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In Search of Sustainability Gains from the Complementarity Between Value Creation, Value Proposition and Value Capture Elements of Circular Business Models

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Abstract

Purpose: Functioning of business models that follow the philosophy of circular economy is a growing research theme but discussion about the potential and the limitations of such business models remains unstructured. We provide a focused perspective on the meaning of complementarity between the elements of business models.

Approach: Cluster analysis techniques allow us to explicate correlations between the business model elements, which in turn enables us to demonstrate how complementarity between these elements can strengthen the creation of both societal and customer value.

Findings: By analyzing 92 companies, we point out why complementarity between the value creation, value proposition and value capture elements is an important phenomenon. We also show how complementarity can be utilized in the development of circular business models.

Social and practical implications: Our findings are promising because numerous societal and customer value propositions seem to be compatible with diverse business model elements. This means that circular features can be attached to various types of business. Based on our analysis, we propose that business model complementarity should be thoroughly considered in the future efforts to develop more ambitious circular business models.

Keywords: business model; circular economy; sustainability; value capture; value creation; value proposition

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Introduction

The circular economy has been identified as a pathway towards reducing the overexploitation of natural resources and the concept has received increased interest within research (Türkeli, Kemp, Huang, Bleischwitz and McDowall, 2018), policymaking (McDowall, Geng, Huang, Bartekova, Bleischwiz and Turkeli, 2017), and business (Murray, Skene and Haynes, 2017) communities across the globe. At its core, the circular economy is a system designed to be restorative with an aim to replace the "end-of-life" concept with the continuous circulation of products and materials (Ellen MacArthur Foundation, 2017; Geissdoerfer, Savaget, Bocken and Hultink, 2017; Kalmykova, Sadagopan and Rosado, 2018). In European Union, for example, circular economy action plan is a key part of Green Deal program that aims to decouple economic growth and resource use while simultaneously achieving net-zero greenhouse gas emissions by 2050. Currently only a small part of the total consumption and production can be considered truly circular (Guzzo, Pigosso, Vidiera and Mascarenhas 2022; de Wit, Verstraeten-Jochemsen, Hoogzaad and Kubbinga, 2019).

Business model approach (Zott and Amit, 2010) has gained attention as a theoretical perspective on the capacity of businesses to advance circular economy (Centobelli, Cerchione, Chiaroni, Del Vecchio and Urbinati, 2020; Linder and Williander, 2015; Merli, Preziosi, and Acampora, 2018). Discussion about circular business models is a part of wider effort to understand how sustainability-related goals can be integrated into business activities (Bocken, Short, Rana and Evans, 2014; Bocken, de Pauw, Bakker, and van der Grinten, 2016; Evans, Vladimirova, Holgado, van Fossen, Yang, Silva and Barlow, 2017; Stubbs and Cocklin, 2008). Research on circular business models aims to explain how societal value – in forms of wellbeing of humans and the nature (Bocken ***et al.***, 2016; Porter and Kramer, 2011) – can be produced in addition to typically considered customer value – in form of a benefit that customer gets from buying a product or service (Anderson, Narus and van Rossum, 2006; Payne, Frow and Eggert, 2017). While research in this area is growing fast (see e.g. Bocken and Ritala, 2021; Ferasso, Beliaeva, Kraus, Clauss and Ribeiro-Soriano 2020; Valve, Lazarevica and Humalisto, 2021), still little is known about how to combine different types of circular value creation in different situations and operational areas (Laasch, 2018; Lüdeke-Freund, Rauter, Pedersen and Nielsen, 2020; Ranta, Aarikka-Stenroos and Mäkinen, 2018a).

Also concerns have been raised regarding the sustainability aspects of circular business models (e.g. Figge and Thorpe, 2019; Stewart and Niero, 2018; Zink and Geyer, 2017). For example, it has been argued that in many cases development of circular business activities overly focuses on the business benefits achieved only through customer value creation (Hofmann, 2019). While the notions about the limitations of circular economy business models (Kirchherr, Reike and Hekkert, 2017; Korhonen, Honkasalo and Seppälä, 2018) are often well justified, criticism has in many cases been unstructured and remained at a general level. For example, it is known that different companies face different challenges in the implementation of circular activities into their business models (Rizos, Behrens, van der Gaast, Hofman, Ioannou, Kafyeke, Flamos, Rinaldi, Papadelis, Hirschnitz-Garbers and Topi, 2016; García-Quevedo, Jove-Llopis and Martínez-Ros, 2020) and in some situations these implementations can have united or unexpected consequences (Di Fabio, 2020; McLaughlin and Börger, 2019). These types of aspects remain often unnoticed in general-level criticisms.

Generality of critical discussions is problematic from the perspective of development of more ambitious circular business models. To facilitate a more focused discussion, we need better understanding about the exact functioning and impacts of circular business models (Levänen, Uusitalo, Härri, Kareinen and Linnanen, 2021). Gaining such understanding, however, is challenging because business activities take place in complex socio-ecological systems and their implications do not realize only in one value dimension (Fehrer and Wieland, 2021). To navigate this complexity, it is important to learn to analyze how different elements of business models interact and how they can strengthen or weaken each other in terms of sustainable value creation. While the extant research has identified different types of circular business models (Lewandowski, 2016;

Lüdeke-Freund, Gold and Bocken, 2019; Urbinati *et al.*, 2017), the complementarity between the business model elements is much less studied area.

This article shows how complementarity between the business model elements can be studied empirically. We demonstrate how different configurations of co-functional business model elements can facilitate positive sustainability-related outcomes in different situations without losing the feasibility of the business. To operationalize our research, we pose the following questions: 1) *what types of value creation elements do firms highlight in their circular business models? 2) what types of value creation and value proposition elements are complementary with each other? and 3) what types of value creation and value capture elements are complementary with each other?* We use cluster analysis techniques to answer these questions. Analysis of 92 companies allows us to explicate correlations between value creation, value proposition and value capture elements of circular business models. By means of identified correlations, we explain why complementarity between the business model elements is important and how it can be utilized in the further development of circular business models.

This article is structured as follows. In section 2, we explain the conceptual basis of the business model complementarity phenomenon. After that, in section 3, we provide information about the materials and methods of this study. In section 4, we present identified linkages between the studied business model elements. Finally, in section 5, we discuss our findings and present key conclusions from this research.

Business model complementarity

Emerging from the strategic management field, the business model approach (Zott and Amit, 2010) aims to capture the holistic nature of business, reflecting "stories that explain how enterprises work" (Magretta, 2002: 4) and how firms create value (Teece, 2010). This approach has turned out useful in research on how firms can facilitate business aligned with circular economy principles (Lüdeke-Freund *et al.*, 2019; Nußholz, 2018; Rizos *et al.*, 2016). The implementation of circular features typically requires significant changes in business conduct (Bocken, Thijs and Geradts, 2020; Levänen, Park and Rosca, 2022) and business model concept helps to understand how these features can be attached to specific business activities (Geissdoerfer, Pieroni, Pigosso and Soufani, 2020; Ranta, Aarikka-Stenroos, Ritala and Mäkinen, 2018b). A common way to conceptualize business model is to present it as a combination of value proposition, value creation, and value capture elements.

Value proposition forms the core of the business model (Teece, 2010) and represents what the firm considers to be valuable, i.e., the proposed value, in their offering(s) (Payne *et al.*, 2017). The value proposition describes the type of value being proposed, which is typically analyzed through a lens of value dimensions (Patala, Jalkala, Keränen, Väisänen, Tuominen, Soukka, Jalkala, Keränen, Väisänen, Tuominen, Soukka,.,., 2016; Rintamäki, Kuusela and Mitronen, 2007), such as customer value and societal value (Baldassarre, Calabretta, Bocken and Jaskiewicz, 2017; Boons and Lüdeke-Freund, 2013). *Value creation* describes how the value proposition is fulfilled (Zott, Amir and Massa, 2011). It includes the activities that the firm undertakes throughout its business activities to "create, produce, sell, and deliver their offering to customers" (Richardson, 2008: 139). In this article, we focus specifically on activities that are aligned with circular economy principles, following the strategies of slowing, closing and narrowing resource loops (Bocken *et al.*, 2016). Finally, *value capture* describes the economic incentive for the firm to perform the business model, highlighting how revenue is generated in a profitable manner (Johnson, Christensen and Kagermann, 2008).

In conceptual terms, this article focuses on business model complementarity. Complementarity has conceptual roots in the field of physics, and since that it has been applied especially in economics, but growingly also in business and management studies (Turner, 2022). In these fields, business model complementarity is mainly discussed as a business benefit gained through successful formulation of activities inside a specific business model element (Teece,

2018), between different business models (Burgelman, Snihur and Thomas, 2022; Snihur, Thomas and Burgelman, 2022) or within a network of multiple actors (Aarikka-Stenroos and Ritala, 2017; Xu, Kemppainen, Ahokangas and Pikkarainen, 2020). Complementarity has also been seen as a possible outcome of collaborative efforts around innovation development (Ballot, Kemppainen, Ahokangas and Pikkarainen, 2015).

An approach where complementarity is understood as an interplay between the business model elements (Ritter and Lettl, 2018) has gained less attention than other above-mentioned perspectives on complementarity. In this article, we make a point that assessment of the complementarity across value proposition, value creation and value capture elements should be considered as a very important part in the analysis and development of circular business models. For example, certain value capture elements may enable utilization of certain value creation elements and thus determine the viability of the entire business model. By directing analytical focus into the interaction between the business model elements, we can learn how different types of elements can support each other in different fields, contexts, and situations (Levänen, Lyytinen and Gatica, 2018).

Materials and methods

We utilized a mixed methods approach combining qualitative and quantitative content analyses of selected firms' business models. Selected companies have been pro-active in the integration of circular features into their business models. Studied companies have been accepted to the "List of most interesting companies in circular economy", which is a program organized by the Finnish innovation fund Sitra – the major facilitator of the circular economy in Finland (see Arponen, Granskog, Pantsar, Stuchtey, Törmänen, Vanthournout, 2015).

Data

We utilized a database of 92 firms engaging in diverse circular activities. The data is based on interviews of firm representatives by Sitra's personnel during their circular economy facilitation activities during the period from 2016 to 2019. Based on the interviews, the team compiled descriptions of each company's business model and its connections to the principles of circular economy. The business model descriptions made by Sitra include a fact sheet about the company and information about the sustainability problem the firm attempts to mitigate. These documents also include relatively detailed information about the firm's solution (value creation element), the firm's revenue model (value capture element), and the benefits for their customers and the society at large (value proposition element). Basic information about the firms whose business models we studied is presented as Appendix A, and in the forthcoming sections we refer to specific firms with their real names. While the studied business model descriptions are static in nature and allow for less depth than deeper case studies with multiple informants per case, the advantage of using this type of dataset is that it enables a relatively broad comparative study.

Methodology

Our data analysis process was comprised of five distinct steps. Firstly, we chose a random sample of the cases (n=30) that was analyzed separately by all three authors. Qualitative coding was performed to the descriptions of the studied business models, linking portions of text to different business model elements. The NVivo 10 software was utilized for the analysis. In this stage, we used key business model elements identified in the literature (value creation, value capture and value proposition for both customers and society) as first-level codes. Within these categories, open-ended, emergent coding was performed, identifying sub-categories under each business model element as second-level codes. In the case of value creation, analysis also included identification of third-level codes. This initial coding process can be described as abductive in nature (Dubois and Gadde, 2002).

In the second stage, the coding frames generated by the three authors were compared and analyzed for similarities and differences. At this stage, each code that was not present in all three coding schemes at any level was discussed separately. Codes that could be merged due to strong similarity were also identified.

In the third stage, the remainder of the cases (n=62) was coded by splitting the sample between the three authors. In this stage, the agreed upon coding scheme was utilized deductively. Two additional second-level codes emerged during this stage, which were then shared among the three researchers so that instances of the code could also be analyzed in all three samples. This stage was concluded by compiling all the codings under a single NVivo project.

In the fourth stage, NVivo's quantitative analysis tools were used to perform a cluster analysis on the coded cases. Codes were clustered according to the number of their co-occurrences across the cases (n=92). Each occurrence was represented by the presence of a particular coding within a single case rather than the length of coded text. This normalizes for the length of codings, as there was some heterogeneity in the descriptions and their relative emphasis on the different business mode elements. The Sorensen-Dice co-efficient was used as the basis for the cluster analysis, which is a commonly employed measure for analyzing the similarity of datasets in a lexical analysis (Manning and Schütze, 1999). It is calculated by dividing the number of shared occurrences in two datasets multiplied by two and divided by the total number of occurrences. This analysis provided a matrix of correlation scores between each code. Based on this, the most frequently co-occurring business model elements were identified and ranked based on the Sorensen-Dice co-efficient between them.

Finally, in the fifth stage, based on the most distinct co-occurrences of circular business model elements, the case descriptions were reviewed to identify illustrative cases for each co-occurrence. The configurations were grouped based on the main value creation type (second-level code), and the most commonly occurring other business model elements (value capture and customer/societal value proposition) are listed with each value creation type. Many of the studied business models combined different ways of circular value creation, and therefore, we also identified major co-occurring value creation types.

Results

In this section we describe our findings concerning the complementarity between the business model elements. Table 1 summarizes the circular business model elements that we have identified. Below we anlyze the dynamics between these elements.

Identified value creation elements

We begin by answering to our first research question: what types of value creation elements do firms highlight in their circular business models? Five second-level codes of circular economy-related value creation elements occurring in the cases were identified: 1) **asset or resource optimization**, 2) **product as a service**, 3) **replacement**, 4) **selling used products**, and 5) **waste to value**. This division of value creation elements represents a typology rather than a taxonomy because many cases combined multiple types of activities. In Figure 1 we illustrate identified value creation elements and their sub-categories, which were identified as third-level codes.

The **asset or resource optimization** consists of three sub-categories. In many cases, optimization of an asset or a resource was facilitated through *an asset sharing marketplace*, where the firm gave customers an opportunity to share their underutilized resources with peers, facilitating the optimization of value creation potential of an asset for customers. In *consultation or installation services*, the firms rely on their expertise of specific customer processes and provide customers with services that help them to optimize the inputs and outputs of a certain customer process or need. These often coincided with *smart monitoring services*, which enable customers or the studied firms to make data-driven decisions about the processes.

The **product as a service** consists of two sub-categories that revolve around turning the exchange of a product into a service-like experience, namely *long-term services* and *short-term rentals*. In long-term services, customers acquire products that they consistently use as a service and in practice outsource the handling of the product to the supplier while always maintaining the availability of the product. In short-term rentals, customers do not have the need for the products consistently and thus rent the

Table 1.			
Value creation elements	**Value proposition elements**		**Value capture elements**
	Societal value proposition	*Customer value proposition*	
Asset or resource optimization	Reduced pollution	Increased revenue	Periodic payments
Product as a service	Reduced resource use	Cost savings	Transaction fees
Replacement	Environmental improvements	Time savings	Pay-per-use
Selling used products	Health benefits	Risk reduction	Product sales
Waste to value	Extended product life cycle	Convenience	Licensing
	Reduced waste	Functional value	Waste management fees
		Brand benefits	

Table 1. Circular business model elements.

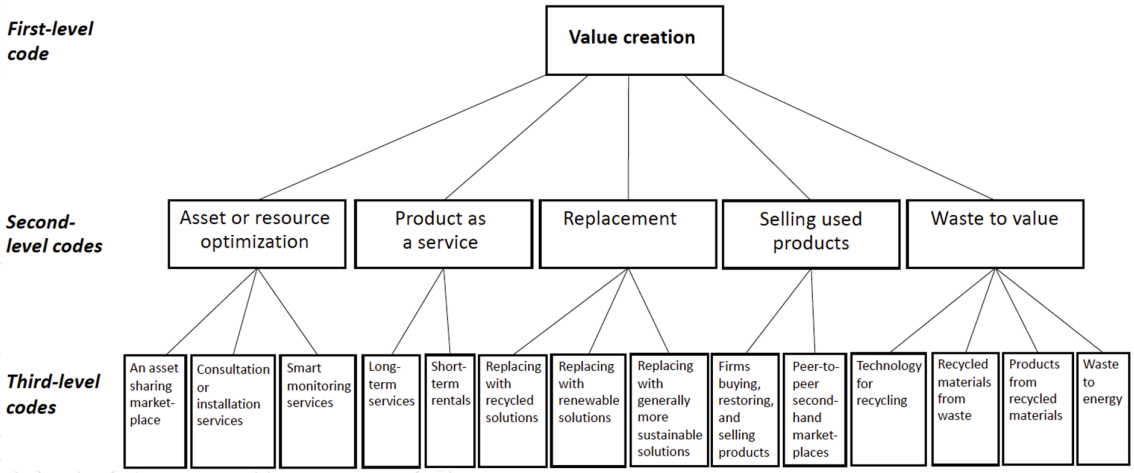

Figure 1. Value creation elements of the studied circular business models.

products when needed. As the underlying logic, both activities change the customers expenses from capital expenses to operational expenses.

The **replacement** consists of three sub-categories describing alternative solutions to replace existing solutions in the marketplace. When *replacing with recycled solutions*, firms engage in recycling materials or providing products from recycled materials and offering them as substitutes for non-recycled products. When *replacing with renewable solutions*, firms offer to customers products that are created from renewable sources, for example by replacing plastic products with wood-based products. For the third option, *replacing with generally more sustainable solutions*, a firm's activity was not necessarily directly focused on the material of the product but rather on the systemic sustainability effect of it, such as in the case of replacing meat with plant-based alternatives.

The **selling used products** consists of two sub-categories that enable customers to choose used products rather than new products. In *firms buying, restoring, and selling products*, the focal firm engages in the acquisition and processing of used products at scale and often refurbishes and remanufactures products that might otherwise be no longer usable. In *peer-to-peer secondhand marketplaces*, firms take a more distant role in the physical exchange of the product and focus on connecting the supply and demand. In some of these cases, the firm handles short-term storage and the delivery of the product between peers, while in other cases, the firm never touches the physical product and only facilitates the connection and communication between peers.

The **waste to value** consists of four sub-categories that all turn waste materials into valuable resources in different ways. Three activities are directly related to recycling, namely *technology for recycling*, *recycled materials from waste* and *products from recycled materials*. These are all connected and form a value chain for turning waste back into products. However, because these activities are performed in separate business models based on the case data analyzed, they emerged as separate codes during the data analysis. The fourth activity, *waste to energy*, is more distinct one as it is focused on extracting value from materials that leak from the circular system. Biofuel operators extracting fuel from biowaste are examples of this type of activity.

Identified links between value creation and value proposition elements

Next, we answer to our second research question: what types of value creation and value proposition elements are complementary with each other? After identification of different value creation elements, we moved forward to analyze different forms of customer and societal value propositions that the studied companies provide. Figure 2 illustrates co-occurring societal and customer value propositions in relation specific value creation elements, implying strong (0,39<co-occurrence), intermediate (0,25<co-occurrence) and low (0,10<co-occurrence) correlation between the business model elements. Detailed co-occurrence values are presented in Appendix B. Next, we will introduce the details of correlating value creation and value proposition elements.

Asset or resource optimization most frequently co-occurred with *reduced pollution*, *reduced resource use*, and *improvement for the environment* in terms of societal value propositions. For example, Lease-Green, a firm that provides services for improving the energy efficiency of buildings, highlights that it had reduced with its project "around 120,000 tons of CO_2 over their life cycles." In relation to customer value, **asset or resource optimization** was proposed to lead to *increased revenue*, *cost savings*, and *time savings*. Thus, the customer value propositions were proposing heavily lean towards quite traditional value perspectives.

In **product as a service**, the most frequently co-occurring societal value propositions were *reduced resource use*, *health benefits*, and *extended product life cycle*. Thus, a social dimension of value from the triple bottom line approach can be identified in this type of value creation activities. Often, the firms of this type were linked to transportation services and proposed that their services could make customers more engaged in physical exercise by opting for service-based transportation rather than use of private cars. The most frequently co-occurring customer

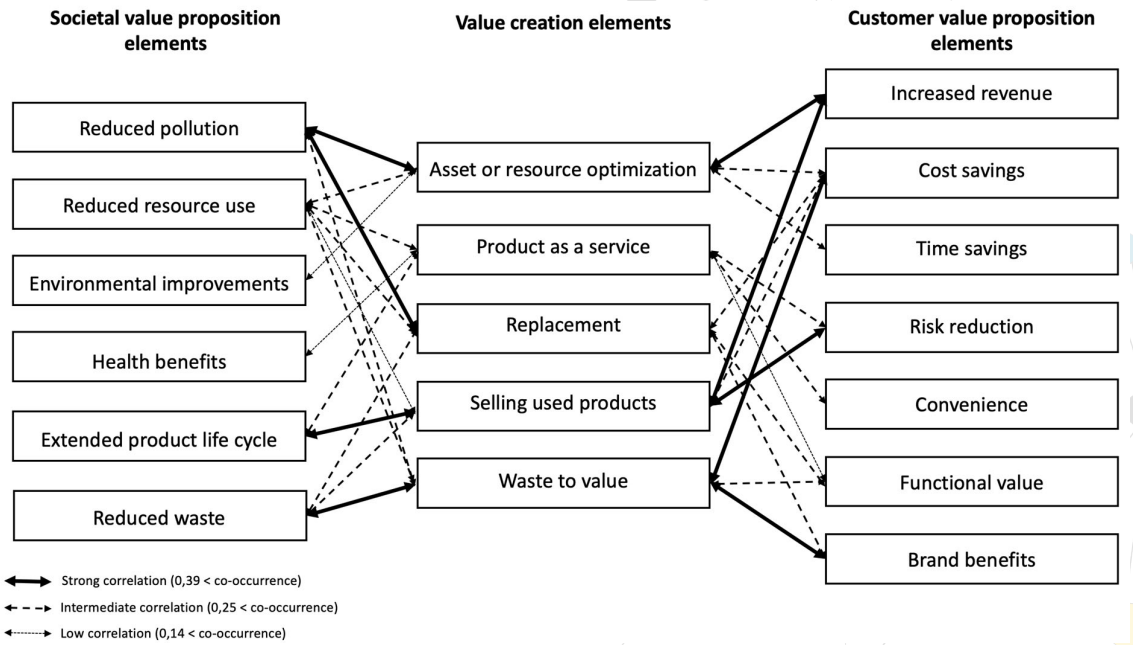

Figure 2. Correlating value creation and value proposition elements.

value propositions were *risk reduction*, *convenience*, and *functional value*, indicating that firms involved in these activities are primarily not focused on directly measurable economic benefits for the customer but rather on providing convenient services that the customers can easily switch to. For example, Lindström provides work clothes as a service and highlights in their value proposition that "customers have easy access to clean, serviced, safe clothes that meet the required quality standards."

In **replacement**, *reduced pollution*, *reduced waste*, and *reduced resource use* co-occurred most frequently as societal value propositions. For example, CrossLam, a company replacing concrete elements with wooden elements in construction industry, states that "traditional concrete construction produces plenty of carbon dioxide emissions and consumes a lot of energy and resources" as opposed to wooden elements, which "commit carbon to buildings and reduce atmospheric emissions." In relation to customer value, these types of value creation elements co-occurred most frequently with *functional value*, *cost savings*, and *brand benefits*, which indicates that they rely on customers who are not expected to make decisions solely based on economic value.

In **selling used products**, *extended product life*, *reduced waste*, and *reduced resource use* were, perhaps not surprisingly, the most frequently co-occurring societal value propositions. In terms of customer value, *risk reduction*, *increased revenue*, and *cost savings* occurred most frequently, all representing economically oriented value dimensions, which is an interesting finding in comparison to activities associated with *replacement*.

In **waste to value**, the most often co-occurring societal value propositions were *reduced waste*, *reduced pollution*, and *reduced resource use*, whereas, *brand benefits*, *cost savings*, and *functional value* were the most frequently co-occurring customer value dimensions. While increased recycling is the most traditional way to improve the circularity of materials, our findings indicate that recycling types of business activities do not only conform to traditional economic value because brand benefits implicate value emerging from a perception of sustainability. For example, Fortum, which produces plastic products from waste plastics, states in its value proposition that "by producing a product with a lower carbon footprint, the customer improves their brand and public image."

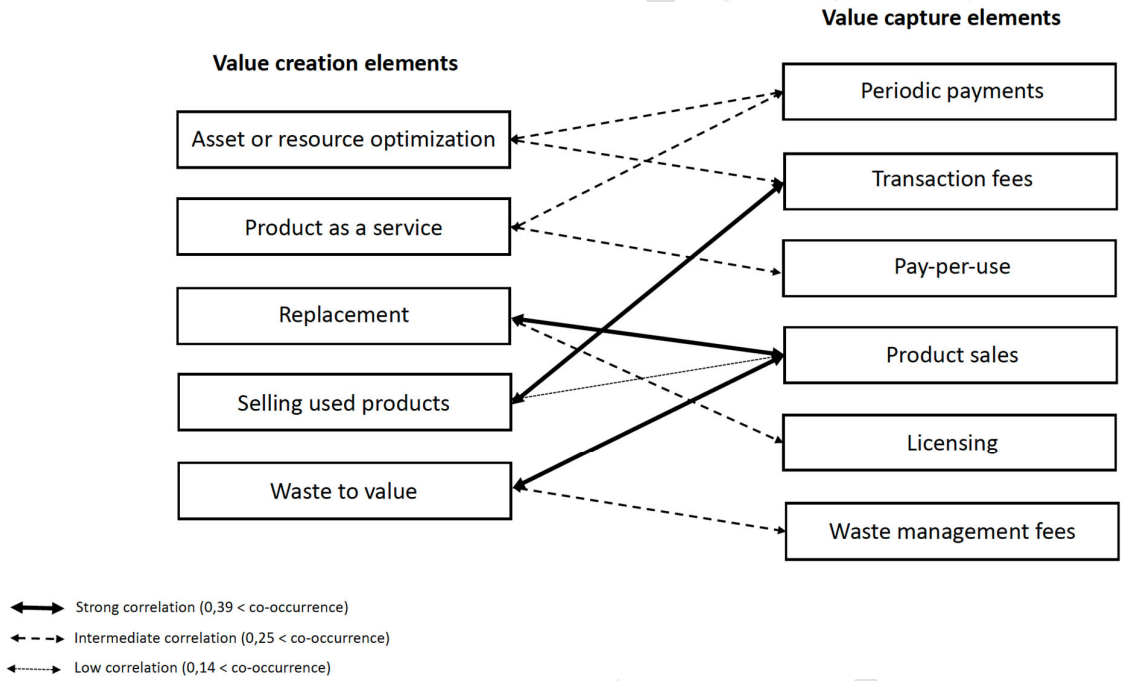

Figure 3. Correlating value creation and value capture elements.

Identified links between value creation and value capture elements

We now answer to our third research question: what types of value creation and value capture elements are complementary with each other? In figure 3, we show correlating value creation and value capture elements of the studied companies' business models. Again, details of co-occurrences are presented in Appendix B.

Asset or resource optimization most frequently co-occurred with *periodic payments* and *transaction fees*, implying that service-type value capture mechanisms are most suitable to include in a circular business model with optimization activities. **Product as a service** was frequently linked with *periodic payments* and *pay-per-use*, showcasing again service-based value capture mechanisms with a product-related offering. **Replacement** most frequently co-occurred with product sales and licensing, implying that these types of value creation activities, while from the customer value perspective being diversified from traditional economic value, are grounded in the creation of improved products and technologies with little focus on services.

Selling used products was typically combined with *transaction fees* or *product sales*. This reflects the two major pathways of organizing a business model around used products, either through a platform that only facilitates transactions or through a system of acquiring and selling onward used products. For example, eRENT, a company providing a platform for sharing and tracking machines, states that they "receive commission on the rental transactions carried out through the portal," whereas Swappie, a company selling used phones, bases their revenue logic on "the revenue earned from the resale of phones." From these two options, the model of facilitating trade through a platform was more frequent in the dataset. **Waste to value** types of value creation activities most often co-occurred with *product sales* and *waste management fees*. In these business models, value is made through extended utilization of recycled raw materials or selling of refurbished products.

Correlations between the value creation elements

In addition to identified links between value creation, value proposition and value capture elements,

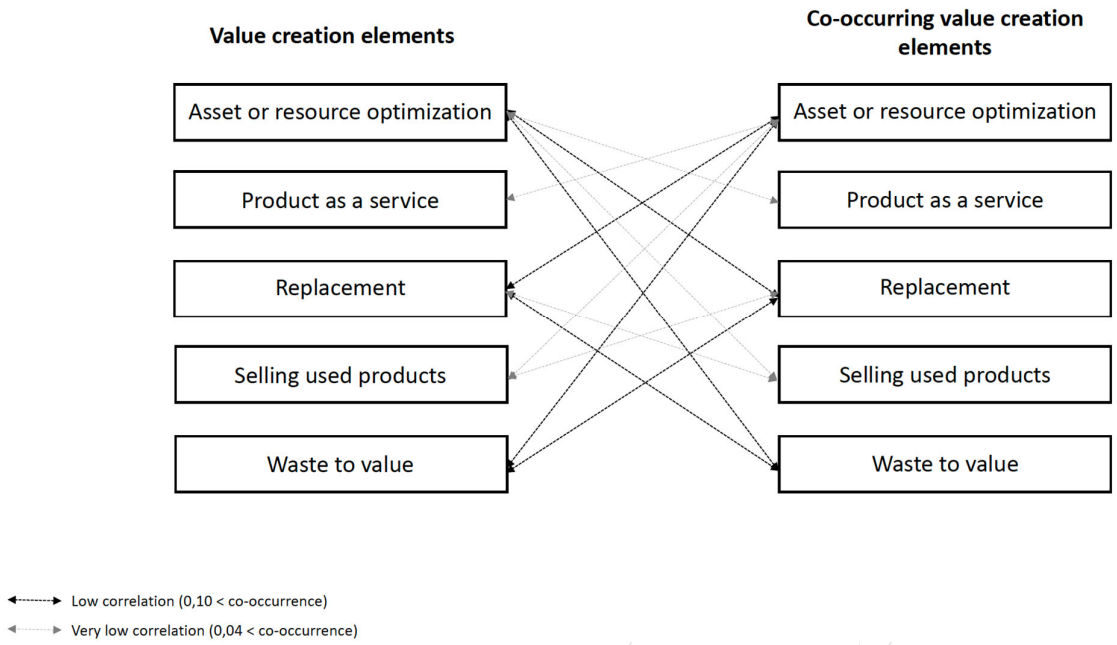

Figure 4. Co-occurring value creation elements.

we identified low and very low (0,04<co-occurrence) correlation between different value creation elements. In figure 4, we present mapping of these correlations. Detailed co-occurrences between these elements are presented in Appendix C.

From the co-occurrences of the value creation types, it can be seen that while the co-efficients are comparatively smaller than for the other business model elements – as every business model did not have co-occurring value creation types – co-occurrence is still present in the cases. In fact, **asset or resource optimization** co-occurred with each of the other value creation elements, indicating that optimization can be applied to all major types of circular business models. Surprisingly, **product as a service** only co-occurred with **asset or resource optimization**, in cases such as Valtavalo, where lighting was sold as a service instead of light bulbs to business customers, leading to the optimization of electricity usage. **Product as a service** was also the rarest value creation type in the entire dataset with 11 cases, which suggests that selling products as services is a relatively uncommon approach to circular business model.

Discussion and Conclusions

Our research highlights the importance of complementarity between the elements of circular business models. The key question is not how different business model elements fit together, but how elements can strengthen each other. Our study suggests that the role of business model complementarity needs to be considered in the future development of more ambitious circular business models more strongly than what has happened before. Increased complementarity may provide context-specific flexibility and adaptability; and when complementarity is considered from the very beginning of business model development, it can open completely new opportunities for innovating between different combinations of business model elements. It is important to note, however, that complementarity between the business model elements alone does not guarantee the performance of the company nor it automatically provides sustainability-related outcomes.

Of the five value creation elements that we identified, **waste to value** types of strategies were the most frequent in our sample (34 of 92 cases). This finding suggests that while it has been recently

emphasized that the circular economy is not only about recycling (Centobelli *et al.*, 2020; Ferassa *et al.*, 2020; Ghisellini, Cialani and Ulgiati, 2016), restoration of waste to valuable materials and products still is a crucial and relevant practice. At the same time, our findings are in line with other studies that have underlined the meaning of design phases of products where it is possible to ensure that value embedded in raw materials can be restored in latter phases of the value chain (den Hollander, Bakker and Hultink, 2017; Moreno, de los Rios, Rowe and Charnley, 2016).

More generally, our research shows that through well-crafted and co-functional business model elements, circular value propositions for both customers and the society at large can be materialized through different forms of value creation and capture. For example, in our sample, societal value of **reduced resource use** and customer value of **cost savings** frequently correlated with **asset or resource optimization**, **selling used products**, **waste to value**, and **replacement** activities. Based on our findings, it is evident that complementarity between some business model elements is easier to achieve than between some other elements. For example, it seems that **asset or resource optimization** can be applied to all major types of circular business models as a value creation element and this type of optimization can increase both customer and societal value in different situations. **Reduced resource use** related to each of the identified value creation activities, and **cost savings** were also frequently observed.

Our findings show that societal benefits and customer value creation can co-exist, and in that context, we have underlined the role of complementarity between business model elements. At the same time, however, we emphasize that business model complementarity needs to be considered only as one important aspect in the development of circular business models. To create a solid foundation for circular business approaches, it important to constantly evaluate their overall sustainability performance in relation to other approaches, such as the planetary boundaries' perspective (Rockström *et al.*, 2021). It is also notable that our analysis has at least two significant limitations. Firstly, our data describes the problems that studied companies aim to address and the solutions they provide, but it does now not allow deeper analysis of circular activities. Secondly, our data is based on interviews of company representatives, which means that it might not always perfectly reflect activities that companies carry out in diverse real-life situations. We encourage further research on complementarity between the elements of circular business models in different operational contexts and with diverse data sets.

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Appendix A. Basic information about the firms whose circular economy business models were studied

Firm Name	Main business	Established	Employees
3StepIt	IT equipment management	1997	> 250
24Rent	Car sharing	2011	1 - 10
Amerplast	Plastics	1952	> 250
Aquazone	Waste-water treatment	2009	1 - 10
Arctic Biomaterials	Bio-based plastics	2014	10 - 250
Betulium	Biotechnology	2013	1 - 10
BioGTS	Bioenergy	2011	10 - 250
Crisolteq	Industrial waste processing	2005	10 - 250
CrossLam	Construction materials	2014	10 - 250
Destaclean	Recycled construction materials	1998	10 - 250
OP DriveNow	Finance, Car sharing	1902	> 250
Durat	Interior design products	1990	10 - 250
Ecolan	Organic Fertilisers	1995	10 - 250
Eko-expert	Recycled construction materials	1990	10 - 250
EkoRent	Car sharing	2014	1 - 10

Firm Name	Main business	Established	Employees
Ekox	IT equipment management	2015	10 - 250
Emmy Second Hand	Second hand clothes	2015	10 - 250
Enevo	Smart waste management	2010	10 - 250
Entocube	Insect farming technology	2014	1 - 10
eRENT	Equipment sharing platform	2015	1 - 10
Fescon	Materials	1984	10 - 250
Finlayson	Textiles	1820	10 - 250
Finsect	Insect farming	2015	1 - 10
Fluid Intelligence	Industrial maintenance	2016	1 - 10
Fortum	Treatment of hazardous waste	1971	> 250
Gasum	Natural gas, biogas and LNG	1994	> 250
Globe Hope	Textiles	2001	10 - 250
Gold&Green	Food	2015	10 - 250
Helsieni	Urban farming	2016	1 - 10
Infinited Fiber	Textile production technology	2015	1 - 10
Innorent	Movable facilities	2016	1 - 10

Firm Name	Main business	Established	Employees
Jarmat	Chemical products	2000	1 - 10
Kekkilä	Organic Fertilisers	1924	10 - 250
Pääkaupunkiseudun kierrätyskeskus	Sales of second hand products	1990	> 250
Konecranes	Cranes and lifting equipment	1994	> 250
Kotkamills	Paper and cardboard products	1990	> 250
LeaseGreen	HVAC systems	2013	10 - 250
LemKem	Lighting equipment	1985	10 - 250
Lindström	Textile rental	1848	> 250
Lovia	Textiles	2014	1 - 10
Lassila & Tikanoja	Waste management, recycling	1905	> 250
ResQ Club	Platform for selling surplus food	2015	10 - 250
Maapörssi	Service for sales of surplus excavation material	2006	1 - 10
MaaS Global	Mobility as a service	2015	10 - 250
Martela	Office furniture	1945	> 250
Metener	Biomass treatment technology	2001	1 - 10

Firm Name	Main business	Established	Employees
Naava	Intelligent interior green walls	2011	10 - 250
Neste	Oil and renewable fuels	1948	> 250
Netflea	Online second-hand retail	2014	1 - 10
Netled	Vertical farming solutions	2007	1 - 10
Nettix	Equipment sharing platform	2000	10 - 250
Novarbo	Vertical farming solutions	2010	10 - 250
Palpa	Deposit-based bottle return system	1996	10 - 250
Paptic	Bio-based packaging materials	2015	10 - 250
Pa-Ri Materia	Sales of used office furniture	1997	10 - 250
Ponsse	Forest machinery	1970	> 250
Pure Waste	Textiles	2013	1 - 10
Raisioagro	Agricultural feed products	1948	10 - 250
Rakeistus	Recycled fertiliser	2012	1 - 10
Remake	Textiles	2007	1 - 10
Rent-a-Park	Parking services	2013	1 - 10
RePack	Reusable packaging	2011	1 - 10

Firm Name	Main business	Established	Employees
Robbes	Smart greenhouses	2001	10 - 250
ShareIt Blox Car	Car sharing	2015	1 - 10
Sharetribe	Platform for second hand product sales and rentals	2011	10 - 250
Silmusalaatti	Food	2012	1 - 10
Skipperi	Equipment sharing platform	2016	1 - 10
Soilfood	Recycled nutrients and fertilisers	2015	10 - 250
Solnet	Solar power systems	2014	1 - 10
Spinnova	Textiles	2014	1 - 10
SR Harvesting	Recycled spare parts	2010	10 - 250
St1	Oil and renewable fuels	1997	> 250
Sulapac	Biodegradable packaging	2016	1 - 10
Suomen Savupiipputeol-lisuus	Recycled construction materials	2016	1 - 10
Swap	Online second-hand retail	2012	> 250
Swappie	Refurbished phones	2015	1 - 10
Taitonetti	Refurbished computers	2005	10 - 250

Firm Name	Main business	Established	Employees
Tamturbo	Industrial air compressors	2010	10 - 250
Tarpaper	Recycled materials	2013	1 - 10
Tori	Online second-hand retail	2009	10 - 250
TouchPoint	Textiles	2008	1 - 10
Tracegrow	Recycled fertilisers	2012	1 - 10
UPM Raflatac	Adhesive laminates, biocomposites	1975	> 250
Valtavalo	Lighting installations and products	2008	10 - 250
Valtra	Agricultural machinery	1990	10 - 250
Watrec	Industrial biogas plants	2003	10 - 250
Venuu	Marketplace for renting venues	2013	10 - 250
Verhoilijamestarit	Furniture upholstering	N/A	1 - 10
VersoFood	Food	2010	1 - 10
Wimao	Biocomposites	2015	1 - 10
Zadaa	Online second-hand retail	2015	1 - 10
Zenrobotics	Waste-sorting technology	2007	10 - 250

Appendix B. Co-occurrences between value creation, value proposition and value capture elements.

	Societal value proposition elements	Customer value proposition elements	Value capture elements
Asset or resource optimization (n=20)	• Reduced pollution (0,4) • Reduced resource use (0,34) • Environmental improvements (0,25)	• Increased revenue (0,4) • Cost savings (0,38) • Time savings (0,27)	• Periodic payments (0,39) • Transaction fees (0,35)
Products as a service (n=11)	• Reduced resource use (0,28) • Health benefits (0,22) • Extended product life (0,15)	• Risk reduction (0,33) • Convenience (0,32) • Functional value (0,24)	• Periodic payments (0,27) • Pay-per-use (0,27)
Selling used products (n=15)	• Extended product life (0,4) • Reduced waste (0,3) • Reduced resource use (0,22)	• Risk reduction (0,41) • Increased revenue (0,4) • Cost savings (0,35)	• Transaction fees (0,41) • Product sales (0,23)
Replacement (n=24)	• Reduced pollution (0,5) • Reduced waste (0,3) • Reduced resource use (0,29)	• Functional value (0,36) • Cost savings (0,34) • Brand benefits (0,29)	• Product sales (0,48) • Licensing (0,36)
Waste to value (n=34)	• Reduced waste (0,67) • Reduced pollution (0,35) • Reduced resource use (0,27)	• Brand benefits (0,47) • Cost savings (0,47) • Functional value (0,28)	• Product sales (0,65) • Waste management fees (0,26)

Appendix C. Co-occurring value creation types and their Sorensen's co-efficients.

Value creation elements	Co-occurring value creation elements
Asset or resource optimization	• replacement (0,18) • waste to value (0,11) • products as services (0,06) • selling used products (0,06)
Products as services	• asset or resource optimization (0,06)
Selling used products	• asset or resource optimization (0,06) • replacement (0,05)
Replacement	• asset or resource optimization (0,18) • waste to value (0,14) • selling used products (0,05)
Waste to value	• replacement (0,14) • asset or resource optimization (0,11)