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Exploring barriers to implementing different circular business models

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ABSTRACT

Even though much attention has been given to barriers related to implementing circular business models, so far, no studies have focused on how the barriers differ between business models. Ignoring the possibility of such differences could lead to unjustified generalizations about the barriers to implementing circular business models (CBMs). We identified barriers to implementation and compared them for different CBMs by analyzing 43 case studies of CBMs, based on in-depth interviews with 31 Dutch firms. Barriers were analyzed for the following CBMs: circular supplies, resource recovery, product life extension, and the product-as-a-service model. The barriers identified were classified into two broad categories: internal problems related to the firm itself and external barriers related to the firm's environment. This study shows that key challenges were related to the firm's external environment, and that the barriers differed between the four business models studied. Whereas most internal barriers encountered by the product-as-a-service model were to do with organization (for instance, of lease models), the other models reported these barriers less frequently. External supply chain issues were challenging in the resource recovery, product life extension, and circular supplies models, mainly because of great dependence on third parties for the input of discarded products and waste materials. We investigated the strategies firms used to overcome these barriers. From our findings we conclude that to stimulate the development of circular businesses, firms and policy makers should focus on bespoke solutions and strategies for different types of CBMs.

1. Introduction

In order to transform current production and consumption processes into sustainable pathways, radical changes are necessary in how products and materials are manufactured, used, and disposed of. The current economic system can be characterized by a take-make-dispose model (Ness, 2008), which is based upon continuous growth and resource extraction and therefore has profound negative impacts on the natural environment and the availability of resources. A contrasting model is the circular economy, defined by Kirchherr et al. (2017) as:

> "*… 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 …. "* (*p. 224*).

The transition toward a circular economy requires large societal changes. Firms are key actors within this transition, since they can develop and implement circular business models (CBMs), thereby contributing to altering production patterns (Planing, 2015). A business model as described by Shafer et al. (2005) and Teece (2010) is the representation of the underlying core logic of the company, and it describes strategic choices for the creation and capture of value within a broader value network (Shafer et al., 2005; Teece, 2010). In other words, it can be viewed as a blueprint of how a company does business (Teece, 2010).

In terms of circularity, new ways of value can be related to the reuse of products and materials (Bocken et al., 2016). Mentink (2014) defines a CBM as *"the rationale of how an organization creates, delivers and captures value with and within closed material loops" (p. 24)*. There are various types of CBMs and they differ in how value is generated (Lewandowski, 2016). Firms can generate value by exploiting the residual value from discarded materials through prolonging product life, or by recovering materials by

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means of recycling, and by providing services rather than selling products (Bocken et al., 2016; Lewandowski, 2016).

Firms could gain different benefits from engagement in the circular economy, such as reduced dependence on external resources, reputational advantages, and economic profit. Moreover, in comparison to the linear system, certain risks, such as supply disruptions and fluctuating resource prices, may be lower (MacArthur, 2013; Schulte, 2013; Bocken et al., 2016). Engagement of firms in CBMs can further contribute to achieving several SDG targets, such as SDG 6 (clean water and sanitation), SDG 7 (affordable and clean energy), SDG 12 (responsible consumption and production), and SDG 15 (life on land) (Schroeder et al., 2018). However, so far, widespread adoption and implementation of CBMs has not happened. This has been attributed to various barriers that firms encounter and perceive when developing and implementing CBMs (Linder and Williander, 2017; Ormazabal et al., 2018). To facilitate the faster uptake of CBMs, it is therefore necessary to identify the barriers that hamper implementation of a new business model.

Earlier studies on CBM barriers have opted for a geographical focus (e.g., China (Geng and Doberstein, 2008), Spain (Ormazabal et al., 2018), Sweden (Whalen et al., 2018), the Netherlands (Kok et al., 2013), European Union (Kirchherr et al., 2018). Other studies focus on specific sectors (e.g., textiles and clothing (Todeschini et al., 2017), construction (Adams et al., 2017), electronics (Kissling et al., 2013) and manufacturing (Ritzén and Sandström, 2017). In addition, some comparisons have been made across sectors, regions, and countries: for example, Rizos et al. (2016) presented an overview of barriers across sectors and countries, and Ranta et al. (2018) performed a cross-regional comparison of barriers for the CE between China, the US, and Europe. Some studies have provided barrier classifications for the implementation of CBMs (e.g., Preston, 2012; Kok et al., 2013; Rizos et al., 2016; De Jesus and Mendonça, 2018; Kirchherr et al., 2018).

Even though these earlier studies have examined barriers through various lenses, none of them has evaluated barriers by distinguishing between specific business models. This shortcoming could lead to generalizations being made about barriers even though the challenges for implementation supposedly differ between specific CBMs. Kirchherr et al. (2018) already state that, "*Future work may attempt to explore CE barriers in specific sectors or business models*" (p. 271). Various earlier studies already provide some valuable insights into the organization of specific business models and related challenges, for instance the literature stream on product-as-services based business models (e.g. Mont, 2002; Tukker, 2015; Reim et al., 2015) Moreover, the literature stream on closed loop supply chains (CLSC) provides valuable insights into barriers to organization of closed loops and reverse logistics, which is key for various CBMs that aim to reuse products and materials, such as models based on remanufacturing or recycling (e.g. Souza, 2013; Govindan and Hasanagic, 2018; Mishra et al., 2018; Wei et al., 2015; Shi et al., 2019). However, up to date a systematic and comprehensive conceptualization of the variety of barriers related to the different CBMs is lacking.

We therefore set out to investigate whether barriers to implementation differ for different CBMs and, if so, how. Barriers to implementation were explored and compared between four different business models. Since it is difficult to assess whether variation in the barriers reported in the literature on individual business models is due to the differences in business models or to context-related variables, such as geographical focus or institutional settings, or differences in time frame or methodological approach, we took an empirical approach to reduce variation in these factors. We collected primary data by conducting semi-structured interviews with 31 frontrunner firms in the Netherlands. Based on our data, we introduce a clear conceptualization of the differences between barriers to implementing CBMs. Further, we investigate the strategies the firms used to overcome these barriers. The next section first provides an overview of the main CBM barriers currently described in the literature, before elaborating on specific types of CBMs, and their organization and related challenges.

2. Theory

2.1. Business models: value creation and capture within CBMs

The business model literature has a strong focus on the creation and capture of (economic) value (Teece, 2010; Zott and Amit, 2010; Osterwalder et al., 2005). In the literature on sustainable business models, value capture is broadened from economic value to include social and environmental values too (Boons and Lüdeke-Freund, 2013; Bocken et al., 2014). The key challenges related to both value creation and capture are related to designing the business model in such a way that it brings the firm economic value and environmental and social benefits (Schaltegger et al., 2012).

For CBMs, new ways of value creation and capture can be found in relation to closing resource loops by reusing products and materials (Mentink, 2014; Bocken et al., 2016). Material cycles can be closed in different ways. The 4R framework of the EU Waste Framework Directive introduced four strategies for achieving this: (1) Reduce (refuse, redesign, rethink, reduce, and prevent resource use) (2) reuse (reuse (excluding waste), close the loop, repair, and refurbish) (3) recycle (remanufacture, recycle, close the loop and reuse of waste) and (4) recover (recover energy by incinerating materials (Kirchherr et al., 2017; European Commission, 2008). These Rs are hierarchical in terms of the extent of circularity, with the most desired option being "reduce", followed by "reuse", then "recycle", and, finally, "recover" (Potting et al., 2017; Kirchherr et al., 2017). Business models in the circular economy can create value along these four dimensions, for instance by developing new activities that eliminate life cycle waste or by organizing new partnerships in which waste is transferred to other firms (Bocken et al., 2014). On one hand, economic value is captured, by reducing costs through reusing materials, and on the other hand, environmental values are enhanced by reducing the environmental footprint and the use of virgin materials (Bocken et al., 2014). To date, CBMs have not been widely adopted in practice. The next section focuses on barriers reported in the literature.

2.2. CBM barriers

A considerable amount of research has already focused on the barriers to implementing CBMs (Table 1). Using these studies, we grouped barriers into barriers *internal* to the focal firm, and *external* to the focal firm (Mont, 2002). Internal barriers were considered to be the pressures within a company that hampered the implementation of their business model. We distinguished three categories: (1) Financial (2) Organizational (3) Knowledge and technology. External barriers were considered to be external forces that hindered companies from developing their CBM (Hoffman, 2000). These too were divided into three categories: (4) Supply chain (5) Market (6) Institutional. Category 6 refers to societal norms and rules that impact CBMs, such as regulations (considered as "hard" institutions) and societal values, habits, and traditions (considered as "soft" institutions) (Crawford and Ostrom, 1995).

As stated above, most studies mention barriers in general terms, and conceptual clarity is lacking regarding how barriers may differ between various CBMs. To explore such differences, the next section first derives a typology from the literature for the main CBMs,

Table 1
Barriers reported for CBMs.

Type of barriers	Description of barriers	References
Internal		
• **Financial**	• Lack of financialresources • High up-front investment costs • Higher costs related to the new CBM (e.g. costs of collection and segregation of components) • Unclear financial business case	Preston (2012); Kok et al. (2013); Rizos et al. (2016); Adams et al. (2017); Ritzén and Sandström (2017); Ormazabal et al. (2018); De Jesus and Mendonça, 2018; Mishra et al. (2018); Govindan and Hasanagic (2018)
• **Organizational**	• Administrative burden • Organization of reverse infrastructures • More complex management and planning processes	Kok et al. (2013); Rizos et al. (2016); Ritzén and Sandström (2017); Ormazabal et al. (2018); Govindan and Hasanagic (2018)
• **Knowledge and technology**	• Lack of technical know-how and expertise • Lack of information/data • Ability to deliver high quality products • Design challenges to create durable products	Geng and Doberstein (2008); Preston (2012); Kok et al. (2013); Rizos et al. (2016); De Jesus and Mendonça, 2018; Ormazabal et al. (2018); Ritzén and Sandström (2017); Todeschini et al. (2017); Kirchherr et al. (2018); Govindan and Hasanagic (2018)
External		
• **Supply chain**	• Lack of partners and low availability of materials • Higher dependence on external parties • Lack of information exchange between supply chain actors • Conflicting interests between actors in the supply chain • Lack of consideration on circular design from supply chain actors • Bad re-use practices/reluctance of third parties	Preston (2012); Kok et al. (2013); Kissling et al., (2013); Rizos et al. (2016); Adams et al. (2017); Ritzén and Sandström (2017); Todeschini et al. (2017); Govindan and Hasanagic (2018); Mishra et al., (2018)
• **Market**	• Low virgin material prices • Lack of consumer interest/non-acceptance of CBMs • Resistance from stakeholders with vested interests in the linear economy (for instance original equipment manufacturers)	Geng and Doberstein (2008); Preston (2012); Kok et al. (2013); Kissling et al., (2013); Planing (2015); Ormazabal et al. (2018); De Jesus and Mendonça, 2018; Kirchherr et al., 2018; Todeschini et al. (2017); Govindan and Hasanagic (2018); Mishra et al., 2018
• **Institutional (hard and soft)**	***Hard institutions*** • Ineffective recycling policies • Incentives that promote material consumption above services, such as V.A.T. (value-added tax) • Specific current accounting rules and management systems that are inappropriate for to the circular economy • Lack of standards and guidelines for quality of refurbishment products	Geng and Doberstein (2008); Preston (2012); Kok et al. (2013); Kissling et al. (2013); Rizos et al. (2016); Ranta et al. (2018); Ormazabal et al. (2018); Kirchherr et al. (2018); Govindan and Hasanagic (2018)
	Soft institutions • Lack of awareness and sense of urgency within society	Geng and Doberstein (2008); Kok et al. (2013); De Jesus and Mendonça, 2018; Adams et al. (2017); Ranta et al., (2018); Kirchherr et al., (2018); Mishra et al., (2018); Govindan and Hasanagic (2018)

and then elaborates on the organization of these specific CBMs and related challenges.

2.3. Types of CBMs

Different taxonomies of CBMs are described in the scientific and gray literature. Scholars categorize CBMs by using different criteria (Lewandowski, 2016), which are often based on the extent to which resource loops are either slowed down or closed (Bocken et al., 2016). Business models that contribute to slowing down can be broken down into two categories: first, "product-as-a-service" models, where firms retain ownership of the product and customers use products as a service, as discussed in the product–service system literature (Mont, 2002; Tukker and Tischner, 2006; Lacy et al., 2014; Tukker, 2015). This category links mostly to the highest R, "reduce" in the 4R framework, since this model implies rethinking how products are used. A second category is product life extension models: business models in which a product's lifetime is prolonged through reuse, remanufacture, maintenance, or repair (Mont, 2002; Lacy et al., 2014; Tukker, 2015; Bocken et al., 2016). This model therefore mostly links to the "reuse" strategy (the second R in the 4R framework). Business models for closing resource loops are described through two main archetypes: resource recovery and circular supplies (Lacy et al., 2014; Bocken et al., 2016; Moreno et al., 2016). The resource recovery business model is related to recovering resources to generate new forms of value, which is mostly related to the "recycle" and "recover" strategies of the 4R framework (Lacy et al., 2014; Bocken et al., 2016). Circular supplies is described as a business model in which fully recyclable, biodegradable, or renewable resource inputs are used, thereby replacing linear input approaches and scarce resources (Lacy et al., 2014; Van Renswoude et al., 2015). This falls within the "reduce" category of the 4R framework. These business models therefore capture the various strategies described in the 4R framework that can contribute to achieving closed material loops in the circular economy.

In the following section, we describe each business model and related challenges in more detail.

2.3.1. BM1: product-as-a-service model

This model is derived from the literature on product–service systems (PSS) (Mont, 2002; Tukker, 2015). A product–service system is defined as a "*marketable set of products and services capable of jointly fulfilling a user's need*" (Goedkoop et al., 1999, p. 18). The value proposition within this BM revolves around the provision of services; central in this model is that ownership of a product remains with the firm instead of the customer, and the product is available for the customer under leasing agreements (Tukker, 2004; Reim et al., 2015; Bocken et al., 2016). Additional services can be provided to ensure a product's durability. These service tasks (e.g., managing the reverse logistics of products back to the firm) are not usually performed by the manufacturer, but instead are outsourced to third parties (Reim et al., 2015).

A few characteristics are highlighted in the literature for this model. First, through leasing agreements, revenues are distributed over a period of time and not generated at a product's point of sale. This often results in the challenge of capital being tied up (Mont et al., 2006; Reim et al., 2015; Linder and Williander, 2017).

Moreover, the product-as-a-service model implies a long-term relationship between provider and customer, which can be customer-specific (Reim et al., 2015). In this model, it is very important that marketing understands the customers' needs for services (Reim et al., 2015). Since product ownership does not lie with the customer, the provider takes on increased responsibilities and (financial) risks which can be perceived as a challenge (Tukker, 2004; Mont et al., 2006; Azarenko et al., 2009). In addition, it is important to conclude formal contracts between customers and providers that capture the complexity of the relationship between both parties, balance their interests, and provide incentives and compensation mechanisms for the risk-bearing party (Azarenko et al., 2009). Acceptance of this model by customers is argued to be challenging, since owning products is still culturally preferred, due to cultural and reputational values (Mont, 2002; Lewandowski, 2016; Masi et al., 2017).

2.3.2. BM2: product life extension

In this model, companies aim to extend the life cycle of products. Firms create value by exploiting the residual value of used products (Bocken et al., 2016). A distinction is made between reuse strategies and product upgrade strategies (Prahinski and Kocabasoglu, 2006). Whereas reuse entails immediate resale or reuse of the product, product upgrade involves activities such as repairing, refurbishing, or remanufacturing before the product is resold and reused (King et al., 2006). These strategies maintain or improve product value without the product losing its function or identity (Prahinski and Kocabasoglu, 2006).

Different activities are executed for extension of product life cycles, depending on the type of product upgrade strategy. Important to most strategies is the collection of discarded products through the organization of take-back systems and reverse logistics (Souza, 2013; Shi et al., 2019). This can be challenging, since the quantity and timing of the returned discarded products can be unreliable and unpredictable (Kissling et al., 2013; Matsumoto et al., 2016; Linder and Williander, 2017). Moreover, how previous owners handled the product can ultimately decrease the quality of a product at its end-of-life state (Kissling et al., 2013; Matsumoto et al., 2016; Shi et al., 2019).

It has been argued that technological expertise and knowledge of the product are important for this business model; however, the amount of technological knowledge needed differs between product upgrade strategies (Linder and Williander, 2017). Whereas repair activities aim to correct a product's specific shortcomings, refurbishment and remanufacturing entail replacing or repairing entire product components (King et al., 2006; Reike et al., 2018). Remanufacturing involves the greatest technological changes, since it entails dismantling the entire product and replacing components, whereas refurbishment involves rebuilding some components (King et al., 2006; Reike et al., 2018). Activities related to the remanufacturing process are disassembling, inspecting, cleaning, repairing, replacing, and reassembling a product's components (Matsumoto et al., 2016). As a result of these, products acquire at least the same quality as newly made products, and product functionality is often improved by adding new functions to a used product (Matsumoto et al., 2016).

Crucial to the success of product life extension processes is product design, which is influenced by the original manufacturer of the product (King et al., 2006; Matsumoto et al., 2016). Power often lies with the original manufacturer. When a firm with a PLE business model is not the original manufacturer that decided on product design, it might become more difficult and less cost-effective to execute PLE processes (Matsumoto et al., 2016; Govindan and Hasanagic, 2018). Sometimes, original manufacturers hamper sale of used products, since they fear these will compete with new products (Kissling et al., 2013). Currently, a lack of incentives to design for disassembly is described as a barrier for greater adoption of these models (Adams et al., 2017).

Various studies show that customers find products with an extended lifetime less attractive (Masi et al., 2017; Govindan and Hasanagic, 2018). Moreover it is argued that consumers embrace fashion, and whereas fashion changes imply different types of products over time, products for PLE models (remanufacturing) favor product design based on modularity and timelessness (Linder and Williander, 2017).

2.3.3. BM3: resource recovery model

A central process within the resource recovery business model is the recovery of materials from discarded products. The value proposition of this business model revolves around exploiting the residual value of resources and converting them into (new forms) of value (Bocken et al., 2016; Moreno et al., 2016). In this process, the function of the original product or component is lost (Jayaraman, 2006). For instance, through recycling of a discarded phone, its original function is lost but the metals are recycled and may be used to manufacture other products.

Activities related to this recovery business model mainly include collecting of discarded materials, sorting, dissembling components and materials, processing, and using the discarded materials to manufacture new products (Thierry et al., 1995; King et al., 2006). This can be related to recycling processes of materials in a technological or biological cycle, such as using biological waste to generate new products. Product variety and composition are becoming more complex, and it has been argued that due to this, the technological challenges for recovery of materials are also increasing (Singh et al., 2014). An important activity for this business model is the organization of take-back systems. Uncertainty of the quality of waste can be a challenge for recycling processes (Singh et al., 2014; Singh and Ordoñez, 2016). When waste is transferred between companies, mismatches can occur in waste supply and demand; if companies do not exchange information on availability and quality of waste, such a match might be hampered (Fraccascia and Yazan, 2018). Moreover, firms that want to recycle waste sometimes face difficulties to obtain permits for waste reuse projects (Golev et al., 2015). Similar to the PLE model, customers' non-acceptance of these models is a challenge, due to resistance to products from recycled materials (King et al., 2006).

2.3.4. BM4: circular supplies

Within the circular supplies model, the key focus is on the replacement of virgin materials in production processes by renewable, recyclable, or biodegradable materials. Value propositions revolve around reducing dependence on scarce virgin materials, reducing environmental footprints, or removing inefficiencies (Lacy et al., 2014; Van Renswoude et al., 2015). Since literature on circular procurement is currently scarce, additional insights can be drawn from studies on sustainable supply management or sustainable procurement (Ageron et al., 2012; Min and Galle, 1997; Tripathi and Pedro, 2011).

The main activities within this model entail the purchase of circular materials and products, and selection of the associated contractors (Tripathi and Pedro, 2011). Initially, procuring circular materials from suppliers might pose financial barriers due to increased costs, related to high initial supplier and buyer investments (Min and Galle, 1997; Giunipero et al., 2012). Moreover, sustainable supply management is often recognized as an additional burden to suppliers, and perceived as increased risks to their competitive advantage (Ageron et al., 2012). This might reduce the likelihood of suppliers adopting sustainable supply practices, and thus makes it more difficult for companies to find a supplier.

Replacing materials and products with circular alternatives might result in challenges for product development since adjustments could be needed. Min and Galle (1997) argue that increasing the biodegradability, recyclability, and reusability of a product as a result of sustainable procurement might also require new product design. A lack of customer awareness was described as a barrier for SSM as well, which is argued to be the result of higher product prices or negative associations with sustainable products (Ageron et al., 2012).

2.3.5. Hybrid models

Often, firms adopt combinations of the business models described above, labeled as hybrid forms (Bocken et al., 2016). For example, firms may combine product life extension with a product-as-a-service model, to facilitate services that simultaneously increase product longevity and maintain ownership to ensure the product can be remanufactured after use. This also provides incentives for manufacturers to remanufacture and facilitate collection of used products (Matsumoto et al., 2016). Large firms may also adopt various CBMs, such as procurement of renewable materials for one product, and recycling of a waste stream for another.

3. Methodology

We employed a qualitative approach to explore whether barriers to implementation differ for different CBMs and, if so, how. To study this phenomenon, a multiple-case-study approach was used. A sample of frontrunner firms with CBMs was collected from the Dutch Network for Sustainable Businesses (De Groene Zaak[1]).

3.1. Case studies and sample selection

In contrast to a single case study, a multiple-case-study approach increases external validity and reduces observer bias (Voss et al., 2002). In case research, the case study is the unit of analysis (Voss et al., 2002). In our research, the unit of analysis was a CBM and, as noted above, the cases were drawn from the Dutch Network for Sustainable Businesses. The Netherlands is renowned for having a well-established government-supported program aimed at stimulating CBMs (the Dutch circular economy program: https://www.circulairondernemen.nl/). Within this program, The Dutch Network for Sustainable Businesses (De Groene Zaak) collects best practices of firms with established CBMs and has developed a specific approach for firms to stimulate the development of CBMs. All the firms in this network have been highlighted as frontrunner firms by the Dutch circular economy program. Since this network consists of a variety of firms with established CBMs, it was a useful source of case studies for our study.

In case research, samples are often built up by selecting cases by applying different criteria, instead of selecting a random or stratified sample (Eisenhardt, 1989). The following main selection criteria were applied in this study: (1) firms were engaged in at least one of the four CBMs described in section 2.3; (2) firms had already implemented their BM, which was therefore no longer in the pilot phase.

When creating our sample, we aimed to ensure that for each business model there was sufficient variety in terms of sector and firm size. Of the total 54 firms in the network, 42 were selected for further analysis in this paper. We reached out to these firms via a representative of The Dutch Network for Sustainable Businesses. Of the 42 firms contacted, 31 firms agreed to be interviewed (response rate: 74%). Some firms appeared to engage in more CBMs than the business model we initially aimed for. We included these cases, as Voss et al. (2002) has stated that multiple cases can be used from the same firm to study the same issue in a variety of contexts in that firm. As a result, we ended up with more case studies for some business models than for others; firms were especially likely to apply the resource recovery model in tandem with another CBM. From the 31 firms selected, we were able to collect data on 43 case studies. Table 2 provides an overview of the number of case studies studied per CBM. Appendix 1 provides an overview of various firm characteristics, such as firm size, sector, number and types of CBMs implemented, and the position of the interviewee within the company.

3.2. Data collection and analysis

Semi-structured interviews were conducted to gain an in-depth understanding of the perspectives of the participants on the barriers encountered within each business model. Interviews were more useful for the purpose of our study than the use of secondary data, since we aimed for a systematic comparison between different business models, and using primary data allowed us to study various business models in the same institutional settings and time frames. In total, 31 interviews were conducted with firm representatives in the course of six months (October 2015–March 2016). A high-level representative of each firm was interviewed; for a start-up it was often the founder/CEO, and for medium to large companies, the interviewee was often a manager responsible for the CBM. The interviews, which lasted 60 min on average, were carried out face-to-face in 18 cases and by phone in 13 cases.

Interviewees were asked three main questions: (1) to explain the organization of their CBM, (2) describe the barriers they encountered within that CBM, and (3) describe how they had tried to overcome these barriers. The interviews consisted of open-ended questions. Regarding the main barriers encountered, first an open question was asked and then the interviewees were told (the predefined) barrier categories, to provide some guidance and structure, and to elicit more specific data (Ritchie et al., 2013). Interviewees could respond freely to the categories that they perceived as relevant for them but were not obliged to respond to all of them, nor were they limited to these categories in their answers. We asked them to explain in which ways these barriers were encountered. When firms applied more than one CBM, we ensured that in the interview it was clear for which CBM the barriers were found, to ensure the barriers could be linked to a specific CBM in the subsequent analysis. All interviews were recorded and transcribed.

All implementation barriers were coded and grouped per business model into the six barrier categories derived from the theoretical framework. The business model analysis considered only the barriers that could be clearly linked to specific business models; barriers that were related to generic start-up issues or general issues related to the circular economy were not attributed to a particular business model. All quotes in section 4 are presented anonymously.

In order to understand how the barriers differ between business

Table 2
Number of case studies for each type of CBM.

CBM	Number of case studies
Product-as-a-service	8
Product life extension	10
Resource recovery	18
Circular supplies	7
Total	43

[1] The Dutch Network for Sustainable Businesses (De Groene Zaak) is the leading sustainable business association in The Netherlands. In January 2018, this network merged with CSR Netherlands (https://mvonederland.nl/csr-netherlands).

models in our sample, for each of the four CBMs we calculated the percentages of firms mentioning a barrier within a certain barrier category. Results were therefore normalized between business models. It is important to note that the percentages given are descriptive and should not be extrapolated into generalizations.

4. Results

4.1. Barriers for different CBMs

In the following paragraphs, we discuss the barriers to implementation we identified and compare them between the four CBMs. Fig. 1 shows, for each specific business model, the percentage of firms mentioning a barrier within one of the six barrier categories. Our findings show that there are differences in types of barriers encountered between the four business models. Firms with a product-as-a-service model mainly mentioned internal organizational and financial barriers (88% and 63% respectively), and external market and institutional barriers (63% and 50% respectively) but did not mention supply chain barriers. Firms with a product life extension model mainly encountered external supply chain and market barriers (70% and 80% respectively). The different internal barriers were each mentioned by 30% of the firms. Most firms with the resource recovery model mentioned supply chain barriers (67%), followed by institutional barriers (56%) and market barriers (50%). Less than half mentioned the internal barriers: 44% mentioned knowledge and technology barriers and 39% mentioned financial barriers. Firms with a circular supplies model mainly mentioned internal knowledge barriers and technology and supply chain barriers (both mentioned by 71% of the firms). Market barriers were mentioned by 57% of the firms.

Table 3 describes the major barrier categories. We considered a barrier to be major when at least 40% of the firms with that specific business model mentioned barriers within this category.

4.2. Internal barriers

4.2.1. Lack of knowledge and technology

The internal barrier of lack of knowledge and technology was mentioned most by firms with the circular supplies model or the resource recovery model. For firms with one of these models, product development from renewable, recyclable, biodegradable, or direct waste was key to their business. For the resource recovery model, this shortage of knowledge and technology specifically concerned recycling for the recovery of waste. Sometimes, machinery had to be adjusted or new knowledge or technology had to be developed. For example, a producer who wanted to cultivate mushrooms on coffee waste first had to experiment before finding the appropriate technology (Firm 1, 2015). Another firm mentioned that as current machinery was not capable of separating and recycling product components, the machines had to be rebuilt, which was a challenge (Firm 2, 2016).

Related to the circular supplies model, the procurement of circular materials also required a change in product development processes; it was perceived as difficult since knowledge and/or technology were lacking. A manufacturer of building blocks made from recycled plastic said: *"My co-manufacturer said that he normally works with virgin materials since recycled materials may behave differently in the machines …. It took a year to find a good design and to know how to set up the machines …. "* (Firm 3, 2015).

4.2.2. Organizational barriers

Organizational barriers were mainly found for the product-as-a-service model, which is highly dependent on organizational arrangements related to the lease model. Numerous firms indicated that they struggled with the legal, administrative, and financial aspects related to ensuring the firm retained ownership of products. One firm noted: *"The legal setting is a challenge …. Assets change with place and ownership, which should be defined in the contract. So this is a very difficult contract …. We found it hard to define and delineate the contract for users"* (Firm 4, 2015). Administrative difficulties were described for the lease contracts since such contracts entail receiving monthly invoices from customers. Moreover, organization of the services related to this business model was mentioned as a difficulty, specifically in relation to logistics and stocks of components. One firm that leased small electronic devices perceived their service to repair product components as a limitation to upscaling their business, since sending, receiving,

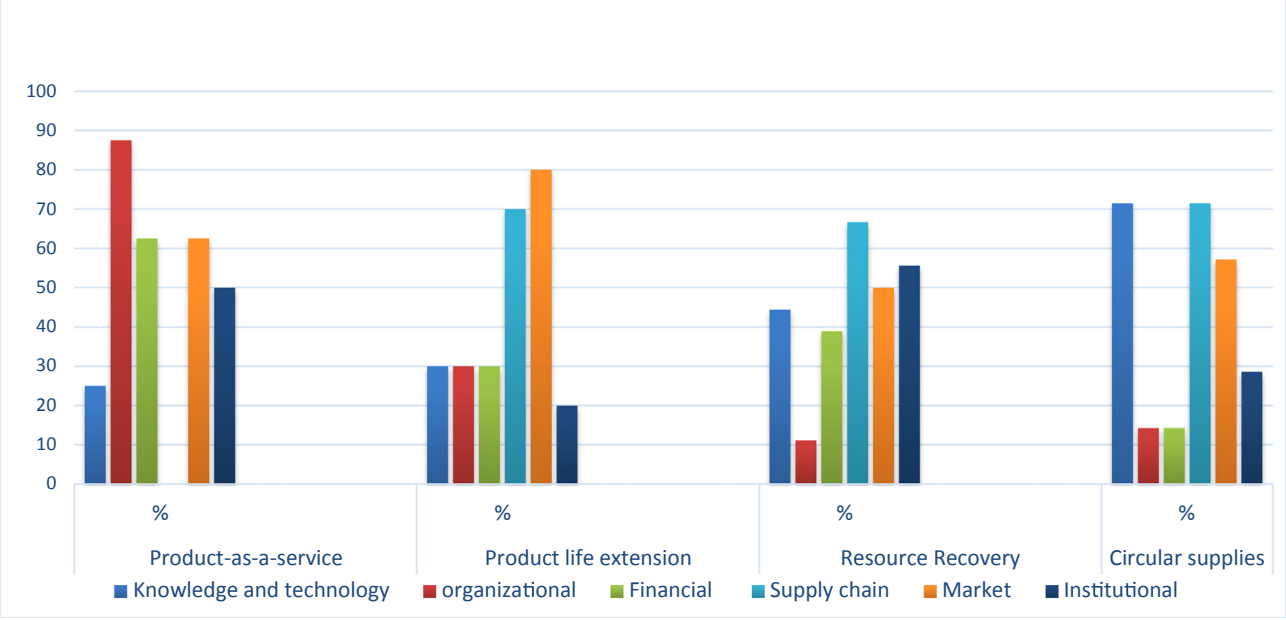

Fig. 1. Percentage of firms in each of the four CBMs mentioning different types of barriers to implementation.

Table 3
Major barrier categories mentioned by firms, per type of CBM. PSS = Product-as-a-service; PLE = Product life extension; RR = resource recovery and CS = circular supplies.

Barrier categories	Type of CBM			
	PSS	PLE	RR	CS
INTERNAL				
Knowledge and technology			• Lack of knowledge of and technology for recycling processes	• Lack of technology on how to use circular materials in production processes
Organizational	• Legal challenges related to contract • Administrative barriers related to lease contracts • Organization of service component of PSS model			
Financial	• Up-front investments needed • Higher costs and economically non-viable BM due to high service costs (especially when product components are cheap)			
EXTERNAL				
• Supply chain		• Dependence on suppliers that: - do not focus on reuse: creates challenges in terms of quality - do not focus on third-party product design and product information: creates conflicting interests in supply chain • Lack of partners	• Dependence on other parties for waste as input: - Uncertainty about suppliers in terms of quality, quantity, and delivery time of waste • Lack of partners and a low volume of waste	• Lack of partners • Current suppliers resist change
• Market	• Resistance from customer: consumer has not understood or accepted lease contracts • Disposable products are cheaper in market: product-as-a-service model option is less attractive	• Resistance from customer: - Not valuing "used" products - Market asks for "make-to-order" instead of standardization • Resistance from competitors: no focus on reuse	• Resistance from customers: distrust of products made from waste • Resistance from competitors • Low prices of virgin materials	• Resistance from customers: image problem, circular product perceived as lower quality • Market price of virgin materials is low and bio-based materials are expensive
• Institutional	• Vested rules in society not focused on circular economy: within companies, key performance indicators and accounting rules focus on linear economy and on products eventually becoming waste • Legislation/policy: V.A.T. • Resistance from society: prevalence of a "buy-and-own" culture • Investors are reluctant to invest in lease models		• Waste legislation hinders use of waste • Lack of policy incentives to use waste; waste is not a competitive resource • Insufficient societal awareness about waste separation	

and stocking those components created logistic challenges and increased costs (Firm 5, 2016). Also perceived as a challenge were new ways of communication with customers due to the continuing lease contract and the provision of services.

4.2.3. Financial barriers

These barriers were mainly relevant for the product-as-a-service model, due to high up-front investments. One firm that leased clothing noted: "*My firm is growing fast, but the faster we grow the bigger our financial need becomes. While I have to pay everything up-front, I only get back small amounts every month*" (Firm 6, 2015). Firms with the other business models mentioned financial barriers less often. The barriers found were mainly attributed to difficulties of making the business model economically viable, but as these were mainly triggered by market or supply chain barriers, they are discussed below under these categories.

4.3. External barriers

4.3.1. Supply chain barriers

Supply chain dependencies were found to be problematic in three CBMs: circular supplies, resource recovery, and product life extension. For the circular supplies model, the problem was mainly caused by the limited number of suppliers of circular materials. Since the circular economy is still in its infancy, few suppliers are already producing biodegradable or recyclable materials. Firm 7, which procures bio-based materials, said: "*Our biggest challenge is resources. There is currently only one manufacturer that can process recycled yarn. So yes, that is a bottleneck. … we already buy half of his output. It is not smart for him or for us to increase this, because we'll become too dependent on each other.*" (Firm 7, 2016).

For the resource recovery and product life extension models, the supply chain barriers were mainly related to the unknown quality of the discarded materials and products. For the resource recovery model, twelve firms in our dataset were dependent on the input of waste from third parties, either from other firms, or from the consumer market. Firms mentioned that as using waste as a resource made it more difficult to be certain the quality of material was comparable with that of material supplied "traditionally", they were more dependent on the supplier. When waste or products are retrieved from the consumer market, a different approach may be required. The extent to which consumers separate waste or treat products influences the extent to which product life extension and resource recovery models could still generate value; when waste is poorly separated, the waste stream becomes impure, which increases the technological and financial difficulties of generating value from recycling processes later (Firm 8, 2015; Firm 9, 2016).

Further, within the product life extension model, firms that depended on third parties for the input of discarded products mentioned that those parties often did not focus on reuse, which resulted in discarded products arriving in a poor state. This made it more difficult to generate value from the discarded product later. One firm said: "*When we went to collect the discarded laptops at another firm, we found 50 laptops stacked on top of each other, while the average laptop weighs a few kilos and can only bear a weight of 10 kilos before getting damaged. That meant that all the laptops at the bottom were damaged*" (Firm 4, 2015).

Not only the quality, but also the timing and volume of waste delivery were sometimes uncertain. One firm that recycled paper waste to produce notebooks indicated that whereas normally the contract with their supplier defined whether new material would be delivered, this was not the case with the deliveries of waste. The firm was therefore dependent on when and how much waste was available, which had implications for the storage of the required stocks (Firm 2, 2016). Firm 10, which recycled clothes from its customers, mentioned that to be able to track the materials it needed data from all its supply chain partners, and therefore stressed the importance of transparency (Firm 10, 2016). Another challenge mentioned was products that had not been designed to be easily disassembled, since this could increase technological challenges for extending product life later. However, designing for future disassembly was not always of interest to the original manufacturer.

4.3.2. Market barriers

One barrier found for all the CBMs was a lack of customers' acceptance. Reasons for non-acceptance differed between the CBMs studied. Customers were hesitant to buy products made of waste in the circular supplies and resource recovery models, since waste was perceived as unsafe to use. Moreover, customers did not clearly see the added value of the product (Firm 8, 2015; Firm 12, 2015; Firm 13, 2016). In the product life extension model, firms found that customers perceive their products as less fashionable or less valuable. They noted that customers do not ask for products that are uniform, but for made-to-order products — yet uniform product designs are favorable for product life extension models (Firm 14, 2016; Firm 15, 2016; Firm 16, 2015). In the product-as-a-service model, customer resistance was mainly related to the loss of ownership. Firms mentioned that customers did not understand the lease concept, since they are used to the "buy-and-own" system. One firm noted: *"A lot of people still want to buy our product. That is by far the most difficult aspect, it is far more difficult than producing a modular or recyclable product"* (Firm 5, 2016).

Another barrier within this category was resistance from competitors, which was encountered in the resource recovery and product life extension models. A few firms with a resource recovery model mentioned that they perceived resistance, since their competitors had released reports on the inefficiency and risk associated with their waste product (Firm 12, 2015; Firm 17, 2015). When firms did not make the original components themselves, their competitor became their supplier too, and sometimes the original manufacturers demanded high prices for specific components. One firm said: "*Some manufacturers are also the supplier of specific parts of the product. They make the components very expensive, to protect their product, so if I want to remanufacture a product, I may pay as much for the specific component as I would pay for a whole product*" (Firm 11, 2016).

4.3.3. Institutional barriers

For the resource recovery model, institutional barriers were related to legislation on the use of waste as a resource. Multiple firms mentioned they wanted to experiment with waste to see if it could be used as a resource, but were hampered by legislation. One firm said: "*When we want to experiment with waste, we usually start at a small scale to test, then we want to scale up and produce more. However, in this case this is difficult, since formally we need all kinds of permits to be able to start experimenting. We don't have a permit for these resources because they are considered as waste from another industry, and we are only allowed to process waste from our own industry*" (Firm 12, 2015). Another perceived problem in addition to legislation that hampered firms from using waste as a resource was a lack of stimulating institutions. One firm mentioned that since the government did not consider their waste as a competitive resource in the market, it did not stimulate them to recycle these materials (Firm 18, 2016).

Another institutional barrier was the difficulty of finding investors willing to invest in firms with a product-as-a-service model. Banks were not perceived as willing investors by some of the firms (Firm 5, 2016; Firm 6, 2015; firm 16, 2015). This increased financial problems for firms with this model. It was also mentioned that

entrenched rules were not focused on a circular economy. For example, KPIs and accounting rules were still very focused on a linear economy (Firm 19, 2016). The circular supplies and product life extension models seemed less influenced by these barriers.

Some barriers mentioned by the firms were not directly related to a specific CBMs but instead were related to the infancy of the circular economy. Currently, a small number of actors are active in the circular economy, which results in low legitimacy for circular products and CBMs. A lack of awareness in society was one of the barriers mentioned. Moreover, a lack of inspiring frontrunner examples and successful business cases might lead to few risk-takers and entrepreneurs being active in the circular economy. One firm noted: "*Hardly any firms within the CE have been really successful so far. Successes in an industry are important: they attract talent, and people dare to take risks. For me the CE feels like the early phases of the internet: a lot of experimentation is going on, but it is in its infancy and therefore we have to figure out everything ourselves. In Silicon Valley there is infrastructure, capital, talent, and a lot of creativity. When these factors are present, you can use these as a firm and start a new company quickly. However, there is no Twitter or Google for the circular economy yet, and I think this should be established, for it will be the biggest driver of success.*" (Firm 20, 2015) Some barriers occasionally mentioned were related to start-up problems or sectors. Among the start-up barriers mentioned were a lack of scale, as a result of which firms could not reduce product prices and were not yet as efficient as they wished (Firm 22, 2016).

4.4. Coping strategies: overcoming barriers

In this section we investigate the strategies the firms used to overcome the barriers described in section 3. Table 4 summarizes the main coping strategies.

4.4.1. Overcoming supply chain barriers

Both the resource recovery and product life extension models encountered barriers that derived from dependence on other parties in the supply chain. Dependence often occurred when firms exploited waste materials and products from other companies, so-called "gap exploiters" (Bocken et al., 2016). Building closer relationships between supply chain actors was perceived as critical. One firm, which receives waste products from a supplier, noted: *"We had to put a lot of effort into the communication and relationship with our supplier, to be able to control the quality of its waste product"* (Firm 9, 2016). Secondly, partnering with other firms in the supply chain could also secure the quality of waste input. One firm mentioned: "*Because we specifically make the material out of waste tires we want to know exactly where the tires come from and what they consist of. It is therefore more logical to have a partnership with a firm in the supply chain*" (Firm 20, 2016).

Retaining ownership of the product could be another strategy to reduce dependence on other supply chain actors. For instance, some firms in our sample combined a product life extension model with a product-as-a-service model, and exploited the residual value of their own products themselves. By so doing they avoided supply chain barriers mentioned by other firms, such as a lack of influence on the design or a lack of knowledge of the production process. On the other hand, these firms pointed to the need for closer customer relationships, since product life extension processes become more expensive and technologically challenging when the end-of-life quality of products is low due to customer behavior (Firm 5. 2016; Firm 6, 2015).

A current scarcity of partners in the supply chain also led to increased dependence. Some firms with the circular supplies model described how they took on a more proactive role to stimulate their suppliers to develop circular materials and products. One firm mentioned that the only way to convince their current suppliers was by co-investing in the development of circular materials (Firm 21, 2016). Another firm mentioned that it had abandoned its traditional role as buyer of materials and was developing circular materials jointly with their supplier (Firm 12, 2015).

4.4.2. Overcoming market barriers

Often, firms faced low customer and societal acceptance and trust in circular products. This was often tackled by proactively creating awareness and building legitimacy. One firm mentioned: "*We had to justify that our products were safe for people and the environment*" (Firm 12, 2015). Another firm said: *"We had to demonstrate the additional value of our product by conducting research and developing the right knowledge, since it had not yet been accepted in the market"* (Firm 17, 2015).

4.4.3. Overcoming knowledge and technology barriers

Often, knowledge and technology were not yet available. Experimentation was mentioned as a possible strategy for a firm to develop technological knowledge itself. Moreover, knowledge was sought in other sectors or fields (Firm 17, 2015). Another strategy was for firms to outsource technical activities related to product life extension or resource recovery models, and to themselves take on a more coordinating role in the supply chain (Firms 4 and 6). In addition, firms with the product-as-a-service model sometimes outsourced the drafting of contracts to law firms, or outsourced services to service providers.

5. Discussion and conclusions

In this study, barriers in various CBMs were explored, to understand whether they differ for different CBMs and, if so, how. Our findings illustrate that barriers do indeed differ for the four CBMs studied. This study therefore helps fill the current gap in scholarly literature resulting from a lack of conceptualization of the variety of barriers for different CBMs. For this analysis, 31 Dutch firms were selected from The Dutch Network for Sustainable Businesses (De

Table 4
Coping strategies mentioned by firms.

Barriers to overcome	Coping strategies
Supply chain barriers:	
• High dependence on waste products and materials from other actors	Building closer relationships with other actors in the supply chain to better influence product quality Retaining product ownership to reduce dependence on third parties
• Lack of actors in the supply chain	Stimulating current or new suppliers to develop circular materials and products through collaboration and co-investment
Market barriers:	Building legitimacy and creating awareness
• Lack of awareness on the part of customers	
Lack of knowledge and technology	Experimenting with technology and developing knowledge Searching for knowledge in new sectors Outsourcing technical activities

Groene Zaak[1]), resulting in the analysis of a total of 43 case studies of CBMs.

Regarding the internal barriers, our results showed that the product-as-a-service model encountered the most organizational and financial barriers. Unlike the other three models, at the core of this model is retention of ownership of a product, which implies large organizational and financial challenges, such as the organization of lease contracts, with high up-front investments and tied-up capital (Azarenko et al., 2009; Reim et al., 2015). The resource recovery and circular supplies models reported the most technological barriers, due to the technological challenges of recycling and changing production processes related to the input of circular materials. Whereas in the literature the importance of technology for the product life extension model has been reported (e.g. King et al., 2006; Matsumoto et al., 2016), in our sample technological barriers were not prominent for this model. This may be explained by the large focus of earlier work on high-tech industries such as electronics and manufacturing, whereas our sample also involved case studies of less high tech industries for product life extension of, among others, furniture, textiles, and carpet tiles.

Barriers related to the external firm environment were major in all four CBMs. Although supply chain barriers have been reported in earlier studies that have not distinguished between business models, we find that such barriers were important for three of the models; the exception was the product-as-a-service business model, which did not report any supply chain barriers. Since the resource recovery, product life extension, and circular supplies models often required input of discarded products and materials obtained from other parties, these barriers are to be expected. Dependencies from the focal firm on third parties resulted in multiple barriers related to unpredictable quality, timing and quantity of discarded products and materials. Aligning incentives in the supply chain, a fair division of cost and benefits, and exchange of information on availability and quality of waste between actors could be beneficial to overcome these challenges (Rizos et al., 2016; Mishra et al., 2018; Fraccascia and Yazan, 2018).

Market barriers were found to be important for all four CBMs studied, mainly due to customer resistance. This is in line with earlier reported barriers (e.g. Planing, 2015; Ormazabal et al., 2018; De Jesus and Mendonça, 2018). Understanding the underlying reasons for consumer behavior with regard to CBM adoption is crucial for firms that aim to design new circular business models (Planing, 2015). Further nuances were found in our study between specific business models in underlying reasons for customer resistance, and bespoke strategies for optimizing the value propositions for various CBMs are needed. A remarkable finding was related to resistance from competitors, which was only found for the product life extension and resource recovery models. Although earlier studies demonstrate resistance from original manufacturers (see for instance Kissling et al., 2013), our findings also show resistance from industry competitors without a supply chain relationship with the focal firm. Resistance from actors with vested interests in the status quo was already mentioned in the literature (Kok et al., 2013), but further research is needed to investigate whether and why specific business models might face more resistance than others.

Institutional barriers were found to be highly important for the resource recovery model, due to the obstructive legislation related to waste. Golev et al. (2015) already mention this barrier specifically for firms that engage in waste reuse activities. The product-as-a-service model also reported many institutional barriers, but of a different kind. An important barrier was that leasing models were still not compatible with investor logic and did not match the accounting rules entrenched in adopting companies.

Many barriers were found to be interlinked. This importance of interaction effects between barrier categories was also mentioned by Kirchherr et al. (2018) and De Jesus and Mendonça (2018). In our study, internal barriers mentioned were often related to an external barrier. For example, low prices of virgin materials in the market made it more difficult for firms to create or maintain an economically viable business model. Furthermore, investor reluctance to invest in product-as-a-service models resulted in a lack of financial resources to finance the lease model. Another problem was that financial and technological challenges occurred when the focal firm was dependent on supply chain actors for discarded products or materials. For instance, some actors in the supply chain put high prices on specific components needed by the focal firm, which increased that firm's financial challenges. Also, technological challenges for recycling or product life extension processes occurred when other actors decided on the product design, or when the product's quality was low at the end of product life.

5.1. Limitations and suggestions for further research

The generalizability of our results is subject to certain limitations. First, our study is confined to the Netherlands, and second, it contains a limited sample for each business model. Our findings are therefore valid within this context but make it difficult to generalize conclusions. It could be that the barriers we found differ not only between business models but also between sectors. Since the sample size did not allow us to differentiate between sectors, this requires further research. If sectoral differences also play a role in determining specific barriers, an even more fine-grained policy approach is required. We therefore recommend focusing future research on further exploring the barriers to implementation of different types of CBMs in a variety of specific sectors. A last promising avenue for further research would be to evaluate the effectiveness of fine-grained policies for promoting the implementation of CBMs, and of bespoke coping strategies and solutions for addressing specific barriers, once these strategies and solutions are in place.

5.2. Implications for theory and practice

Our findings illustrate that barriers differed for the four types of CBMs studied. We have provided an overview of the major barriers for each CBM and have shown how firms have coped with various barriers. Regarding theory, these insights increase scholars' understanding of how specific CBMs are obstructed. Moreover, they show that it is useful to distinguish between business models when analyzing barriers.

These insights are particularly relevant for firms and policy makers, since they imply that instead of a one-size-fits-all approach, a more fine-grained approach to stimulate the development of CBMs, and a focus on bespoke solutions and strategies could be useful, for instance when developing specific instruments for different CBMs. Moreover, insights in variation in barriers between specific business models may help to better understand how various business models could be better aligned in order to achieve closed-loop supply chains.

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Appendix 1. Firm characteristics

Case no.	Firm size	Sector	CBM no.	type of CBM	Core activities of CBM	Interviewee's position in firm
Firm 1	Small	Food	1	RR	Recycling of coffee grounds	Founder
Firm 2	Small	Paper	2	RR	Use of discarded writing paper to produce notebooks	Founder
Firm 3	small	Furniture	3	CS	Procurement of recycled (waste) plastic for development and production of building blocks	Founder
Firm 4	Small	Electronics	4	PLE	Coordination of supply chain for refurbishment of discarded laptops	Founder
			5	PSS	Lease model for refurbished laptops	
Firm 5	Small	Electronics	6	PSS	Lease model for small electronic devices	Founder
			7	PLE	Supplying customers with components for repair and upgrade	
Firm 6	Small	Textiles and clothing	8	PSS	Lease model for clothing	Founder
			9	RR	Coordination of supply chain for recycling of cotton from discarded clothes	
Firm 7	larger	Flooring	10	CS	Development and use of bio-based materials and/or fully recyclable materials	Sustainability manager
			11	RR	Recycling of discarded nylon products for the manufacture of carpet flooring	
			12	PLE	Repair and reuse of used carpet flooring	
Firm 8	Larger	Food	13	RR	Recycling of food waste to produce different products	CEO and sustainability manager
Firm 9	Small	Food	14	RR	Recovery of discarded supermarket food	Founder
Firm 10	Small	Textiles and clothing	15	CS	Development and supply of 100% recyclable materials	Project manager
			16	RR	Recovery of raw materials (polyester yarns)	
Firm 11	Small	Mechanics	17	PLE	Remanufacture, revision, and refurbishment of electromechanical motors	CEO
Firm 12	Larger	Paper	18	CS	Procurement of circular materials	QHSE coordinator
			19	RR	Recycling of discarded products	
Firm 13	Small	Water	20	PSS	Leasing waste water recovery systems to customers	Founder
			21	RR	Water recovery systems	
Firm 14	Larger	Furniture	22	RR	Recycling of materials to produce office furniture	Circular economy manager
			23	PLE	Maintenance, refurbishment, and remanufacture of office furniture	
Firm 15	Small	Manufacturing	24	PLE	Remanufacturing of bikes	Founder
Firm 16	Small	Furniture	25	PSS	Lease model for furniture	Founder
			26	PLE	Refurbishment of furniture	
			27	RR	Recycling of construction materials	
Firm 17	Larger	Water	28	RR	Recovery of a waste stream	Project manager
Firm 18	Small	Water	29	RR	Recycling of water and scrap metals	Director
Firm 19	Small	Manufacturing	30	PSS	Lease model for washing machines	Founder
Firm 20	small	Automotive	31	RR	Recycling materials from waste car tires	CEO
Firm 21	small	Packaging	32	CS	Procurement of bio-based coffee cups	Director of operations
Firm 22	Small	Food	37	RR	Coordination of chain for recovery of discarded farm products, to make food products	Founder
Firm 23	Larger	Soap/ detergents	34	RR	Coordination of a supply chain to manufacture plastic bottles from ocean plastic waste through recycling	Project manager
Firm 24	Larger	Water	35	RR	Recycling of water and minerals	Process and technology manager
Firm 25	Small	Electronics	36	PLE	Coordination of chain for refurbishment of discarded phones	Founder
Firm 26	Small	Furniture	33	PLE	Up-cycling of discarded furniture	Founder
Firm 27	Larger	Electronics	38	PSS	Lease model for printers and pay-per-use of printers	Circular economy project manager
			39	PLE	Remanufacturing of printers	
Firm 28	Small	Clothing and textiles	40	CS	Procurement of recyclable plastic yarns (made from ocean plastic)	Financial director
Firm 29	Small	Food	41	RR	Use of waste coffee grounds and cardboard substrate	Founder
Firm 30	Small	Textiles and clothing	42	PSS	Lease model for clothing	Founder
Firm 31	Larger	Packaging	43	CS	Development and production of bio-based drink packages	CEO

*Firms with less than 99 employees were classified as small, firms with more than 99 employees were classified as larger.

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Firm 13, 2016. Interview Conducted in Person on the 26th of January 2016.
Firm 14, 2016. Interview Conducted in Person on the 1st of February 2016.
Firm 15, 2016. Interview Conducted by Phone on the 27th of January 2016.
Firm 16, 2015. Interview Conducted by Phone on the 9thof December 2015.
Firm 17, 2015. Interview Conducted in Person on the 5th of November 2015.
Firm 18, 2016. Interview Conducted by Phone on the 23rd of March 2016.
Firm 19, 2016. Interview Conducted in Person on the March 2016.
Firm 2, 2016. Interview Conducted in Person on the 8th of February 2016.
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Firm 21, 2016. Interview Conducted by Phone on the 22nd of January 2016.
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Firm 4, 2015. Interview Conducted by Phone on the 2nd of November 2015.
Firm 5, 2016. Interview Conducted in Person on the 3rd of February 2016.
Firm 6, 2015. Interview Conducted in Person on the 4th of November 2015.
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