular output models, circular use models and circular input models, in order to ensure case heterogeneity. Next to that, they were in different stages of the CE transition, which was highly desired for the analysis of the different stages. Next to that, they were all involved in the CE or interested in the CE. The interviewees were either with top management or CE-specialists.

3.2 Data collection

For the data collection, two interviews with each company were held with one or two employees. Prior to the first interview, the interviewees filled in a questionnaire, in order to determine the stage of transition the business is currently in. During the first interview, the stage of the CE transition was covered and the perceived barriers during this transition – taking the influence of these barriers in different stages into account. In the second interview, the dynamic capabilities needed for CE transition was discussed, which were matched with the earlier identified barriers. Questions were asked about the earlier identified barriers and how businesses could try to overcome these. The interview protocols can be found in Appendix A and B.

3.3 Data analysis

The questionnaire was based on the Circular Maturity Model of Löwik (2019) where the stages of transition were described. The description and characteristics of each stage were converted into statements per stage, and answers were based on a Likert scale where an answer of 1 meant that the respondent scored non-circular on this statement and an answer of 5 meant

the respondent scored circular on this statement. During the analysis, the average score of the different statements per stage was calculated and when the score was equal or more than 4, the case firm has passed that stage. A sensitivity analysis was performed on the threshold value of 4. When this value was either set lower than 4 (e.g. 3), Case C, for example, was scaled into stage 5, even though they still have many linear principles in their company. When this threshold value was set higher than 4 (e.g. 4.5), Case C, for example, would be scaled into stage one, even though they are already using a circular business model.

There were several phases completed during the analysis of the interviews. First, the interviews were fully transcribed. Next, codes were developed in ATLAS.ti. and were based on i. the 5 stages of a CE transition, ii. the barriers of a CE transition and iii. the dynamic capabilities needed to diminish these barriers, resulting in 33 codes. For the dynamic capabilities, distinction was made between dynamic capabilities the case firm already possessed, is still developing or has mentioned missing. An overview of these codes is shown in Appendix C. After that, the 10 interview transcripts were analyzed in ATLAS.ti. In order to guarantee the construct validity of this research, the interview questions were thought through critically and each respondent has been asked the same type of questions and answered these individually. To ensure content validity, the interview questions were based on the theoretical framework, but the questions were open to not push the interviewee in a certain direction. Besides that, the interviews were analyzed twice (although by the same researcher), and additional codes were used if needed. Furthermore, each interview starts with the question what the employee perceives as a CE. After that, the definition used in this paper was mentioned, in order to ensure that the interviewee and researcher were on the same page when it comes to the definition of CE. Next to that, answers given by the interviewees were summarized by the researcher, to ensure that the answer given by the interviewee was interpreted correctly by the researcher. In order to ensure reliability, codewords were developed for each variable to make reproducibility possible. In addition, the interview protocols have been based on an extensive literature review. Next to that, the interviews started with the goal of the research to ensure that was clear to the respondents. Each interview was conducted via a videocall, permission to record the interview was asked and anonymity was ensured in order to guarantee that the interviewees felt secured enough to give honest answers.

4. Results

4.1 Case A

Case A is a recycling company which produces 50 different types of plastic as a secondary raw material. They came up with the idea of plastic recycling 20 years ago, when there was no market for it yet. Now, they are a major player in the field of plastic recycling, mainly because of their rich experience in the field. An overview of all the barriers and dynamic capabilities mentioned by Case A is shown in Table 5.

Stage of transition

Case A is currently in the last stage of the transition, the advanced stage. They make use of a business model which is based on circularity and have full insights in the emissions across all levels of the operations. Next to that, they aim to make the production process as efficient as possible, in order to minimize emissions. An overview of the results of the questionnaire about the stage of transition can be found in Appendix D.

Barriers and dynamic capabilities

20 years ago, *through scanning the environment and markets*, the CEO recognized an opportunity to recycle plastic and decided to develop this entirely new activity. They completely changed their business model and circularity is completely part of the strategy of Case A. Because of *business model innovation* a completely new business model is used which is centered around the CE:

“The circular economy is our business model. Without a circular economy our business model does not exist anymore.”

The circular activity was added to the portfolio of Case A, which is why they never perceived the barrier that their *strategy and CE did not align*. Next to that, because CE was entirely part of the strategy of this new business unit, there was a long-term focus. That was why they did not perceive the barrier of *high upfront investment costs, but focus on short term results*. In addition, because their business model is based on producing raw material made of recycled plastic, they do not face the barrier of a *lack of a reverse logistics or supply-chain*, because their business model does not require them to take back their own product. Because they

produce a raw material, they also do not need the dynamic capabilities *circular design of products* and *close the resource and materials loops*.

In the first two stages of the transition, Case A perceived a lacking *availability of CE knowledge and skills* as barrier. At first, there was limited knowledge how to produce high-quality recycled plastic which could be used as raw material:

“The first four years we had to figure out how to recycle all these different types of plastic and how to produce one type of recycled plastic out of all these different types and that can be used by the industry as raw material.”

This led to the fact that they were *not able to deliver a high-quality circular product* in beginning the first two stages of the CE transition.

In order to solve this barrier, Case A set up an entirely new business unit for the new circular activities of the company. This meant there was a lot of *local independence* and *knowledge* was easily created because new people with the right skill level were being hired:

“We just set up an entirely business unit and hired new people. It was a new activity for us, so we just brought in a lot of new people with the right skill level. That is why we had a lot of flexibility and why the transition caused no problems lower in the organization.”

Because Case A set up an entirely new business unit and hired a lot of new people, they did not face a *rigid organizational structure* and did not perceive a *hesitant company culture* as a barrier.

In order to be able to produce high-quality recycled plastic and to ensure this plastic can be used as raw material without giving up quality compared to virgin plastic, Case A has invested time and money in disruptive technological innovation in the first two stages of the transition:

“It was trial and error. In the beginning we did not know anything about which technologies we needed to produce high-quality recycled plastic. But now we have a lot of new technologies making it possible to produce the best quality recycled plastic.”

Because Case A was already a mature company at that time, they did not need to *acquire funding through alliance and acquisition*, so they did not face the barrier of *limited funding for circular business models*.

Another barrier mentioned in the first two stages of the transition was a *lacking consumer awareness and interest*. After having figured out how to produce high-quality recycled plastic materials, there was no market for this recycled plastic at all:

“In 2010 we mastered the recycling process, but no one wanted to buy it. 10 years ago, there was just no circular way of thinking at all in the plastic industry.”

After a few years, there was enough demand, but not enough supply, because of the low combustion rates in the Netherlands. These were half the price than before, due to overcapacity. At that point in time there were no taxes on combusting plastic and these *obstructing laws and regulations* had a big influence on Case A. This meant combusting plastic was cheaper than transporting it to a recycling factory, leading to the barrier that there were *no financial incentives for circularity while there were for linearity*.

The current most pressing barrier mentioned by Case A are *low virgin material prices* and more specifically the low oil prices:

“There is no demand at the moment because everyone buys virgin plastic due to the low oil price. De oil price is leading whether there is enough market demand.”

In order to influence the effect of the low virgin material prices, the obstructing laws and regulations and the lack of incentives for circularity, Case A is very involved in lobbying. For example, they participated in a tv-show where they addressed these issues and have politicians visiting to talk about how to solve these problems:

“Because of the oil crisis, we hope there will be measures taken by the government soon. That is why we participated in the tv-show, why the state secretary came to visit and why members of the parliament will come

in order to raise the awareness about the problem and to ensure there will be a recycled content obligation in plastic products in the future.”

The decisions whether to recycle plastic of the partners in the value network of Case A are still price driven. Case A mentioned that *collaboration in the value network* is very hard. For example, they do not have much influence whether partners decide to combust the plastic or bring it to recycling factories. Next to that, making use of greener logistics is also not possible, because Case A outsources all the logistics activities and has no say in making this process more sustainable, according to the interviewee. That is why they are still missing the dynamic capability of *collaboration in value network*.

4.2 Case B

Case B is a remanufacturing company which manufactures products as a service. They have high technical expertise in manufacturing products and their customers are suppliers or manufactures that want to remanufacture a product (or product line) but do not want to – or are not able to – do this inhouse. An overview of all the barriers and dynamic capabilities mentioned by Case B is shown in Table 5.

Stage of transition

Case B is currently in the fourth – engaged – stage. They have a completely circular business model – where they provide manufacturing of products as a service. However, they have one important area of improvement: they have no insights in the emissions of their used resources and the emissions of their value network. An overview of the results of the questionnaire about stage of transition can be found in Appendix D.

Barriers and dynamic capabilities

Case B started with a new business model about 10 years ago. Case B was a company specializing in electrical engineering and started a spin-off that focused purely on refurbishing of products. They deliver a service to companies that want products remanufactured when the original supplier does not want to or cannot deliver this service. They do not design the products themselves, so they do not possess the dynamic capability of *circular design*. Because Case B started a spin-off they were *decentralized and had high local independence* from the beginning, which is why they did not perceive a *rigid organizational structure* and a *hesitant company culture* as barriers. Because CE was part of the strategy of this spin-off from the

beginning, the barriers *operating in a linear system – strategy and CE does not align* was also not perceived. Case B did not need additional investment, which is why the barriers *limited funding for circular business models and high upfront investment costs, but focus on short term results* were not an issue.

Case B mentioned that they can help companies to organize their *reverse logistics* system. Case B can help as an intermediate that refurbishes the products and will sell these refurbished products back to these suppliers:

“We can buy the parts of products at the junkyard, refurbish it and sell it back to the supplier. That infrastructure already exists, and companies do not always have to organize this reverse logistics all by themselves. They can also use this detour by making use of a remanufacturer.”

Case B often mentioned that *collaboration in the value network* is a frequent perceived barrier, especially in the third and fourth stage of the transition. Especially the fact that the partners in their value network are still operating in a very linear nature makes collaboration hard because their supply-chain is also organized in a linear way. Next to that, the producers of the products Case B remanufactures are not really cooperative:

“Producers do not like the fact that a remanufacturer takes care of their products because they do not get a return on investment because the product is being remanufactured instead of a new product being sold.”

However, this lack of collaboration also means more business for Case B:

“The reason of existence of our company is based on the fact that suppliers don’t remanufacture. My customers first ask the supplier to remanufacture a certain product, but they don’t want this because they’re primarily linear based. In the optimal circular world, our company would not exist.”

During the remanufacturing process it can happen that Case B needs a certain part and thus needs collaboration with the supplier. Even though Case B takes business from the supplier, this collaboration can go quite smoothly, but there is still enough area for improvement.

But not only producers are not interested in remanufacturers, *consumers are hesitant* too when it comes to the quality of remanufactured products. Case B mentioned that consumers still prefer new products – although not in every industry, in the automotive industry refurbishing is completely normal – and also rapid fashion changes hamper the acceptance of refurbished products:

“Refurbishing of products still leaves a bad taste. I want a new product, why should I want an old product. That’s what rules in the market.”

Case B emphasized that the current policy regarding taxes and subsidies still has a lot to improve in order to stimulate CE. There are way too less *financial incentives* for companies to operate in the CE:

“Actually, subsidies that could really help us do not exist. Whereas if you really want to boost the circular economy, subsidies should play a way bigger role in the government policy.”

Next to that, the *current laws and regulations* are hampering Case B, especially the current labor taxes:

“A major part of the work we do is labor. I plead for making labor cheaper and to pay way less tax and to increase the tax on raw materials.”

Even though Case B perceives these last two barriers, they are not involved in *lobbying* activities, mostly because of their small size and bargaining power.

Even though Case B is very advanced in their circular operations, they still have *difficulties in delivering a fully circular product* and they especially struggle with completely closing the resource loops. They strive to reuse 80-90% of the parts of the original product they remanufacture, but the parts they need to add in the remanufacturing process are not 100% recycled. In addition, sometimes their customer wants certain adjustments to the product, which means they have to use materials that are not circular:

“Sometimes we have to spray a product, because that looks better or for protection. That is of course not sustainable or circular and we should use more sustainable products in this process.”

Although Case B is already very aware of the use of materials and resources, they still need to take their materials choice to a higher level in order to make the CE transition complete and *close the resource and materials loops*:

“I know we can do better with choosing materials we use. However, I don’t exactly know how. You can always go as detailed as you want to go but you have to decide whether it’s worth it.”

Case B is always involved in *developing the knowledge* of the employees, throughout every stage of the transition. By developing new knowledge, they aim to deliver the highest quality circular products and to increase the CE knowledge and skills across the company. Mostly they learn by doing and taking on new challenges:

“We dive into a project and that always requires specific knowledge and skills and we have to acquire that specific knowledge. For example, one employee went to Italy once to follow a course for the remanufacturing of a specific product.”

They also use *scanning the environment and surveillance of markets and technologies* in order to create more knowledge and skills within the organization, but they started doing this in the third stage of the transition. Case B mentioned that by investigating how other industries operate, they would like to determine which *disruptive technological innovations* they can use in order to take their business to the next level and to deliver remanufactured products of the best quality. In addition, they also bring in specialists or buy certain knowledge. Case B mentioned that knowledge creation and learning of technical knowledge is one of their key capabilities, which is why they never really perceived a *lacking availability of CE knowledge and skills* as a barrier.

4.3 Case C

Case C is a manufacturer of facades for buildings. They started with developing circular facades a few years ago, with pilot projects. For their circular facades, they are making use of a leasing model and also focus on circular design of their products. Circularity is not the core business (yet), but the importance of circularity within the company is growing. An overview of all the barriers and dynamic capabilities mentioned by Case C is shown in Table 5.

Stage of transition

Case C is currently in the third – improving – stage of the CE transition, but it has already developed circular capabilities which will take them to the fourth stage of the transition. For example, they already have a circular strategy, because part of their strategy is that they want to have a sustainable relationship with their customers, based on a long-term leasing relationship. Next to that, they make use of a circular business model: facades as a service. However, they do not have a circular culture yet and they do not have insights in the value network emissions and do not actively aim to minimize these impacts, leading to the fact that they are currently categorized in the third stage. An overview of the results of the questionnaire about stage of transition can be found in Appendix D.

Barriers and dynamic capabilities

The first often mentioned barrier by the interviewee was that the company is still *operating in a linear system*:

“The chain is formed as it is: linear obviously. We mine a material somewhere and that results in a product [...] Then the property is transferred, the new building owner then has a facade that he has bought with the property and must be maintained. But you have to prepare for this chain when you go circular, because this chain is totally not ready for this.”

In order to align the CE goals and strategy of the business more, Case C started using *business model innovation* in the second and third stage of the transition and changed their business model from direct selling to a leasing contract where they build long-term relationships with their customers. They keep responsibility of their product and thereby focus on life-time expansion. It is part of their vision that they want a long-term relationship with their customers, and they want to influence the design and materials used in an early stage. They use circularity as a means to realize this vision. The way they exactly formulate their business

model depends on the market and the environment. They look at what their customers want, what governments promote and what investors think:

“We are adjusting over-time. We look at what customers and the market wants, what governments promote and the direction the law is taking. Based on that we adjust our development.”

Because the chain is still of a very linear nature, they found out that their *customers were lacking CE interest*. But instead of trying to increase the CE interest of these customers, Case C chose to change their target group as part of their new business model:

“We found out we had the wrong type of customers. [...] The customer was the contractor, but they do not have any interest in buying a circular façade [...] A circular façade means you build long-term relationships with your customer, but that is not the contractor, because he is not going to use the building. The customer should be developers, real estate corporations or governments.”

According to the interviewee, this new target group did have a lot of interest in circular facades. They were really pushed by the market and the transition to build more circular facades was “really stimulated up front”.

Case C has hired a circular specialist who has very high expertise of circularity in the sector. His knowledge about CE and what it entails is very extensive and he is the pioneer who inspires and informs the rest of the company to take the next step when it comes to circularity. *The lacking CE knowledge and skills* barrier was not really perceived as hampering the transition. The interviewee mentioned that in some occasions he needs to give some presentations to the engineering department, but it was not really perceived as a barrier worth mentioning. Next to that, the barrier of a *hesitant company culture* has also been reduced, since the circular mindset has been accepted more and more:

“The circular way of thinking is not perceived as odd anymore. It is really starting to land, even at the board of directors. They see the advantage of the circular mindset, and also the advantage for the entire company.”

The interviewee mentioned that they use projects and project teams to implement circularity in a very *flexible, decentralized* manner and for that reason they do not perceive the barrier *rigid organizational structure*. The formation of that project team depends on the type of project and changes according to. They *create knowledge and skills* simply by doing these projects.

The interviewee mentioned that they are neither pushed nor restrained by the *government's laws and regulations*. The interviewee mentioned that they are not really forced by the government to become more circular. However, they do see a shift in the market, they are getting more responsibilities when it comes to circular design and sustainability of the product. Next to that, the new law of quality assurance of ten years forces companies to assure a product lifetime of 10 years and continuous responsibility of this product lifetime for the manufacturer. This does lead to the fact that Case C chose to really focus on lifetime extension and offering a service to the customer and thereby being more circular.

Collaboration in their value network is very important for Case C. They do not experience a *limited willingness to collaborate in the value network*. For example, they have formed an alliance with two other façade constructors to build a new (circular) system. Because of the new predictive maintenance of their product, Case C had to change the way of collaboration with their supplier, which was very important. For example, they had to intensify their collaboration because they had to track when the façade needed maintenance. In addition, in order to close their resource and materials loops, Case C has a collaboration with their supply-chain partners, such as a melting company and scrap collector. Recently, they formed an *alliance* with another company in order to close the resource chain and to connect with the right partners. Next to that, Case C is part of a frontrunners group with business from the east of the Netherlands, where they share experiences with circular business models, financing, formulating KPIs and other things and by means of that they *scan the environment, markets and technologies*.

Case C is really aware that circularity means that *thinking in systems* is very important. That is why they focus on optimizing all the links in their business:

"If you only make the product circular, but you do not mobilize this circularly and no one thinks about and takes responsibility for re-use or prolonging lifetime, then you are still missing the point. Circularity is a

concept, with a new product, service and with an entirely new chain and system.”

In order to produce a more circular product, Case C uses *disruptive technological innovation*, especially concerning smart technology. For example, they make use of predictive maintenance technology where they are keeping track of the maintenance cycles in order to optimize the maintenance processes and to eliminate waste of oil during maintenance.

Concerning the *circular design* of the product, Case C is already in an advanced stage of the modular design of the product. They focus on easy and fast disassembly using click connectors, made from recyclable materials without any added elements. They aim to design the product as modular as possible, meaning that the product can be used directly in a new location after initial use, without going back to the factory after disassembly. This means that they have not set up an entire *reverse logistics system* yet, because the number of products coming back will be minimized. However, the procedure of the reverse logistics system needs to be thought through critically and a lot of practical aspects are still unclear, which is perceived as a barrier. By making use of recyclable materials, modularity, maintenance and easy disassembly, Case C wants to *close their resource and materials loops*. Because of their materials choice they can upgrade the product endlessly and, in that way, aim to close their loops.

The most pressing barrier mentioned was the problems faced while *acquiring funding for their circular business model*. Banks are organized in a very linear way with a lot of processes and protocols and that is why Case A faced high financing expenses with high percentages. They especially faced difficulties with banks that do not want to finance the cash flow that comes along with the lease contract:

“They use so-called project funding, where you don’t get security from the producer’s holding company anymore. Banks find that very difficult, because they actually want collateral from all holding companies. But banks do not want to finance cash flow with only the securities that you can contractually agree on with the client. The cash flow will come later.”

4.4 Case D

Case D is a manufacturer of customized bikes for people with a disability. They produce several types of bikes such as tricycles, scooter bikes and wheelchair bikes. Each model is also available as an electric pedelec bike. They operate across entire Europe, but the Netherlands is their main market. Currently, they still use a wholesaler system as business model. An overview of all the barriers and dynamic capabilities mentioned by Case C is shown in Table 5.

Stage of transition

Case D is in stage 2 – basic – of the CE transition. They have started with the transition and thought through some new circular business models and started with using renewable energy. Even though they are really aware of the need of the CE transition, they still have many linear principles. For example, they do not have full insights in the material use and even though they use renewable energy, they are not entirely aware of the energy consumption of the production process. An overview of the results of the questionnaire about stage of transition can be found in Appendix D.

Barriers and dynamic capabilities

The first barrier perceived is a *hesitant company culture* towards CE. Employees perceive a circular product as something unreachable and when management formulates fully circular operations as the goal to achieve, people become hesitant because this goal is way too big. Case D rather describes the goal as sustainability, where they focus on life-time expansion and the use of sustainable materials. The use of this different term is very important according to Case D:

“Circularity creates hesitance, whereas sustainability is more common. If I say to R&D, you have to make a circular bike, they will go nuts: they believe it’s not possible to be fully circular and it’s too big of a deal.”

The hesitance towards circularity originates from the *lack of CE knowledge and skills*. There is too little knowledge within the company how to create a circular bike and what steps should be undertaken to achieve this. Even top management is still focused on sustainability, reducing waste and renewable energy use, and has not focused on circularity as a way to achieve a fully sustainable product.

Concerning *decentralization and local independence*, Case D mentioned they have a very flexible organization within the business units and therefore do not have a *rigid organizational structure*. They have a lot of young employees and flexibility is one of their core values. They use this flexibility for *knowledge creation and learning*. Apart from general workshops about sustainability, they learn by doing:

“We love to experiment. We experiment on a small scale and we want quick results. Once we had these results, we will implement it throughout the organization. This is all very flexible and everyone really likes these new experiments.”

Next to learning by doing, they also look in other industries and *use surveillance of markets and technologies* to determine how other industries deal with certain things:

“We look how other industries deal with things, for example the automotive industry. We really use them as an inspiration. But we also look into our own industry, but more as an example how to not handle things. For example, the use of carbon as raw material.”

Another barrier perceived is that CE is *not part of the strategy* yet. However, they are focusing on sustainability, but not particularly on CE:

“Another thing is, CE is not part of our strategy yet. We are focusing more and more on sustainability, but not really on CE. This makes things harder when you really want to achieve something.”

In an effort to incorporate CE to their strategy, Case D has been researching and developing two circular *business models*: pay-per-use and product-as-a-service. These business models are not implemented yet, because of the current wholesaler infrastructure in place. However, Case D mentioned that they want to implement these business models in new markets, where they do not have a wholesaler network yet.

When implementing these two new business models, another barrier arises: *the lack of reverse logistics* at the moment. They have no reverse logistics system in place yet, even

though it is one of their top priorities to organize. The most important reason why they do not succeed in organizing this, is the fact that their customers (the wholesalers) keep the bikes, because of the high residual value of the product:

“We don’t get enough bikes back. That’s because our customers keep the bikes themselves, because it’s very interesting for them to sell again. Only in case the electrics of the bikes break, it’s not interesting for wholesalers to resell bikes, but frames essentially don’t break.”

Currently, *the reverse logistics* are organized via a third party. This third party is also responsible for selling the product as a second-hand bike and Case D is not involved in this. They want to be more involved in the future and organize the reverse logistics themselves, especially in the Netherlands, which is a small country and where they sell high volumes. Case D mentioned that organizing reverse logistics in markets other than the Netherlands will be an issue because of the smaller volumes.

Case D decided to develop these circular business models because of a market pull. Case D mentioned that most of their customers are public organizations that are focusing on sustainability more and more. That is why they do not face the barrier *lacking consumer awareness and interest*. Because these public organizations are pushed by the government’s policies to make use of more circular products, Case D mentioned that they do not perceive any *obstructing laws and regulations* yet, the government’s policies rather stimulate to start with a CE transition.

Another important aspect of these circular business models is the fact that the products in these business models should be of a circular nature. Currently, Case D still has problems with producing a *high-quality circular product*. Especially when it comes to fully closing the resource loops, there is still area for improvement. Case D did start with researching the possibility to use a *more circular design* in their products, and especially focus on easy disassembly of the product. Next to that, they think about their material usage in order to be able to *close the resource and materials loops*. However, they only look into materials used of the frame, which they assemble themselves, but they do not have insights in the material usage of all parts of the bike, for example saddles. That is why they still lack the dynamic capability of *system thinking*:

“We really think about the types of plastics we use; we don’t want to use polluting materials. But we don’t know the materials of all the products. For example, we don’t know which materials are in saddles. In the future we should also look into which rubber the saddle contains or which plastic. We have to take into account all links within the production of the bike. We are not there yet.”

In addition, Case D has already invested in *disruptive technological innovation*. They have made – and are still working on making – their production processes way more energy-efficient, by making use of the newest technologies. Next to that, they use 3D printing within their production process:

“We are still looking into how we can reduce energy usage during the production process. We use solar energy and don’t want to run our ovens on gas anymore. Next to that we use 3D printing a lot and everyone loves it!”

Because CE is not part of the strategy yet, Case D still has a very linear supply chain, where they make use of wholesalers. *Collaboration* with these wholesalers is really hard. Case D is really willing to implement new business models, such as pay-per-use or leasing business models, but the fact that they deliver their products to wholesalers makes implementing this new business model really hard:

“We don’t want to compete with our customers. We want to lease the bikes, but it is really hard because then we take the business from the wholesalers. These wholesalers have a lot of bargaining power, and we can’t just surpass these wholesalers, because that would be bad for our business.”

In order to create a more circular value chain, Case D tries to *collaborate within the value chain*. Even though they do have difficulties to collaborate with their wholesalers, they really try to collaborate with other (smaller) partners on a strategic level. They mentioned they have changed partners in case these were hesitant or reluctant towards their sustainability vision.

“We are not using partners that are hesitant anymore, we will go for alternatives. Ones we have some influence on. We are not using the big guys anymore, unless they cooperate with use concerning our sustainability vision. Otherwise we’ll look for new ones or produce it inhouse.”

Case D also mentioned that *low virgin material prices* make it hard to compete with competitors using cheap materials. Especially because price is still leading in the buying decisions of customers:

“Competitors that offer a very cheap product have a lot of influence on our business. Some competitors just do not care about sustainability at all and when the customer is a party that really look at the numbers, it really affects our business.”

Case D does not need any additional investment for the CE transition, they have used their own funds until now and have not *acquired funding*. That is why they do not face the barriers *limited funding for business models* and *high upfront investment costs but focus on short term*.

4.5 Case E

Case E is a manufacturer of mobile sanitary systems, fridges, cooking appliances and toilet additives. Currently, Case E still makes use of a linear business model, where they sell their products to wholesalers or manufacturers of campers or caravans. Case E mentioned that they will first focus on the toilet additives product line in the transition to CE. This product is directly sold to customers and is therefore the best option to start the CE transition with. An overview of all the barriers and dynamic capabilities mentioned by Case E is shown in Table 5.

Stage of transition

Case E is currently still in stage 1 – unformed – of the CE transition. They mentioned that they still have many linear principles and only comply with the minimal legal requirements concerning sustainability and circularity. However, they are progressing to stage 2, since they have insights in their energy consumption and are now focusing on gaining insights in material usage. They hired a circular specialist a few months ago who focuses on CE and sustainability

in general and this person should take circularity in Case E to the next level. An overview of the results of the questionnaire about stage of transition can be found in Appendix D.

Barriers and dynamic capabilities

The CE transition of Case E is still in its infancy. That is why they face a *hesitant company culture* when it comes to CE. The focus within the company is not on CE and it is definitely not priority number one. Case E also mentioned that they have faced difficulties in the past with an innovation project five years ago:

“It was very difficult. There has been a change compared to back then, we needed a change in culture. And that shift in culture is still happening.”

In addition, there is also a *lack of CE knowledge and skills*. Employees do not really know what CE entails and they do not yet understand that you have to manage the entire value chain, instead of only using recycled materials. However, Case E did not face a *rigid organizational structure* and mentioned that they are organized in a very *decentralized and flexible manner*.

Currently, Case E is very active in *scanning the environment*. The CE specialist is visiting other companies, both within and outside their market, for inspiration how these companies handle certain aspects regarding CE and innovation in general. In that way, this specialist tries to gain more knowledge and spreads this knowledge across the company. However, the dynamic capability of *knowledge creation and learning* across the entire company is still missing. They mentioned that first priority is that CE should be covered in the business plan:

“There is not enough knowledge at the moment because CE is not covered in the business plan. If it will be covered, people will read more about CE and what it entails. Next to that, I now have a spot in the engineering meeting to tell more about the circular economy. That is how I spread the word and gain more knowledge about CE company-wide.”

Because CE is not covered in the business plan, it is not part of the strategy yet and therefore Case E is still *operating in a linear system*. In addition, Case E still has a very linear value network, where they deliver most of the products to suppliers. For these suppliers, price is the most important factor and they are *not interested* in sustainable products, whereas end-users can be interested. However, Case E mentioned that there is not real market demand at

the moment. They have tried returnable packaging in the past, but it did not work with end users.

Due to the linear value network, *collaboration* is needed. This is easier said than done, because all the partners in this chain want to get a piece of the pie:

“If we would sell our products directly to the end user, we will take business from the shops. These shops will not be happy about this. And we are afraid that we cannot make use of shelves in these stores anymore and that will affect our brand awareness.”

In order to include CE in the business strategy, Case E is working on *business model innovation*. They are currently at an early stage of business model innovation, meaning that they are orientating which business model would be best. They will hire an intern which will focus on business model innovation and what the possibilities are for exploiting a circular business model for their business. For example, they are considering a pay per use business model for the bottles with additives. To realize this, they need a change in the way of *collaborating within their supply chain*, another dynamic capability mentioned:

“We need to collaborate with the wholesalers. The current logistics is only one-way: we dispatch the products and the only products we get back from wholesalers are the defect ones.”

One of the biggest challenges Case E faces is the fact that campers and caravans last for 30 years and are not traceable after use. Therefore, it is really hard to organize a *reverse logistics or reverse supply-chain*:

“Chain management all the way to the end is really hard. We are talking about 30 years; we don’t know where these caravans and campers are located. Usually they end up somewhere in the east of Europe and how are we ever going to organize to return these caravans?”

By collaborating with their supply-chain Case E wants to realize a *reverse logistics system*, because they do not sell their products directly to the end user. They have been successful in

collaborating with returnable packaging with a partner manufacturer and they hope to expand this collaboration.

Currently, Case E is still orientating how to *deliver high-quality circular products*. Until now, an entire batch of for example fridges will be scrapped if something is wrong with the product and disassembly is not possible at all. They also are aware that they should make use of different materials, need a different way of producing and should change the design of the products:

“Of some products the parts are completely attached to each other because of spraying. Disassembly is just not possible, and we do not reuse these parts of these products.”

Case E is currently focusing on *closing the materials loop* and *circular design*. They mentioned the first next step they want to take is to gain insights in the materials flow and to reduce these materials where possible. They also want to study all the links and therefore want to apply *system thinking*. They want to make use of recycled plastic in the future and bring used products to recycling companies:

“Understanding the entire chain and all the links, making use of a more circular design and reduce the materials usage is the most important thing for us at the moment.”

Case E also mentioned the *low virgin material prices* as a barrier, more specifically the low oil prices. They expect these low oil prices to raise the costs of transition, but this does not hold them back.

Case E has not needed any additional investment for the CE transition until now and have not *acquired funding*. That is why they also do not perceive the barriers *limited funding for business models* and *high upfront investment costs but focus on short term*.

Barrier	Case A	Case B	Case C	Case D	Case E
Rigid organizational structure					
Hesitant company culture			✓	✓	✓
Lacking availability of CE knowledge and skills	✓			✓	✓
Operating in a linear system – strategy and CE does not align			✓	✓	✓
Limited willingness to collaborate in the value network	✓	✓		✓	✓
Lacking consumer awareness and interest	✓	✓	✓		✓
Lacking standards					
No (financial) incentives for circularity, while there is for linearity	✓	✓			
Obstructing laws and regulations	✓	✓			
Low virgin material prices	✓			✓	✓
High upfront investment costs, but focus on short term results			✓		
Limited funding for circular business models			✓		
Lack of reverse logistics/reverse supply-chain			✓	✓	✓
Lacking ability to deliver high-quality circular products	✓	✓	✓	✓	✓

Dynamic capability¹

Business model innovation (CIM, CUM, COM)	✓	✓	✓	🕒	🕒
The ability to manage the residual materials flow		✓	✗	🕒	🕒
System thinking	✗		✓	✗	🕒
Disruptive technological innovation	✓	🕒	🕒	✓	
Circular design of products			✓	✓	🕒
Close the resource and material loops		🕒	🕒	🕒	🕒
Collaboration in value network	✗	🕒	✓	🕒	🕒
Decentralization and local independence	✓	✓	✓	✓	✓
Knowledge creation and learning	✓	✓	✓	✓	✗
Scanning the environment & Surveillance of markets and technologies	✓	✓	✓	✓	✓
Alliance and acquisition			✓		
Lobbying	✓				

Table 5 Barriers and dynamic capabilities Case A-E

¹ ✓ = Dynamic capability (DC) is possessed, 🕒 = DC is being developed, ✗ = DC is mentioned missing

4.6 Cross case analysis

CE-specific dynamic capabilities

An overview of the cross-case analysis with the dynamic capabilities and the corresponding barriers is shown in Table 6. The table contains the different dynamic capabilities and shows whether these case firms possessed, were developing or missed these dynamic capabilities. In addition, the table shows the stages these dynamic capabilities are possessed or developed. Moreover, the table presents the barriers that were overcome by means of the dynamic capabilities.

All cases mentioned *business model innovation* as a dynamic capability needed in the early stages of the CE transition. Most cases started developing the new business model in stage 2 of the transition and implemented this in the third stage of the transition. Only Case B started with their business model in the first stage, as this new business model was not hard to implement for them. This dynamic capability was mainly used to solve the barrier of *operating in a linear system – strategy and CE does not align*. Only Case C used business model innovation to solve the barrier of a lacking consumer awareness and interest, by changing their target group in their new circular business model.

The ability to manage the residual materials flow was a dynamic capability mentioned by all cases (except for Case A, but this dynamic capability was not applicable for their operations). However, managing the residual materials flow was mentioned as very challenging by the interviewees. Only Case B was able to set up a reverse logistics system, but that was because it was part of their core business and therefore also helped other companies to organize this. Case C even mentioned that they hoped that they do not have to set up a reverse logistics system, because they hope that in the ideal situation the products do not come back to them. Therefore, this dynamic capability was still missing. It became clear that this dynamic capability is most important in the third stage – where businesses should start developing this dynamic capability – and fourth stage – where businesses should implement this dynamic capability – of the transition.

System thinking was only mentioned by three cases, surprisingly the ones in the earlier stages of the transition. Case A and B strikingly did not mention system thinking as something important for them, whereas Case C emphasized the importance of system thinking for being able to *produce a high-quality circular product*. Case D mentioned that they should develop the dynamic capability in the future, but system thinking is currently not present. The

transition of Case E is only in its infancy, which is why they did mention that they are currently focusing on identifying what the links in the processes are, but system thinking is not regarded as part of the processes yet.

Disruptive technological innovation was mentioned by all cases, except for Case E, which is only in the first stage of the transition. Disruptive technological innovation meant something different for each case. For example, Case A used it to be able to deliver a high-quality circular product and therefore started using disruptive innovation already early in the transition. Case B and C on the other hand, are using disruptive technological innovation to take the quality of their circular products to the next level and started developing this capability in the fourth and third stage of the transition. Case D is only in the second stage of the transition, but is already using disruptive innovation, such as 3D printing, for a while now. All cases did use this dynamic capability to solve the barrier of *lacking ability to deliver high-quality circular products*.

Three cases mentioned *circular design* as an important dynamic capability to solve the barrier of *lacking ability to deliver high-quality circular products* (for Case A and B this dynamic capability was not applicable). Case C, D and E started with developing the circular design capability in the beginning of the transition, leading to the fact that Case C and D already possessed this capability in the third and second stage of the transition. Case E has only started with the CE transition and is already developing this dynamic capability right from the start.

The dynamic capability *close the resource and material loops* was mentioned as most difficult by all cases. None of the cases already fully possesses this dynamic capability even though it should help to *produce a high-quality circular product*, which shows the complexity of closing the loops. In contrast to the theory – where this dynamic capability was mentioned to be most important in the second and third stage of the transition – closing the resource and materials loops is considered a dynamic capability mastered in the advanced stage of the transition.

Collaboration in the value network is a dynamic capability mentioned by all cases, throughout all the stages of the transition. The importance of collaboration within the value network has been emphasized by Case E, already in the first stage of the transition. By collaborating in the supply-chain businesses became able to *deliver high-quality circular products* and they needed collaboration to organize their *reverse logistics*. However, it is not an easy dynamic capability to master, because most cases mentioned they were quite stuck

in their value network. Next to that, two cases made use of wholesalers, which were not really interested in circular business models such as product-as-a-service or pay-per-use, which made collaborating hard, although this wholesaler network is very important for these cases.

General dynamic capabilities

The dynamic capability of *decentralization and local independence* was a dynamic capability mentioned by all cases and important throughout the entire transition. Every case firm mentioned the importance of decentralization, local independence and flexibility within the organization and across different departments. None of the cases mentioned that they ever experienced a *rigid organizational structure*, because of this dynamic capability. Next to that, they used this dynamic capability to overcome a hesitant company culture, because the transition was not pushed by top management, but rather stimulated bottom-up. In addition, Case D mentioned they used their flexibility to *create knowledge and skills*.

According to all case firms, *knowledge creation and learning* is an important aspect to take the CE transition to the next stage. It is a dynamic capability needed right from the start of the transition, all the way to the end. Except for Case E, all case firms possessed the dynamic capability of knowledge creation and learning in order to diminish the barriers *lacking availability of CE knowledge and skills* and *lacking ability to deliver high-quality circular products*.

By *scanning the environment and surveillance of markets and technologies* case firms managed to create additional knowledge. Some cases started doing this right away, such as Case E. They are only in the exploratory first stage, which is why they look at how other companies approach CE-related topics or deal with certain problems. They use this knowledge to start their CE transition and to diminish the barriers *lacking availability of CE knowledge and skills* and *lacking ability to deliver high-quality circular products*. Case B and C on the other hand, started with scanning the environment in a later stage (stage 2 and 3). They use this dynamic capability to look in-depth how other markets or companies deal with problems concerning very specific CE-related or technology-related issues. So, in contrast to the theory – where it was expected that this dynamic capability was mostly used in the beginning stages of CE – this dynamic capability is also important in the more advanced stages, but in a somehow different setting.

The dynamic capability *alliance and acquisition* was surprisingly only mentioned by Case C. They mentioned that acquiring *funding* was perceived as most difficult throughout

Dynamic capability ²	Case A (stage 5)	Case B (stage 4)	Case C (stage 3)	Case D (stage 2)	Case E (stage 1)
CE-specific dynamic capabilities					
Business model innovation (CIM, CUM, COM)	✓ <i>Stage 2-3</i> <u>Barrier:</u> Operating in a linear system – strategy and CE does not align	✓ <i>Stage 1-2</i> <u>Barrier:</u> Operating in a linear system – strategy and CE does not align	✓ <i>Stage 2-3</i> <u>Barrier:</u> Operating in a linear system – strategy and CE does not align; lacking consumer awareness and interest	🕒 <i>Stage 2</i> <u>Barrier:</u> Operating in a linear system – strategy and CE does not align	🕒 <i>Stage 1</i> <u>Barrier:</u> Operating in a linear system – strategy and CE does not align
The ability to manage the residual materials flow	✗ <i>N/A</i>	✓ <i>Stage 2-3</i> <u>Barrier:</u> Lack of reverse logistics / reverse supply-chain	✗ <i>Missing</i> <u>Barrier:</u> Lack of reverse logistics / reverse supply-chain	🕒 <i>Stage 2</i> <u>Barrier:</u> Lack of reverse logistics / reverse supply-chain	🕒 <i>Stage 1</i> <u>Barrier:</u> Lack of reverse logistics / reverse supply-chain
System thinking	✗ <i>NM</i>	✗ <i>NM</i>	✓ <i>Stage 3</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	✗ <i>Missing</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	🕒 <i>Stage 1</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products
Disruptive technological innovation	✓ <i>Stage 1-2</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	🕒 <i>Stage 4</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	🕒 <i>Stage 3</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	✓ <i>Stage 2</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	✗ <i>NM</i>
Circular design of products	✗ <i>N/A</i>	✗ <i>N/A</i>	✓ <i>Stage 2-3</i>	✓ <i>Stage 2</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	🕒 <i>Stage 1</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products

² ✓ = Dynamic capability (DC) is possessed, 🕒 = DC is being developed, ✗ = DC is mentioned missing, not mentioned (NM) or is not applicable (N/A)

			<u>Barrier:</u> Lacking ability to deliver high-quality circular products		
Close the resource and material loops	✗ <i>N/A</i>	🕒 <i>Stage 4</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	🕒 <i>Stage 3</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	🕒 <i>Stage 2</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	🕒 <i>Stage 1</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products
Collaboration in value network	✗ <i>Missing</i> <u>Barrier:</u> Limited willingness to collaborate in the value network	🕒 <i>Stage 3-4</i> <u>Barrier:</u> Limited willingness to collaborate in the value network	✓ <i>Stage 2-3</i> <u>Barrier:</u> Limited willingness to collaborate in the value network	🕒 <i>Stage 2</i> <u>Barrier:</u> Limited willingness to collaborate in the value network; lacking ability to deliver high-quality circular products	🕒 <i>Stage 1</i> <u>Barrier:</u> Limited willingness to collaborate in the value network; lack of reverse logistics / reverse supply-chain

General dynamic capabilities

Decentralization and local independence	✓ <i>Stage 1-5</i>	✓ <i>Stage 1-4</i>	✓ <i>Stage 1-3</i> <u>Barrier:</u> Hesitant company culture	✓ <i>Stage 1-2</i> <u>Barrier:</u> Hesitant company culture; lacking availability of CE knowledge and skills	✓ <i>Stage 1</i>
Knowledge creation and learning	✓ <i>Stage 1-5</i> <u>Barrier:</u> Lacking availability of CE knowledge and skills; Lacking ability to deliver high-quality circular products	✓ <i>Stage 1-4</i> <u>Barrier:</u> Lacking availability of CE knowledge and skills; Lacking ability to deliver high-quality circular products	✓ <i>Stage 1-3</i> <u>Barrier:</u> Lacking availability of CE knowledge and skills; Lacking ability to deliver high-quality circular products	✓ <i>Stage 1-2</i> <u>Barrier:</u> Lacking availability of CE knowledge and skills; Lacking ability to deliver high-quality circular products	✗ <i>Missing</i>

Scanning the environment, markets and technologies	✓ <i>Stage 1-2</i> <u>Barrier:</u> Lacking availability of CE knowledge and skills	✓ <i>Stage 3-4</i> <u>Barrier:</u> Lacking availability of CE knowledge and skills	✓ <i>Stage 3</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products	✓ <i>Stage 2</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products; lacking availability of CE knowledge and skills	✓ <i>Stage 1</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products; lacking availability of CE knowledge and skills
Alliance and acquisition (acquiring funding)	✗ <i>NM</i>	✗ <i>NM</i>	🕒 <i>Stage 3</i> <u>Barrier:</u> Lacking ability to deliver high-quality circular products; limited funding for circular business models	✗ <i>NM</i>	✗ <i>NM</i>
Lobbying	✓ <i>Stage 4-5</i> <u>Barrier:</u> Low virgin material prices; obstructing laws and regulations; no (financial) incentives for circularity, while there is for linearity	✗ <i>NM</i>	✗ <i>NM</i>	✗ <i>NM</i>	✗ <i>NM</i>
<i>Other barriers perceived, but no dynamic capability</i>	N/A	Lacking consumer awareness and interest; obstructing laws and regulations; no (financial) incentives for circularity, while there is for linearity	N/A	Low virgin material prices	Low virgin material prices

Table 6 Cross-case analysis

their CE transition, and they are still dealing with this. Other case companies mentioned that they do not need additional funding at this point in time and therefore are not focusing on alliances and acquisitions.

The dynamic capability *lobbying* was only mentioned by Case A, mostly to influence the direct effect of the *low virgin material prices* on their business. Next to that, Case A also faced obstructing laws and regulations which they hope to influence by means of lobbying. Case B, D and E also faced the barrier of *low virgin material prices*, but because of their small size and impact were not involved in lobbying.

5. Discussion

In this paper, I attempted to address the research gap on dynamic capabilities needed and barriers faced in the transition towards circular practices in SMEs. The emphasis lies on the general and CE-specific dynamic capabilities and this paper takes the stages businesses go through during the CE transition into account (Löwik, 2019). Table 7 shows the comparison of the theory on dynamic capabilities, barriers and its stages (Table 3) and the cross-case results (Table 6).

Dynamic capability	Barrier addressed		Stage		Remark
	Theory	Results	Theory	Results	
Business model innovation (CIM, CUM, COM)	- Operating in a linear system – strategy and CE does not align	- Operating in a linear system – strategy and CE does not align	3	1 & 2	DC used and developed earlier than assumed in theory
The ability to manage the residual materials flow	- Lack of reverse logistics/reverse supply-chain	- Lack of reverse logistics/reverse supply-chain	3 & 4	2 & 3	DC used and developed earlier than assumed in theory
System thinking	- Operating in a linear system – strategy and CE does not align - Limited willingness to collaborate in the value- and supply chain	- Lacking ability to deliver high-quality circular products	3 & 4	3 & 4	DC only mentioned by two cases
Disruptive technological innovation	- Lacking ability to deliver high-quality circular products	- Lacking ability to deliver high-quality circular products	2	2	In line with theory

Circular design of products	- Lacking ability to deliver high-quality circular products	- Lacking ability to deliver high-quality circular products	3	2 & 3	In line with theory
Close the resource and material loops	- Lacking ability to deliver high-quality circular products	- Lacking ability to deliver high-quality circular products	2 & 3	3 & 4	None of the case firms entirely possessed this DC.
Collaboration in value network	- Lack of reverse logistics/reverse supply-chain - Limited willingness to collaborate in the value- and supply chain	- Lack of reverse logistics / reverse supply-chain - Limited willingness to collaborate in the value- and supply chain - Lacking ability to deliver high-quality circular products	4	3 & 4	DC also used to be able to produce high-quality circular product
Decentralization and local independence	- Rigid organizational structure	- Hesitant company culture - Lacking availability of CE knowledge and skills	3	1-5	DC seen as prerequisite for a successful CE transition
Knowledge creation and learning	- Hesitant company culture - Lacking availability of CE knowledge and skills	- Lacking ability to deliver high-quality circular products - Lacking availability of CE knowledge and skills	2 & 3	1-5	DC seen as prerequisite for a successful CE transition
Scanning the environment & Surveillance of markets and technologies	- Lacking consumer awareness and interest	- Lacking availability of CE knowledge and skills - Lacking ability to deliver high-quality circular products	1 & 2	1-4	Used in the earlier stages as well as the later stages of the transition, although in a different nature
Alliance and acquisition (acquiring funding)	- Limited funding for circular business models	- Limited funding for circular business models - Lacking ability to deliver high-quality circular products	2	3	Only used by one case
Lobbying	- Lacking standards - Low virgin material prices - No (financial) incentives for circularity, while there is for linearity - Obstructing laws and regulations	- Low virgin material prices - No (financial) incentives for circularity, while there is for linearity - Obstructing laws and regulations	1 & 2	4 & 5	Only mentioned by one case, in the later stages

Table 7 Comparison theory and results

5.1 Non- and limited perceived barriers

Looking into the barriers faced by the case firms, none of the businesses that were studied perceived a rigid organizational structure and hesitant company culture as barriers. A possible explanation for this might be that SMEs are usually organized in a more flexible manner, resulting in a small number of management layers, and the absence of rigid structures and formalization reduces a resistance to change (Ghobadian & Galleary, 1996).

When looking into the barriers linked to the funding of circular business models, only Case C mentioned this as a barrier. Strikingly, Case C mentioned this as the most pressing barrier for them. Apparently this was the only case firm that needed a lot of investments, whereas the other case firms did not need it because of their larger size and using retained earnings to fund the transition (Case A), because their circular transition did not involve additional investment (Case B), or because they did not require any investment for their transition yet (Case D and E). This is also the reason why only Case C mentioned alliance and acquisition as an important dynamic capability. This contradicts the findings of Khan et al. (2020) and Agarwal & Helfat (2009), who mentioned the importance of capital investments in R&D and acquisition in CE-implementation. However, Pheifer (2017) did mention that especially product-as-a-service business models experience difficulties with funding, and until now, Case C was the only one using this business model, which explains why only this case firm perceived the funding barrier.

The regulatory barriers, such as obstructing laws and regulations and no (financial) incentives for circularity were only perceived by case firms that were more advanced in the CE transition. The case firms that were in the beginning stages of the transition mentioned that they were either stimulated by the government to think about sustainability and circularity or did not feel any legal or regulatory obstructions during their transition so far. This is in line with Reike et al. (2018), who mentioned the implementation of several policies and programs that should stimulate the diffusion of the CE philosophy. Case A and B however, respectively in the fifth and fourth stage of the transition, emphasized the hindering effect of the laws and regulations of the government. It seems possible that these results stem from the fact that in the more advanced stages of the transition – when the complexity of implementing CE-practices increases – the current rules, regulations and policies are still being designed in a linear way, which interferes with the circular principles of the firm. Even though governments try their best to stimulate a CE transition – which is why case firms in the

beginning stages of the transition do not perceive this barrier – when you look at the bigger picture (such as tax policies), the current rules and regulations are still designed for the linear way of doing business. Therefore, next to stimulating the CE transition up-front, policy makers should try to focus on reforming tax policies to enhance CE in the advanced stages as well. For example, labor tax could be reduced since remanufacturing products is very labor-intensive, whereas material usage is minimized. Next to that, the use of virgin materials over recycled materials should be stimulated better, by increasing the tax on virgin materials and by increasing the costs of incinerating used plastic. In addition to the rules and regulations barrier, neither of the case firms mentioned lacking standards as an obstructing barrier. This is interesting, because the adoption of standards has a big influence on the transition to circularity (Flynn & Hacking, 2019). On the other hand, Fransen (2011) mentioned that standards might fail to provide an efficient and objective way of stimulating sustainability and circularity within a global value chain. This can explain why some case study firms do not really value standards and therefore also do not really see a lack of them as a barrier. In addition, ISO have released the new standard ISO/TC 323 in 2018, which might be the reason why the organizations in this research have not perceived the lacking standards barrier (ISO, 2020).

5.2 Linkage between dynamic capabilities and barriers

When looking into the linkage between the dynamic capabilities and the barriers, i.e. the dynamic capabilities needed to solve the identified barriers, the results mostly comply with the assumed theory. However, some dynamic capabilities were used to solve additional barriers compared to the assumed theory. Knowledge creation and learning, for example, was not only used to solve the barrier of a lacking availability of CE knowledge and skills, but also to use this knowledge to be able to produce a high-quality circular product. On the other hand, this dynamic capability was not used to solve a hesitant company culture, mostly because this barrier was not really perceived.

Next, in order to be able to exploit a circular business model, collaboration within the value network was seen as key by the case firms. This is consistent with other papers that stated that collaboration is essential to address environmental challenges (Hofmann et al., 2012; Khan et al., 2020). The case firms needed to collaborate to organize their reverse logistics, but also used collaboration to be able to produce a high-quality circular product, by forming partnerships with other suppliers for example. That collaboration was also used to be able to produce a high-quality circular product is an additional insight, which was not assumed

in the theory. As stated in the results, Case C was the only case firm that succeeded in collaborating within their value network. Case C collaborated with research institutions, suppliers and customers. Other cases, such as Case D and E mentioned that especially collaborating with their wholesalers was important, but also the most difficult aspect of collaboration within the value network. Collaboration with wholesalers is needed for various reasons, of which reverse logistics for refurbishment, pay-per-use business models, or product-as-a-service business models are some examples. The results of the study made clear that collaboration with these wholesalers is often difficult because these partners usually have no CE-interest, something Prendeville & Bocken (2017) also underline. When looking at the development of this dynamic capability throughout the different stages of the transition, it became clear that the type of collaboration changed over time. The case firms mentioned that they have to change the way of collaborating when implementing their circular business model (e.g. to organize the reverse logistics) or that they might have to change their partners within their value network to make collaboration possible.

5.3 Stages

The results made clear that during the different stages of the CE transition, different barriers were perceived, and different dynamic capabilities were being developed and possessed. However, some of these dynamic capabilities did not align with the assumed theory concerning the stage of developing and possessing the dynamic capability. First, business model innovation is developed and implemented in an earlier stage than expected. The development of the circular business model started right away in stage one, and implementation took place before the third stage. The results show that all cases are using, or are developing, a circular business model, by means of which the companies in the case studies aim to align their strategy with CE-objectives. This is in line with many scholars that have addressed the importance of circular business models during the CE transition (e.g. Kirchherr et al., 2017; Prieto-Sandroval et al., 2019). All cases started developing their circular business models in the first two stages of the transition and implemented it before the third stage. The fact that the development of these business models starts earlier than expected, could be explained by the fact that business model innovation is seen as the core of the circular transition, and developing and implementing a new business model is complex and time-consuming (Linder & Williander, 2017). Case A and B started right away with the

implementation of their circular business model and made circularity their core business, both approximately 20 years ago, which is considered very early in comparison to the global CE-trend. For example, the European Commission released their first circular economy action plan only in 2015 (European Commission, 2015). This could be explained by the fact that top management of Case A and B discovered the sustainability opportunity early and felt a responsibility to contribute to the shift to a circular economy. This shows that environmental leadership plays an important role in the transition to CE, which is in accordance with previous studies (e.g. Rizos et al., 2015; Khan et al., 2020).

Another important dynamic capability that was mentioned was the organization of the residual materials flow, or otherwise known as reverse logistics. Case firms mentioned that collaboration in their value network was essential to be able to organize this reverse logistics system. These findings are consistent with Olorunniwo & Li (2010) who stated that information sharing and collaboration are crucial for a reverse logistics system. Most of the case firms that were subject to this paper did not have such a reverse logistics system in place yet, often because of the complexity of organizing it. However, they did already start developing it very early-on (stage 1 and 2) and Case B had already implemented this reverse logistics in stage 3. This is earlier than was assumed in the theory, which can be explained by the fact that developing the circular business model also started earlier and setting up a reverse logistics is an important part of a circular business model.

In addition, to influence the aforementioned regulatory barriers and the market barrier low virgin material prices, firms can decide to use lobbying or external lobbyists. Only Case A mentioned they were active in lobbying and they use it in a way later stage than originally assumed in the theory. They used lobbying to address barriers that occurred in the advanced stages of the transition, which is why they possessed this dynamic capability later than originally assumed. Perhaps their larger size and experience within their industry explains their lobbying activities. The reason why the other case firms did not mention lobbying as a dynamic capability might be that lobbying for SMEs usually is performed by external associations and this usually is a collective lobby rather than a lobby for individual firms (Bennett & Ramsden, 2007).

5.4 Distinction between CE-specific and general dynamic capabilities

In attempting to answer the research question, it became clear that the general dynamic capabilities are usually needed to solve the more general barriers that usually occur with changes or innovations in the organization. However, many of these general dynamic capabilities are either not mentioned by the case studies or are seen as normal dynamic capabilities that are used throughout the entire transition and therefore have not been adapted throughout the CE transition. These general dynamic capabilities, such as knowledge creation and learning and decentralization and local independence can be seen as prerequisites for a successful CE transition, which are therefore also used and needed throughout all the stages of the transition. Another general dynamic capability used throughout most of the stages is scanning the environment, even though it was expected that scanning the environment takes place in the first two stages of the transition. It became clear that the nature of this dynamic capability did change: whereas it was used as an explorative means to gain first knowledge of the CE in the first stages, it was used more in-depth to tackle specific problems in the more advanced stages.

On the contrary, CE-specific dynamic capabilities are required to be developed from scratch and as mentioned before, the results of the study showed that the importance of these dynamic capabilities differed across the different stages of the transition.

5.5 Developing and missing dynamic capabilities

In some cases, barriers were perceived, but the dynamic capability to overcome this barrier was not possessed or still being developed. Looking into the dynamic capability disruptive technological innovation, Case B and C were still in the development phase to overcome the barrier of a lacking ability to deliver a high-quality circular product. This is interesting, since these two cases were more advanced in the transition compared to Case D, who did already possess this dynamic capability. However, in Case B and C disruptive technological innovation was used to take their circular product to an even higher level. So, even though this dynamic capability does support producing a high-quality circular product, it is not a prerequisite to be able to do so.

Being able to implement a circular design in products within a circular business model is essential to be able to close the resource and materials loops (Moreno et al. 2016). The case

firms used modularity, lifetime expansion (product lifetime and use lifetime) and ease of disassembly to guarantee a circular design. Even though the case firms did focus on the circular design of their products, they mentioned that it was very challenging to close the resource and materials loops. This can be explained by the fact that closing the loops is seen as something unachievable by the case firms, even though making use of a product-as-a-service business model or reducing the amount of materials used already contributes a lot to the ability to close the resource loops (KPMG, 2018; van der Laan & Aurisicchio, 2019). Seemingly, there is a discrepancy between what the case firms think about their ability to close the loops and the fact that there are many business opportunities to do so.

When looking into the dynamic capability of collaboration in the value network, only Case C possessed this dynamic capability, whereas Case A missed this and Case B, D and E were still developing this dynamic capability. Collaboration within the value network is especially very important in the beginning stages of the transition, because firms have to set up a new way of collaborating (e.g. organizing the reverse logistics), which is needed for their circular business model to be implemented. This means that especially Case D and E really need to possess this dynamic capability, in order to proceed to the next stages of the transition. Case A and B, even though in the final stages of the transition, mentioned that collaboration within the value network is still missing or being developed. This could be explained by the fact that both these cases use a circular output business model (respectively a recycling facility and a remanufacturer), where collaboration within the value network in the later stages involves dotting the i's and crossing the t's. Since organizing a reverse logistics system is key for companies using a circular output business model (KPMG, 2018), Case A and B already have collaborated with various partners to organize this residual materials flow. That they did not mention this dynamic capability as possessed is surprising but might be explained by the fact that they already take this for granted.

Surprisingly, Case C was the only case firm that applied system thinking. Case D and E did mention it, but do not possess this dynamic capability yet, probably because they are in the begin stages of the transition. Case A and B, on the other side, did not possess this dynamic capability and did not mention it as important. This is surprising, as system thinking is seen as a core principle of the CE (EMAF, 2015). The lack of system thinking by the case firms could be explained by the complexity of adopting this principle. Trying to understand the links between the organization, its environment, customer, and its place in the industry it is in can be very

confusing and is hard to accomplish (Mortimer, 2019). On the other hand, Case A and B could also unconsciously possess this dynamic capability, because system thinking is seen as something normal and is already part of their DNA.

Seemingly, the case firms had difficulties with recognizing their own (dynamic) capabilities, such as collaboration and system thinking. Capabilities are intangible assets of a firm, which cannot be seen or touched (Smallwood & Ulrich, 2004). Measuring these (dynamic) capabilities is not easy, which is why managers tend to pay less attention to them than tangible investments such as plants and equipment (Smallwood & Ulrich, 2004). However, even though managers tend to pay less attention to certain dynamic capabilities, that does not mean they do not possess these dynamic capabilities. This could also apply to the dynamic capabilities system thinking and collaboration, which were not mentioned by case firms A and B, even though they are in the final stages of the transition. In these final stages, it can be expected that system thinking is a dynamic capability possessed, because it plays such a vital role in the CE principle (EMAF, 2015). Smallwood & Ulrich (2004) researched how (dynamic) capabilities can be identified and build up to create more market value and mentioned auditing as the best way to do this. During this audit, (dynamic) capabilities are chosen and operationalized – keeping in mind the overall business strategy – to assess the performance on each of the capabilities and rank the capabilities in terms of improvement needed (Smallwood & Ulrich, 2004).

5.6 Theoretical contributions

General and CE-specific barriers and dynamic capabilities

This paper has several implications. First of all, the results showed that literature focusing on the barriers and dynamic capabilities in the CE-context should distinguish between general innovation/change barriers and dynamic capabilities on the one hand, and CE-specific barriers and dynamic capabilities on the other hand. Barriers such as a rigid organizational structure and a hesitant company culture are general barriers that can occur with innovation and change within an organization but are not specifically linked to a CE transition. For this reason, these barriers were not always perceived by the case firms.

Stage of transition

Moreover, when distinguishing between general and CE-specific barriers and dynamic capabilities, the current stage of the transition in which the case firm finds itself matters. This

is something that has not been taken into account until now. This paper showed that several CE-specific barriers and dynamic capabilities were more needed in the beginning stages of the transition, such as business model innovation and circular design, whereas others were required in the later stages, such as collaboration and closing the loops. These implications contribute to the literature that the stage of the transition a firm is currently in matters to understand the context when researching barriers or (dynamic) capabilities. Next to that, this paper provides additional empirical results on the topic of circular dynamic capabilities, a topic that has not been empirically researched often in the current literature available. Figure 1 shows an overview of the dynamic capabilities needed throughout the different stages to solve the perceived barriers.

5.7 Managerial contributions

Types of barriers and dynamic capabilities

The results lead to different managerial contributions. First, managers might gain insights in the types of CE barriers that they could face during the transition and how they can overcome these hurdles by making use of the CE-specific dynamic capabilities. This means that firms should be aware that a CE transition asks for CE-specific knowledge and skills, which means that they should focus on CE-specific learning routines early-on in the transition. In addition, firms might not perceive obstructing laws and regulations in the beginning of the transition, but these might be perceived later on, when CE takes more shape and gets more detailed.

Timing of dynamic capabilities

The second managerial contribution that the study outlines concerns the timing of dynamic capabilities in the CE transition. Managers can use the study results to examine what types of dynamic capabilities they should focus on in the beginning of the transition, and which of these dynamic capabilities are needed later on in the transition. For example, business model innovation is a dynamic capability needed to be developed in the begin stages, whereas closing the loops was developed later on.

Role of green leadership

Third, the results have shown the importance of the role of green leadership when it comes to a successful CE transition. Firms or lower-level employees that want to pursue CE opportunities should define clear CE-goals and -strategies and try to gain support from top-management early-on in the transition.

5.8 Limitations and future research

Next to its insights, this paper also has its limitations. First of all, this paper used cases across the Dutch manufacturing industry. However, the cases researched in this paper used different types of circular business models or strategies, in order to create case heterogeneity. That is why some barriers or dynamic capabilities did not apply to certain CE-strategies. Second, one of the case firms was a lot smaller in terms of number of employees compared to the other four cases. While this can be seen as a limitation, it also enriched the research of this paper, because it brought more heterogeneity in the case firms. Third, because this paper took into account the stage of transition the business was currently in, some dynamic capabilities or barriers did not apply to cases in the earlier stages of the transition, simply because the businesses were not there yet. Having studied companies that would have gone through all stages of the CE transition may have resulted in richer qualitative data on experiences with the entire transition process. Fourth, the interviews were only held with top management or CE-specialists of the case firms. Because of the complexity of CE-implementation, support from lower-level employees across different departments is very important (Ritzén & Sandström, 2017; Hart et al., 2019). Therefore, it would have been interesting to gain more insights in the CE transition from different perspectives.

This paper opens up for future research avenues. First of all, future research could look into the specific barriers faced and dynamic capabilities needed for the different types of circular business models. Second, future research could perform a similar study, but in different contexts (other industries, large companies and on a greater scale) or different countries. Third, it became clear that measuring and identifying dynamic capabilities by making use of solely interviews was difficult. Because identifying the possession of certain dynamic capabilities was hard for managers, and the interview should not be biased by spelling everything out, future research should use a mixed-methods approach to identify dynamic capabilities. For example, conducting interviews could be combined with a questionnaire, observational research or an activity research. Fourth, future research could focus on the evolution of the different dynamic capabilities in a longitudinal study in order to research the adaptation and change of the dynamic capabilities in-depth throughout the

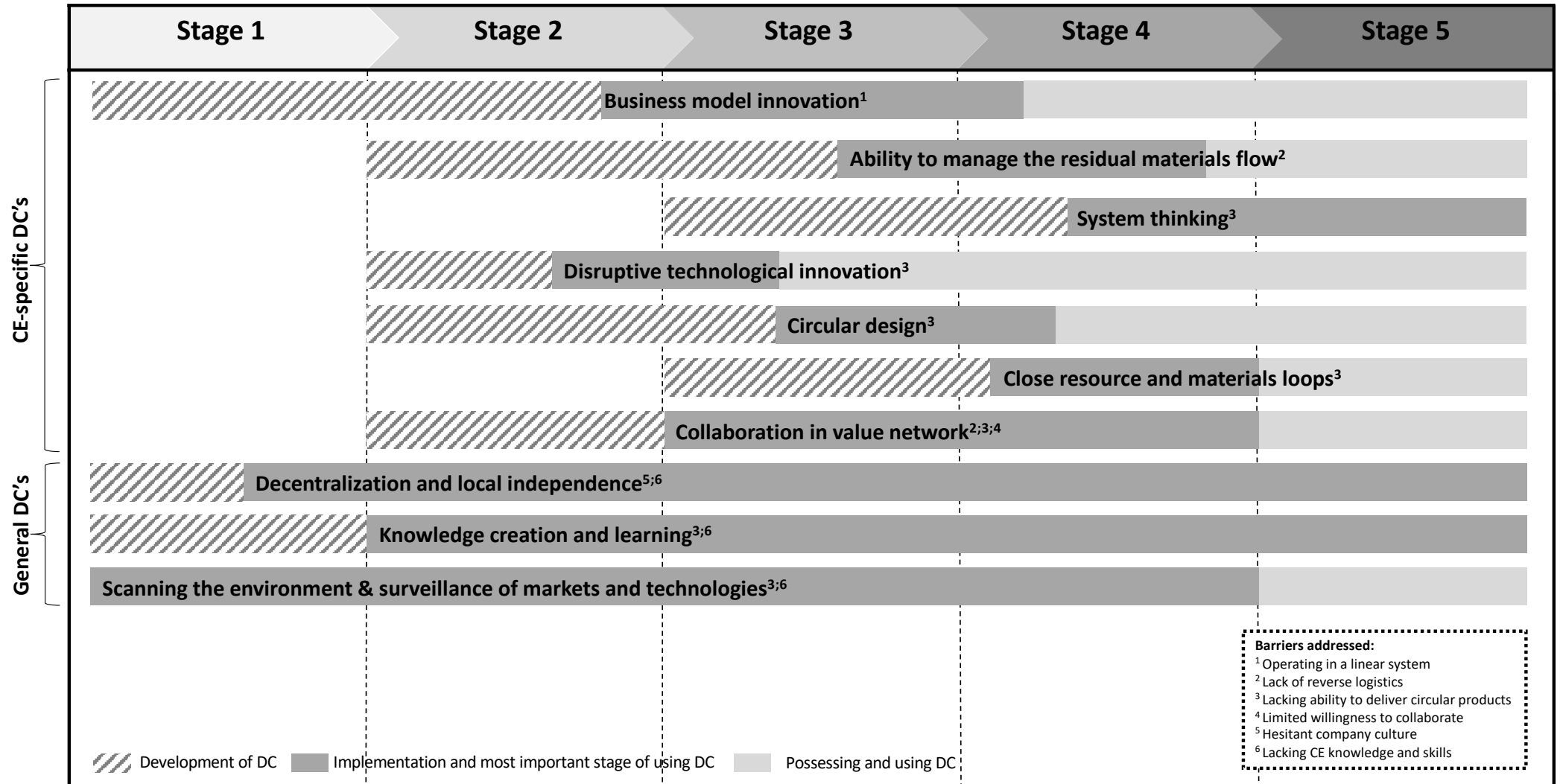


Figure 1 Dynamic capabilities per stage

different stages of a CE transition. Fifth, future research could focus on how regulatory barriers might be diminished for SMEs, as these barriers were not diminished by an in-house dynamic capability, since lobbying was not a dynamic capability possessed by most case firms. In other words, future research could focus on how governments or policy makers can stimulate a successful transition all the way to the end of a CE transition.

6. Conclusion

This paper aimed to answer the research question *“Which dynamic capabilities are needed to overcome the barriers faced while transitioning from linear to circular operations?”*. This question will be answered by addressing each of the capabilities one by one. First of all, circular business model innovation is needed to align the business strategy with CE goals. Second, the ability to manage the residual materials flow is important to organize the flow of products coming back after the leasing period is over or when products come back in the after-use phase to be refurbished. In order to organize this, collaboration in the value network is an essential dynamic capability, as the way of collaboration might change due to the new circular business model. Third, disruptive technological innovation, such as 3D printing or smart technology, is needed to be able to produce high-quality circular products. Fourth, the basic dynamic capability to be able to produce a high-quality circular product is circular design. Thinking about modularity, materials choice and disassembly is a fundamental aspect of a circular product. By means of that, firms can make a start to close the resource and material loops, a dynamic capability seen as difficult to possess, but highly needed for a successful CE transition. In the fourth place, while several general dynamic capabilities were needed to solve CE-barriers, these can be seen as conditional and supporting dynamic capabilities, needed when a company is in a change process. For example, the dynamic capability of knowledge creation and learning is needed to gain the right CE knowledge and skills required throughout the entire transition. Next to that, the case study firms also scanned the environment, markets and technologies to gain knowledge, both in the beginning and in the advanced stages of the transition. Fifth and last, decentralization and local independence is a dynamic capability needed in order to accumulate the knowledge needed for the CE transition throughout the organization.

The change towards a CE is very promising and highly needed, but more empirical data and academic literature is needed to learn how the long and winding road of a successful CE transition can best be walked. With more research conducted, more information will become available for businesses that want to start a CE transition. By means of that, businesses will gain more knowledge about what is needed for a circular transition which will accelerate steering our linear economy to a more sustainable and circular one.

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Appendix A – Interview protocol 1

Interview protocol for cases in the more advanced stages of the transition (stage 3-5)

English version

Introduction

This research maps out the facets of a transition to more circular practices. In the first instance, I look at which barriers companies encounter at the beginning and during the transition (i.e. both barriers that companies have already encountered and barriers that companies are currently encountering). I also try to define where the company is currently located in the transition. Once the barriers have been mapped out, I will investigate how companies have dealt with and are currently dealing with these barriers. In other words: what competences (dynamic capabilities) do they possess to make the CE transition successful? Or, what dynamic capabilities do they need to make CE transition a success? I am conducting these interviews at 5 companies, some of which are already very far into the CE transition, and some of which are still in the early stages.

I am going to encode and analyse the data I am gathering from this interview. I will then process these in my results, anonymously.

I would now like to officially ask if I can record this interview, so that I can analyse it later.

- What do you understand by circular economy?
- In your opinion, what is a circular product?

Circular economy definition:

"A circular economy describes an economic system based on business models that replace the "end-of-life" concept by the reduction, or re-use, recycling and recovery of materials in production/distribution and consumption processes, with a view to sustainable development, which means the creation of environmental quality, economic prosperity and social justice, for the benefit of present and future generations".

Examples of circular business models are:

- Focus on the input:
 - Circular design
 - Long lifetime
 - Circular processes
 - Circular materials
- Focus on use
 - Product as a service
 - Sharing platforms (airbnb)
 - Sell and buy back (leasing)
- Focus on output

- Male/redistribution
- Support lifecycle
- Refurbish & maintain
- Recycling company

General introduction circular at company

- What is your relationship to the circular economy?
 - Where are you now with regard to circular?
 - What kind of circular business model do you use?
- How did the transition to more circular work?
 - How did that come about?
 - What did you run into?

Knowledge of circularity

- How is the knowledge of circularity throughout the company?
 - Does this have an impact?

Organization

- To what extent is CE embraced within the organisation?
 - Is it part of the strategy/vision/mission?
 - If not, does this affect CE transition?
 - Is it part of the corporate culture?
 - If not, does it affect CE transition?
- What is the structure of the organization? Decentralized or hierarchical?
 - Does this affect CE transition?

Customers and circular economy

- How does the market receive your circular product?
- To what extent did customers influence your choice whether or not to work circularly, or the way circularity is filled in?
 - So e.g. type of business model?

Value network (partners)

- In the transition to circular working, did that affect your supply of value chain?
 - Partners, distributors, logistics etc.
- Was/is collaboration to make your network greener necessary and possible?
 - Or are you experiencing resistance from your partners and are you preventing this?

Regulatory and government policy

- Do you receive subsidies for circular work?

- Are these subsidies comparable to when you will not work circularly?
- Are there also subsidies that you will no longer receive when you make a circular transition?
- To what extent did government policy (laws/regulations) influence both the choice to work circularly and the transition to working circularly?

Funding & competition

- Was additional funding needed (or is it necessary) for the circular transition?
 - Yes: how did you experience finding investors for a circular business model?
- Did you experience problems with the large pre-investment, but the lack of short-term results?
- Do competitors have influence that offer non-circular products at a lower price?

Logistics

- During transition from circular working, did your logistical process have to change or has it been extended?
- Do your products get back from the customer?
 - How do you deal with products that return after use by the customer?

Circular design and production

- What circular products do you have?
 - In what way is this product circular?
 - Leasing business model?
 - Remanufactured?
 - Circular design?
- How could one of your products be even more circular?

Wrap up

- What are the biggest barriers to making circular products?
 - Circular design?
 - Disassembly, repair, refurbishment and remanufacture?
 - Qualified personnel?
 - Circular production

I would like to schedule a follow-up appointment, in order to be able to map out the competencies in the second interview.

Dutch version

Introductie

Dit onderzoek brengt de facetten in kaart van een transitie naar circulair werken. Hierin kijk ik in eerste instantie naar welke barrières bedrijven tegenkomen aan het begin en tijdens de transitie (dus zowel barrières die bedrijven al zijn tegen gekomen en barrières waar bedrijven op dit moment tegen aan lopen). Hierin probeer ik ook af te kaderen waar het bedrijf zich op dit moment bevindt in de transitie. Wanneer de barrières in kaart zijn gebracht, ga ik onderzoeken hoe bedrijven om zijn gegaan en op dit moment omgaan met deze barrières. In andere woorden: welke competenties (dynamic capabilities)

bezitten zij om de CE-transitie succesvol te maken? Of, welke dynamic capabilities hebben zij nodig om CE-transitie tot een succes te maken? Deze interviews neem ik af bij 5 bedrijven, waarvan sommige al heel ver zijn in de CE-transitie, en sommige juist nog volledig in de beginfase zitten.

De data die ik uit dit interview vergaar, ga ik coderen en analyseren. Deze zal ik vervolgens verwerken in mijn resultaten, anoniem.

Ik zou nu officieel willen vragen of ik dit interview mag opnemen, zodat ik het later kan analyseren.

1. Wat versta jij onder de circulaire economie?
2. Wat is naar jouw mening een circulair product?

Circulaire economie definitie:

"Een circulaire economie beschrijft een economisch systeem dat gebaseerd is op businessmodels die het "end-of-life" concept vervangen door vermindering, of hergebruik, recycling en terugwinning van materialen in productie/distributie- en consumptieprocessen, met het oog op duurzame ontwikkeling, wat inhoudt dat er milieukwaliteit, economische welvaart en sociale rechtvaardigheid wordt gecreëerd, ten voordele van de huidige en toekomstige generaties"

Voorbeelden van circulaire business modellen zijn:

- Focus op de input:
 - o Circulair design
 - o Long lifetime
 - o Circulaire processes
 - o Circulaire materialen
- Focus op het gebruik
 - o Product as a service
 - o Sharing platforms (airbnb)
 - o Sell and buy back (leasing)
- Focus op output
 - o Reuse/redistribute
 - o Support lifecycle
 - o Refurbish & maintain
 - o Recycling bedrijf

Algemene introductie circulair bij bedrijf

3. Wat is jullie relatie tot de circulaire economie?
 - a. Waar staan jullie nu wat betreft circulair?
 - b. Wat voor circulaire businessmodel gebruiken jullie?
4. Hoe ging de transitie naar meer circulair werken?
 - a. Hoe komt dat tot stand?
 - b. Waar liep je tegen aan?

Kennis van circulariteit

5. Hoe is de kennis van circulariteit door het bedrijf heen?

- a. Heeft dit invloed?

Organisatie

- 6. In hoeverre wordt CE omarmd binnen de organisatie?
 - a. Is het onderdeel van de strategie/visie/missie?
 - i. Zo nee, heeft dat invloed op CE transitie?
 - b. Zit het in de bedrijfscultuur?
 - i. Zo nee, heeft dat invloed op CE transitie?
 - c. Wat is de structuur van de organisatie? Gedecentraliseerd of hiërarchisch?
 - i. Heeft dit invloed op CE transitie?

Klanten en circulaire economie

- 7. Hoe ontvangt de markt jullie circulaire product?
- 8. In hoeverre hadden klanten invloed op je keuze om wel/niet circulair te gaan werken, of de manier waarop circulariteit wordt ingevuld?
 - a. Dus bijv. type business model?

Supply en value network (partners)

- 9. In de transitie naar circulair werken, had dat invloed op je supply of value chain?
 - a. Partners, distributeurs, logistiek etc.
- 10. Was/is samenwerking om je netwerk groener te maken nodig en mogelijk?
 - a. Of ervaren jullie weerstand vanuit jullie partners en weerhoud je dit ervan?

Regulair en overheidsbeleid

- 11. Ontvangen jullie subsidies voor circulair werken?
 - a. Zijn deze subsidies vergelijkbaar met wanneer je niet circulair zal werken?
 - i. Zijn er ook subsidies die je niet meer krijgt wanneer je een circulaire transitie maakt?
- 12. In hoeverre had het beleid van de overheid (wetten/regels) invloed op zowel de keuze om circulair te gaan werken en de transitie naar circulair werken?

Financiering & competitie

- 13. Was er extra financiering nodig (of is dat nodig) voor de circulaire transitie?
 - a. Ja: hoe hebben jullie het ervaren om investeerders te vinden voor een circulair businessmodel?
 - b. Ervaren jullie problemen met de grote voorinvestering, maar het gebrek aan korte termijn resultaten?
- 14. Hebben competitors invloed die niet-circulaire producten aanbieden voor een lagere prijs?

Logistiek

15. Tijdens transitie van circulair werken, heeft jullie logistieke proces moeten veranderen of is deze uitgebreid?

16. Krijgen jullie producten terug van de klant?

a. Hoe gaan jullie om met producten die terugkeren na gebruik van de klant?

Circulair design en productie

17. Welke circulaire producten hebben jullie?

a. Op wat voor manier is dit product circulair?

i. Leasing business model?

ii. Remanufactured?

iii. Circulair design?

18. Hoe zou een product van jullie nog meer circulair kunnen zijn?

19. Wat zijn de grootste barrières om circulaire producten te maken?

a. Circular design?

b. Disassembly, repair, refurbishment and remanufacture?

c. Gekwalificeerd personeel?

d. Circulair produceren (gebruik maken van IoT, bio-based energy, etc.)?

Algemeen

20. Welke barrières hebben het meeste invloed gehad op de transitie naar circulair werken?

Ik zou graag een vervolgspraak willen inplannen, om in het tweede interview de competenties in kaart te kunnen brengen.

Interview protocol for cases in the beginning stages of the transition (1 and 2)

English version

Introduction

This research maps out the facets of a transition to more circular practices. In the first instance, I look at which barriers companies encounter at the beginning and during the transition (i.e. both barriers that companies have already encountered and barriers that companies are currently encountering). I also try to define where the company is currently located in the transition. Once the barriers have been mapped out, I will investigate how companies have dealt with and are currently dealing with these barriers. In other words: what competences (dynamic capabilities) do they possess to make the CE transition successful? Or, what dynamic capabilities do they need to make CE transition a success? I am conducting these interviews at 5 companies, some of which are already very far into the CE transition, and some of which are still in the early stages.

I am going to encode and analyse the data I am gathering from this interview. I will then process these in my results, anonymously.

I would now like to officially ask if I can record this interview, so that I can analyse it later.

- What do you understand by circular economy?
- In your opinion, what is a circular product?

Circular economy definition:

"A circular economy describes an economic system based on business models that replace the "end-of-life" concept by the reduction, or re-use, recycling and recovery of materials in production/distribution and consumption processes, with a view to sustainable development, which means the creation of environmental quality, economic prosperity and social justice, for the benefit of present and future generations".

Examples of circular business models are:

- Focus on the input:
 - Circular design
 - Long lifetime
 - Circular processes
 - Circular materials
- Focus on use
 - Product as a service
 - Sharing platforms (airbnb)
 - Sell and buy back (leasing)
- Focus on output
 - Make/redistribution
 - Support lifecycle
 - Refurbish & maintain
 - Recycling company

General introduction circular at company

- What is your relationship to the circular economy?
- Where are you now with regard to circularity?

- How would you like to be more circular in the future?
- What kind of circular business model could you use?
- Why haven't you managed to be circular so far? What did you run into?

Knowledge of circularity

- How is the knowledge of circularity throughout the company?
 - Does this have an impact?

Organization

- To what extent is CE embraced within the organisation?
 - o Is it part of the strategy/vision/mission?
 - If not, does this affect CE transition?
- Is it part of the corporate culture?
 - o If not, does it affect CE transition?
- What is the structure of the organization? Decentralized or hierarchical?
 - o Does this affect CE transition?

Customers and circular economy

- Do you feel that your (potential) customers are interested in circular products?
 - o What is the market like?
- To what extent do customers influence your choice whether or not to work circularly, or the way circularity is filled in?
 - o So e.g. type of business model?

Value network (partners)

- Does a circular transition affect your supply or value chain?
 - o Partners, distributors, logistics etc.
- Is cooperation to make your network greener necessary and possible?
- Or do you experience resistance from your partners and prevent this from happening?

Regulatory and government policy

- To what extent does government policy (laws/regulations) influence both the choice to work circularly and the transition to working circularly?

Funding & competition

- Is additional funding needed for the circular transition?
 - o Yes: how do you feel about finding investors for a circular business model?
- Do you experience problems with the large pre-investment, but the lack of short-term results?
- Do competitors have influence that offer non-circular products for a lower price?

Logistics

- During the transition to circular working, would this affect the logistical process?
 - o If so, how?
- Do you need to set up a reverse logistics for your future business model?

Circular design and production

- What circular products could you have?
 - o In what way could this product be circular?
 - o Leasing business model?
 - o Remanufactured?
 - o Circular design?

Wrap up

- What are the main barriers to making circular products or to a CE transition?
 - o Circular design?
 - o Disassembly, repair, refurbishment and remanufacture?
 - o Qualified personnel?
 - o Circular production (using IoT, bio-based energy, etc.)?

- Which barriers have the most influence on the transition to circular working?

I would like to schedule a follow-up appointment, in order to be able to map out the competencies in the second interview.

Dutch version

Introductie

Dit onderzoek brengt de facetten in kaart van een transitie naar circulair werken. Hierin kijk ik in eerste instantie naar welke barrières bedrijven tegenkomen aan het begin en tijdens de transitie (dus zowel barrières die bedrijven al zijn tegen gekomen en barrières waar bedrijven op dit moment tegen aan lopen). Hierin probeer ik ook af te kaderen waar het bedrijf zich op dit moment bevindt in de transitie. Wanneer de barrières in kaart zijn gebracht, ga ik onderzoeken hoe bedrijven om zijn gegaan en op dit moment omgaan met deze barrières. In andere woorden: welke competenties (dynamic capabilities) bezitten zij om de CE-transitie succesvol te maken? Of, welke dynamic capabilities hebben zij nodig om CE-transitie tot een succes te maken? Deze interviews neem ik af bij 5 bedrijven, waarvan sommige al heel ver zijn in de CE-transitie, en sommige juist nog volledig in de beginfase zitten.

De data die ik uit dit interview vergaar, ga ik coderen en analyseren. Deze zal ik vervolgens verwerken in mijn resultaten, anoniem.

Ik zou nu officieel willen vragen of ik dit interview mag opnemen, zodat ik het later kan analyseren.

21. Wat versta jij onder de circulaire economie?

22. Wat is naar jouw mening een circulair product?

Circulaire economie definitie:

"Een circulaire economie beschrijft een economisch systeem dat gebaseerd is op businessmodellen die het "end-of-life" concept vervangen door vermindering, of hergebruik, recycling en terugwinning van materialen in productie/distributie- en consumptieprocessen, met het oog op duurzame ontwikkeling, wat inhoudt dat er milieukwaliteit, economische welvaart en sociale rechtvaardigheid wordt gecreëerd, ten voordele van de huidige en toekomstige generaties"

Voorbeelden van circulaire businessmodellen zijn:

- Focus op de input:
 - o Circulair design
 - o Long lifetime
 - o Circulaire processes
 - o Circulaire materialen
- Focus op het gebruik
 - o Product as a service

- Sharing platforms (airbnb)
- Sell and buy back (leasing)
- Focus op output
 - Reuse/redistribute
 - Support lifecycle
 - Refurbish & maintain
 - Recycling bedrijf

Algemene introductie circulair bij bedrijf

23. Wat is jullie relatie tot de circulaire economie?
- a. Waar staan jullie nu wat betreft circulair?
24. Op welke manier zou je in de toekomst meer circulair willen zijn?
- a. Wat voor circulaire businessmodel zouden jullie kunnen gaan gebruiken?
 - b. Waarom is het tot nu toe nog niet gelukt om circulair te gaan werken? Waar liep je tegen aan?

Kennis van circulariteit

25. Hoe is de kennis van circulariteit door het bedrijf heen?
- a. Heeft dit invloed?

Organisatie

26. In hoeverre wordt CE omarmd binnen de organisatie?
- a. Is het onderdeel van de strategie/visie/missie?
 - i. Zo nee, heeft dat invloed op CE transitie?
 - b. Zit het in de bedrijfscultuur?
 - i. Zo nee, heeft dat invloed op CE transitie?
 - c. Wat is de structuur van de organisatie? Gedecentraliseerd of hiërarchisch?
 - i. Heeft dit invloed op CE transitie?

Klanten en circulaire economie

27. Heb je het idee dat je (potentiele) klanten interesse hebben in circulaire producten?
- a. Hoe is de markt?
28. In hoeverre hebben klanten invloed op je keuze om wel/niet circulair te gaan werken, of de manier waarop circulariteit wordt ingevuld?
- a. Dus bijv. type business model?

Supply en value network (partners)

29. Heeft een circulaire transitie invloed op je supply- of value chain?
- a. Partners, distributeurs, logistiek etc.
30. Is samenwerking om je netwerk groener te maken nodig en mogelijk?
- a. Of ervaren jullie weerstand vanuit jullie partners en weerhoud je dit ervan?

Regulair en overheidsbeleid

31. In hoeverre heeft het beleid van de overheid (wetten/regels) invloed op zowel de keuze om circulair te gaan werken en de transitie naar circulair werken?

Financiering & competitie

32. Is er extra financiering nodig voor de circulaire transitie?

- a. Ja: hoe ervaren julli het om investeerders te vinden voor een circulair businessmodel?
- b. Ervaren jullie problemen met de grote voorinvestering, maar het gebrek aan korte termijn resultaten?

33. Hebben competitors invloed die niet-circulaire producten aanbieden voor een lagere prijs?

Logistiek

34. Tijdens transitie naar circulair werken, zou dit het logistieke proces beïnvloeden?

- a. Zo ja, hoe?
- b. Reverse logistics?

Circulair design en productie

35. Welke circulaire producten zouden jullie kunnen hebben?

- a. Op wat voor manier zou dit product circulair kunnen zijn?
 - i. Leasing business model?
 - ii. Remanufactured?
 - iii. Circulair design?

36. Wat zijn de grootste barrières om circulaire producten te maken?

- a. Circular design?
- b. Disassembly, repair, refurbishment and remanufacture?
- c. Gekwalificeerd personeel?
- d. Circulair produceren (gebruik maken van IoT, bio-based energy, etc.)?

Algemeen

37. Welke barrières hebben het meeste invloed op de transitie naar circulair werken?

Ik zou graag een vervolgspraak willen inplannen, om in het tweede interview de competenties in kaart te kunnen brengen.

Appendix B – Interview protocol 2

English version

Business model innovation

- How can you ensure that the company's strategy and vision is more in line with CE?
- How did the process of developing a new business model go?
- What do you need to implement a new business model?

Ability to manage residual materials flow

- How can the reverse logistics and supply chain be arranged?
- How do you deal with or would you like to deal with recurring products in the future?

System thinking

- How do you look at the links and relationships you find yourself in as a company? Are you focusing on that?

Collaboration in supply value chain

- How does collaboration work within the value and supply chain?
- How can you better collaborate within the value and supply chain?

Disruptive technological innovation / Close resource and material loops / circular design

- How could you produce better circular products?
 - o Circular design
 - o Way of producing
 - o How can you close the loop?
- How are "disruptive technological innovations" normally received in the organization?

Decentralization and local independence

- How do you deal with major organisational changes such as a CE transition within the organisation?
 - o Project teams?
 - o How will this be implemented organisation-wide?

Knowledge creation and learning

- How do you ensure that there is more knowledge and skills throughout the organization about CE?
 - o Will this be standardized (routines)?
 - o Learning cycle

Acquiring funding

- Is additional funding needed for the circular transition?
- How do you experience finding investors for a circular business model?
- Do you experience problems with the large pre-investment, but the lack of short-term results?
- How do you provide enough funding to set up a circular business model?

- How does that process work?

Lobbying

- Are you involved in lobbying? Or the branch organisation

Scanning the environment & market

- To what extent are you becoming more circular based on what the current market or competitors want/are doing?
 - E.g. what do others do and what does the market want?
 - Which processes and technologies could you also apply?

Dutch version

Businessmodel innovation

- Hoe kunnen jullie ervoor zorgen dat de strategie en visie van het bedrijf meer overeenkomt met CE?
- Hoe ging het proces van het ontwikkelen van een nieuw business model?
- Wat hebben jullie nodig om een nieuw businessmodel te kunnen implementeren?

Ability to manage residual materials flow

- Hoe kan de reverse logistics en supply chain worden geregeld?
- Hoe gaan jullie om of zouden jullie in toekomst om willen gaan met terugkerende producten?

System thinking

- Hoe kijken jullie naar de links en relaties waar jullie je als bedrijf in bevinden? Zijn jullie daar mee bezig?

Collaboration in supply- value chain

- Hoe werkt het samenwerken binnen de value- en supply chain?
- Hoe kunnen jullie beter samenwerken binnen de value- en supply chain?

Disruptive technological innovation / Close resource and material loops / circular design

- Hoe zouden jullie betere circulaire producten kunnen produceren?
 - Circular design
 - Manier van produceren
 - Hoe kunnen jullie ervoor zorgen om de kringloop te sluiten (close loops)?
- Hoe worden “disruptive technological innovations” normaal gesproken ontvangen in de organisatie?

Decentralization and local independence

- Hoe gaan jullie organisatorisch om met grote veranderingen zoals een CE-transitie binnen de organisatie?
 - Projectteams?
 - Hoe wordt dit doorgezet organisatie breed?

Knowledge creation and learning

- Hoe zorgen jullie ervoor dat er meer kennis en skills komen door de hele organisatie heen over CE?
 - o Wordt dit gestandaardiseerd (routines)?
 - o Leercyclus

Acquiring funding

- Is er extra financiering nodig voor de circulaire transitie?
 - a. Hoe ervaren jullie het om investeerders te vinden voor een circulair businessmodel?
- Ervaren jullie problemen met de grote voorinvestering, maar het gebrek aan korte termijn resultaten?
- Hoe zorgen jullie voor genoeg funding voor het opzetten van een circulair businessmodel?
 - o Hoe gaat dat proces in zijn werk?

Lobbying

- Zijn jullie actief in lobbying? Of de brancheorganisatie

Scanning the environment & market

- In hoeverre zijn jullie bezig met meer circulair worden op basis van de huidige markt?
 - o Bijv wat doen anderen en wat wil de markt?
 - o Welke processen en technologieën zouden jullie ook kunnen toepassen?

Appendix C – Coding scheme

Variables	Codewords
Stage 1	Minimal legal requirements; slightly aware of CE; linear principles; energy consumption; material usage
Stage 2	Recycling; efficiency improvement; CO ₂ emissions; complying to minimal regulatory requirements
Stage 3	Maintenance; repair; extend product life cycles; raw materials emissions; emissions from purchased energy
Stage 4	New business model; pay per use; leasing; pay per performance; circular strategy; circular systems; circular culture; minimize impacts; value network; minimize value networkemissions
Stage 5	Best-practice, improvement of circularity, circular technologies
CO_RigidOrgStruct	Bureaucratic, formality, legislative, official, controlling, departmental, governing, regulative
CO_CompCulture	Ignorance, mentality
CO_KnowledgeSkills	Ability, knowledge, skills, familiarity, insights, impotence, misunderstanding,
CO_LinearSystemStrategy	No circular strategy; no re-use; one-time use;
CO_CollabValueSupplyChain	Collaboration with partners, distributors, logistics; working together with; cooperation; supply-chain; wholesalers
CO_ConsAwarenessInterest	Customers; consumers; users; knowledge; interest; consciousness; recognition; realization; ignorance
R_FinIncentives	No subsidies; incentives; tax
R_LackingStandards	Certifications; guidelines; standards
R_LawsReg	Rules; policy; regulations; tax; government
M_VirginMatPrices	Low plastic prices; cheap materials
M_Funding	Funding; investment; interest rates; banks
M_ReverseLogisticsSupplyChain	Reverse logistics; residual materials; reverse supply-chain; products coming back
T_RemufacturedProducts	Technological; circular products; high-tech;
CEDC_BusinessModInno	Product-as-a-service, pay-per-use, leasing; circular business model
CEDC_ResidualMatFlow	Reverse logistics; residual materials; reverse supply-chain; products coming back
CEDC_SystemThinking	Links; system of the organization; industry; connections
CEDC_DisruptiveTechInno	3D printing; new innovation; smart technology
CEDC_CircularDesign	Easy disassembly; modularity; life-time expansion; ease of maintenance
CEDC_CloseResourceMaterialLoops	Product-as-a-service; less materials; reduce materials usage; choice of materials

CEDC_CollabValueSupplyChain	Collaboration with partners, distributors, logistics; working together with; cooperation; supply-chain; wholesalers
GDC_Decentralization	flexible; units; teams; projects; non-hierarchical
GDC_KnowledgeCreation	Learning; skills; expertise; master; understand; knowledge
GDC_ScanningEnv	Competitors; markets; other industries; industry;
GDC_Lobbying	Lobbying
GDC_AcquireFunding	Banks; loans; investors; acquisition

Codes:

Transition Codes	Barrier Codes	DC Codes
Stage1 Stage2 Stage3 Stage4 Stage5	Cultural/Organizational CO_RigidOrgStruct CO_CompCulture CO_KnowledgeSkills CO_LinearSystemStrategy CO_CollabValueSupplyChain CO_ConsAwarenessInterest	CE DC CEDC_BusinessModInno CEDC_ResidualMatFlow CEDC_SystemThinking CEDC_DisruptiveTechInno CEDC_CircularDesign CEDC_CloseResourceMaterialLoops CEDC_CollabValueSupplyChain
	Regulatory R_LackingStandards R_FinIncentives R_LawsReg	DC General GDC_Decentralization GDC_KnowledgeCreation GDC_ScanningEnv GDC_Lobbying GDC_AcquireFunding
	Market M_VirginMatPrices M_Funding M_ReverseLogisticsSupplyChain	
	Technological T_RemufacturedProducts	

Appendix D – Questionnaire results

Stage	Statement	Case A	Case B	Case C	Case D	Case E
Stage 5	We can be regarded as best practice in the field of the circular economy	5	4	4	2	1
	Our products we supply are fully circular	5	3	3	1	1
	Average score	5	3,5	3,5	1,5	1
Stage 4	We have a circular strategy (circularity/sustainability is part of our strategy, mission, vision)	5	4	4	2	3
	We use a circular business model (leasing, pay per use, pay per performance, etc.).	5	5	4	2	1
	We understand the emissions of our value and supply chain and try to minimize these emissions by designing our value and supply chain circularly.	5	1	3	3	2
	We have a circular culture within our company	5	4	3	3	3
	Average score	5	3,5	3,5	2,5	2,25
Stage 3	We try to minimize the negative impact of our production processes and our products on the environment.	5	4	2	4	2
	We focus on extending the product life cycles of our products	5	5	5	5	3
	We offer maintenance and repair of already sold products in order to make our products more circular.	N/A	3	5	4	4
	We have insights into the emissions/pollution of the raw materials used	5	3	3	3	2
	We are aware of the energy consumption and emissions of our energy supplier and try to use green energy.	5	5	3	5	2
	We are consciously engaged in recycling	5	5	4	4	3
	We are consciously improving the efficiency of our products and production processes.	5	4	5	3	4
	We know the CO2 emissions of our products and production processes	5	4	2	2	3
Average score	5,00	4,13	3,63	3,75	2,88	
Stage 2	We adhere to the regulatory requirements with regard to sustainability and energy policy	5	5	5	5	4
	We are fully aware of our energy consumption	5	5	4	3	2
	We are fully aware of our material use	5	5	5	2	2
	Average score	5,00	5,00	4,67	3,33	2,67
Stage 1	We are fully aware of what a circular economy means	5	5	4	4	2
	We comply with the minimum legal requirements regarding durability and circularity	5	5	5	5	4
	We have no linear principles within our company	5	4	4	3	1
	Average score	5,00	4,67	4,33	4,00	2,33
	Result	Stage 5	Stage 4	Stage 3	Stage 2	Stage 1

Table 8 Questionnaire results