Circular business model implementation : Design choices, orchestration strategies, and transition pathways for resource-sharing solutions

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CIRCULAR BUSINESS MODEL IMPLEMENTATION: DESIGN CHOICES, ORCHESTRATION STRATEGIES, AND TRANSITION PATHWAYS FOR RESOURCE-SHARING SOLUTIONS

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Abstract

Prominent political and societal stakeholders argue that business models (BMs) are pivotal in making a successful transition to a circular economy (CE). However, the existing CE literature has paid little attention to design choices that allow companies to implement circular business models (CBMs) that meet the requirements of their specific situations. Resource sharing (alternatively called asset sharing) is a key practice in making the transition to a CE. The present article, therefore, seeks to gain deeper insights into the CBMs of firms that orchestrate resource-sharing solutions. For this purpose, it uses a qualitative multiple case-study approach and analyzes nine firms that orchestrate virtual power plants in Germany and Switzerland. Specifically, the article explores the design choices with which firms are faced when they implement this CBM, and it examines different implementation strategies that flow from making certain design choices. The article also identifies transition pathways that enable firms to move between different implementation strategies in order to increase economic and environmental gains. The present article can serve as a stimulus for further detailed analyses of other BMs that are important to a CE in the future.

Keywords: Circular Business Model; Value Creation and Delivery; Resource Sharing; Circular Economy; Resource Modification; Virtual Power Plant

1. INTRODUCTION

Circular-economy (CE) thinking seeks to minimize virgin-material input as well as waste and emission output without jeopardizing prosperity (Geissdoerfer et al., 2018; Manninen et al., 2018). Many scholars, political institutions, and societal stakeholders believe that business models (BMs) provide a pivotal foundation for transitioning to a CE (Pieroni et al., 2019; Ranta et al., 2018). They reason that companies will make critical contributions to this transition, if they find BMs that make this move economically attractive (Geissdoerfer et al., 2018). Without such BMs, the transition to a CE "will be an uphill battle" (Ranta et al., 2018: 988).

While the CE paradigm goes back to the 1980s, the academic literature on CE began to flourish approximately five years ago (Homrich et al., 2018; Rosa et al., 2019). Since then, this literature has devoted much attention to BMs that incorporate CE thinking (so-called 'circular business models', CBMs) and the managerial implications of implementing CE thinking in firms (Merli et al., 2018). Importantly, the analysis of CBMs has substantial implications for the implementation of CE thinking because firms often incorporate such reasoning into their BM through "a process of mimicry", where the analysis of existing CBMs serves as inspiration for managers who seek to innovate their own BMs (Frishammar and Parida, 2019: 25).

However, previous research has mainly focused on defining and classifying CBMs (e.g., Bocken et al., 2016; Brehmer et al., 2018; Lewandowski, 2016; Lüdeke-Freund et al., 2019; Ranta et al., 2018; Ritter and Schanz, 2019). It has paid little attention to the specific CBMs as implemented by companies and the differences that exist in the implemented CBMs across firms. While its predominantly abstract treatment of CBMs provides a valuable overview of the CE, prominent scholars such as Herman Daly and Nicholas Georgescu-Roegen caution against "fixing attention on abstract principles only, […] in abstraction from social community and biophysical dependence" (Borgström Hansson, 2003: 26). Consequently, the observed imbalance brings several shortcomings to our attention.

First, a knowledge gap can be identified regarding different design choices in the implementation of CBMs – that is, how to design and implement the value proposition, value creation and delivery, and value capture. Such design choices allow firms to innovate and customize a CBM. Since insights into these design choices are valuable but scarce, several scholars have called for a more detailed analysis of CBMs to detect alternative design options (e.g., Bocken et al., 2016; Brehmer et al., 2018; Bressanelli et al., 2018; Leising et al., 2018; Lewandowski, 2016; Urbinati et al., 2017).

Second, asset sharing – alternatively called resource sharing – is an integral component of a CE (Ellen MacArthur Foundation, 2015; Rosa et al., 2019). Sharing otherwise underutilized assets (e.g., cars, tools, lodging) with other actors represents a product-service system (PSS) solution that allows for a more intensive and, hence, resource efficient use of these assets (Homrich et al., 2018; Tukker and Tischner, 2006). Interesting and highly relevant CBMs emerge around asset sharing (Ritter and Schanz, 2019). In most cases, sharing is facilitated by an orchestrator of a sharing network who enables the system of decentralized assets, their owners, and the consumers of their functionality to work together as a harmonious whole (Pitelis and Teece, 2018). However, the issue of how firms implementing sharing-related CBMs can orchestrate the sharing network remains under-researched (Merli et al., 2018; Parida et al., 2019).

Third, scholars have called for a more detailed exploration of CBMs in the business-to-business (B2B) setting and of how different implementation strategies for PSS solutions – which are the most common type of CBMs – lead to different outcomes (Matschewsky et al., 2018; Song and Sakao, 2017). The implementation of CBMs in the complex B2B setting has not been studied to the extent that it merits. The energy sector is a prime example of this research deficit, where the transition from BMs related to fossil fuels needs to be accelerated by implementing alternative and sustainable CBMs. Hence, the energy sector offers an intriguing empirical context to study sharing and resource orchestration in CBMs (cf. Palmié et al., 2019).

Responding to these three calls, the present article presents an in-depth investigation of the main BM dimension that needs to be adapted for resource sharing – that is, the value-creation-and-delivery element. This study investigates how CBMs adopted by orchestrators and the resource providers of asset-sharing solutions differ and how they offer distinct economic and environmental gains. Using a qualitative multiple case-study approach, the CBM transition in the energy industry is explored by examining nine firms that orchestrate Virtual Power Plants (VPPs). A VPP is a network of distributed energy resources typically owned by small- to medium-scaled energy producers and consumers controlled by a central orchestrator (Leisen et al., 2019; Hooshmand et al., 2018).

This article reveals important differences in the way orchestrators and resource providers of asset-sharing solutions create and deliver value. Based on the differences identified, this paper introduces a distinction between four strategies for implementing resource orchestration. Moreover, this study shows how companies can move between orchestration strategies when implementing CBMs.

The article is structured as follows. The next chapter provides the background on sharing and the circular economy as well as on sharing and circular business models. The third chapter describes the empirical setting, data collection, and analysis. The fourth chapter explains the differences identified in value creation and delivery, four implementation strategies that emerge from these design choices, and transition pathways by which companies can move towards the implementation of a particular CBM. The fifth chapter discusses the implications of these findings for the academic literature and management practice. The sixth chapter draws together the conclusions from this study.

2. THEORETICAL BACKGROUND

2.1 Sharing, Decoupling, and the Circular Economy

The modern economic system was built on a linear energy- and material-flow model (*extract-produce-use-dump*), which has proven to be problematic in terms of economic, social, and environmental sustainability (Korhonen et al., 2018b). CE thinking seeks to overcome the limitations of this traditional linear model. It is firmly grounded in practice, with political institutions and non-governmental organizations leading its development and dissemination (see Homrich et al., [2018] and Korhonen et al., [2018b]). Leading sustainability actors such as the Ellen MacArthur Foundation and the United Nations promote the CE as a means to decouple economic development from the degradation of natural capital (Kjaer et al., 2019; Lonca et al., 2019). Following the United Nations Environment Programme (UNEP, 2011), two types of decoupling can be distinguished: resource decoupling, which reduces the utilization of finite resources, and impact decoupling, which reduces the generation of waste, emissions, and other negative environmental impacts (Moutinho et al., 2018; Suarez-Eiroa et al., 2019). Emphasizing decoupling as the ultimate goal of CE thinking has substantial implications for the conceptualization of a CE. The laws of thermodynamics imply that CE-based recovery processes cannot be perfectly efficient and that "both available energy and available matter are irrevocably degraded into unavailable states" during these processes (Georgescu-Roegen, 1986: 7). Thus, the laws of thermodynamics impose limits on decoupling and the effectiveness of CE-based recovery processes (Lonca et al., 2019). Illustrating these limits, the analysis by Schandl et al. (2016) of three scenarios for 13 world regions in 2050 suggests that an absolute reduction of the carbon footprint could be achieved, while no scenario leads to an absolute reduction in the energy and material footprints. In order to maximize the benefits of CE thinking, it is therefore necessary to adopt a broad view of circularity that goes beyond closing resource loops and also includes measures to narrow and slow resource loops – that is, reduce the material throughput of the economic system (Lonca et al., 2019; Moreau et al., 2017). The Ellen MacArthur Foundation proposes the ReSOLVE framework to provide companies with an overview of practices that support the transition to a CE (Ellen MacArthur Foundation, 2015; Manninen et al., 2018). The six practices – presented in greater detail in Figure 1 – are Regenerate, Share, Optimize, Loop, Virtualize, and Exchange.

<< *Insert Figure 1 about here* >>

While CE thinking supports the pursuit of decoupling, not every CE initiative is likely to achieve the goal of reducing resource utilization and/or environmental impact. A CE initiative must meet three criteria in order to result in actual decoupling: (1) It must ensure net resource (and/or impact) reduction; (2) it must avoid burden shifting between life-cycle stages; and (3) it must mitigate rebound effects (Kjaer et al., 2019). Net resource reduction requires that the new, "circular" solution induces less resource consumption (and/or less environmental impact) than the traditional, "linear" solution. Burden shifting between life-cycle stages occurs when the circular solution induces less resource consumption (and/or less environmental impact) during one life-cycle stage (e.g., because it entails a more intensive product use), but its resource consumption (and/or environmental impact) over-proportionally increases in another life-cycle stage (e.g., because the production of a more durable product may require a higher resource input than the production of a less durable one). Rebound effects occur when people spend money they save with the circular solution (e.g., sharing a product may be cheaper than having to buy it) for alternative consumption that involves resource input (and/or environmental impact) that is higher than the reduction achieved by switching from a linear to a circular solution (Kjaer et al., 2019). Since it seems likely that the way in which CE initiatives are implemented affects the extent to which they meet these criteria, these requirements underscore the relevance of studying CE implementation.

Similar to practice-oriented accounts, the academic literature also displays a broad understanding of CE, which has caused some fragmentation in how CE has been conceptualized in this literature (Homrich et al., 2018). To overcome this fragmentation, Korhonen et al. (2018a) have recently developed a "new scientific definition" of CE, which states that CE "maximizes the service produced from the linear nature-society-nature material and energy throughput flow" (Korhonen et al., 2018a: 39). Korhonen et al. (2018a) point out that such maximization involves a new form of consumption, in which actors do not consume the functionality of products owned by themselves but *share* the use of a product's functionality. This emphasis on the utilization instead of the ownership of products is not new but has for long existed in some of the original texts on CE (e.g., Stahel, 1982).

Notwithstanding some variety in the scholarly definitions of CE, asset sharing emerges as a cornerstone of CE thinking in both academic and practice-oriented treatments. Hence, a CE can be characterized as a "functional service economy, unlinked to individual ownership" (Merli et al., 2018: 718). Companies that wish to compete successfully in such an economy and make a contribution to decoupling will likely have to alter their BM fundamentally (Urbinati et al., 2017).

These delineations have two major implications for studies that investigate the contribution of firms to decoupling and the transition to a CE. First, asset sharing, corresponding BMs, and the implementation of sharing-related BMs are essential topics for such studies. Second, decoupling and CE are anchored in a macroeconomic perspective – these concepts were mainly developed to assess and improve the sustainability of countries, regions, and sectors. Hence, investigating the contribution of firms faces "an old problem in social theory, i.e. the question of how to combine studies of social systems with an understanding of agency" (Borgström Hansson, 2003: 50). The concept of lifeworld can provide a basis for tackling this problem (Borgström Hansson, 2003). The lifeworld is "the transcendental site where [… people] meet" (Habermas, 1987: 126); it provides a "social setting for action" (Baxter, 1987: 73) that is less abstract than the macroeconomic view and a meaningful perspective to analyse specific BMs. Since the administrative and economic systems are dependent upon and grounded in this "sphere of action" (Baxter, 1987: 73), the lifeworld "defines the pattern of the social system as a whole" (Habermas, 1987: 154). Thus, paying attention to "concrete places[, …] interpreted as specific places that are appropriated by humans […], in contrast to general statements and abstract debates about place or places" can lead to a better understanding of macrosystems and the context in which CBMs are executed (Borgström Hansson, 2003: 27). The present article, therefore, analyzes how specific firms have implemented sharing-based BMs for the CE and what differences emerged in the implementation.

2.2 Sharing and Circular Business Models

A BM articulates how the focal organization will convert resources into economic value (Ritter and Schanz, 2019; Teece, 2010). It links the technical/physical domain and the economic domain of an organization (Pieroni et al., 2019). Fostered by the emergence of e-commerce, the BM concept became popular in the 1990s and proved very useful in planning, structuring, communicating, and analyzing how a business works (Geissdoerfer et al., 2018; Zott et al., 2011). Designing and implementing promising BMs is now considered a strategic priority for managers (Chesbrough, 2010; Urbinati et al., 2017).

A BM describes *what* an organization offers to its clients (its value proposition), *how* it creates, produces, sells, and delivers the value proposition (value creation and delivery), and *why* it expects to benefit from engaging in the above value-creation and value-delivery activities and from offering the suggested value proposition (value capture) (e.g., Dentchev et al., 2018; Ritter and Schanz, 2019). To innovate their BMs – for example, in order to transform them into 'circular business models' – companies do not need to change all of these elements but can selectively alter one or two of them (e.g., Ciulli and Kolk, 2019; Nussholz, 2018).

The term 'circular business models' designates BMs that are suited to the Circular Economy because they reduce resource input into the organization and its value network and/or minimize waste and emission leakage from the system (Geissdoerfer et al., 2018). While BMs concerned with asset sharing form an integral part of CBMs (Bocken et al., 2016; Merli et al., 2018), the systematic literature review by Merli et al. (2018) concludes that other CBMs have been studied much more extensively.

Since asset sharing and many other CBMs are based on a product-service system (PSS) rather than traditional product sales (Ritter and Schanz, 2019; Urbinati et al., 2017), they differ fundamentally from linear BMs in the way in which they create and deliver value (Geissdoerfer et al., 2018; Nussholz, 2018). Asset sharing represents a particularly intriguing case of value-creation-and-delivery activities because its PSS involves numerous elements – decentralized assets, their owners, and the consumers of their functionality. Due to their complexity, asset-sharing systems are likely to benefit from orchestration (Parida et al., 2019). Orchestrating asset-sharing networks refers to making selected technologies, actors, and resources work together harmoniously across organizational boundaries and geographical distances (Pitelis and Teece, 2018). The way in which the asset-sharing network is orchestrated defines the way in which it creates and delivers value. Firms that adopt the orchestration of asset sharing as a BM offer the value proposition to expand the value created by the network and try to capture some of this value for themselves (Dhanaraj and Parkhe, 2006). It can be expected that the way in which these firms orchestrate the asset-sharing network affects how much economic and environmental value is created by the network. In other words, the design of the value-creation-and-delivery element is likely to affect the amount of value created. The present article seeks to understand the design by which the orchestrators of asset-sharing networks intend to create and deliver this value.

3. DATA AND METHODS

3.1 Case study method

Given the exploratory nature of this research, a case-study approach in the tradition of Eisenhardt (1989) and Yin (2009) was chosen. As recommended by Eisenhardt (1989), a multiple case study was conducted to facilitate a cross-case analysis so that the similarities and differences in the BMs of firms that orchestrate resource-sharing solutions could be detected. Overall, nine companies were identified and contacted. Data was collected from multiple data sources to triangulate and corroborate the results (Eisenhardt, 1989; Yin, 2009). The main and primary data sources are 40 semi-structured interviews with executives from companies that act as resource orchestrators in a VPP. Table 1 gives an overview of the nine case companies.

<<< Insert Table 1 around here >>>

3.2 Empirical setting and case selection

The energy sector offers an intriguing empirical context to study sharing and resource orchestration in CBMs for two reasons. First, energy systems are currently undergoing fundamental changes in response to decarbonization efforts, sustainability goals, and the nuclear phase-out in many regions around the world (European Climate Foundation, 2010; Hillman et al., 2018). These changes affect the nature, ownership, and geographic dispersion of power production sites (Bergek et al., 2013). VPPs integrate various actors with their distributed renewable energy resources and flexible energy demands, which is crucial for a reliable, high-quality, low-cost energy supply (Nosratabadi et al., 2017). While the actors that enter their distributed energy resources into the VPP's resource pool maintain ownership of these resources, they give control over them to a central entity that acts as the orchestrator of the VPP (Hooshmand et al., 2018; Leisen et al., 2019). Thus, VPPs represent a fruitful setting for research on resource sharing and resource orchestration across firm boundaries.

Second, energy plays a major role in decoupling and in the transition to a CE. At first sight, it may seem counter-intuitive to consider energy in the context of a CE because, strictly speaking, energy cannot be recycled (Korhonen et al., 2018a). Since energy moves unidirectionally from high to low temperature or from a concentrated to a dispersed condition (Hussen, 2004) and "you can't burn the same lump of coal twice" (Daly, 1997: 273), some actors suggest that "energy should not be part of the circular economy" (Kovacic et al., 2019: 22). However, CE thinking ultimately seeks to decouple economic growth from environmental impact (Ghisellini et al., 2016) and renewable energies are key to this end (Moutinho et al., 2018; Pao and Chen, 2019). Many accounts, therefore, consider replacing conventional with renewable energies to be a core element of the transition from linear to CE thinking (e.g., Geissdoerfer et al., 2017; Korhonen et al., 2018a). The Ellen MacArthur Foundation (2013) even calls the idea of fueling the CE with renewable energies one of the three basic principles underpinning the CE. In this sense, VPPs are not only built on CE thinking and provide valuable insights into resource sharing and resource orchestration across firm boundaries, but also provide a crucial foundation for the entire CE.

The cases were selected based on theoretical sampling with maximum variation in order to gain broad insights into the orchestration of VPPs. Companies were chosen that engaged in Virtual Power Plants and faced the challenge of finding ways to orchestrate distributed energy resources (DER) across firm boundaries. Moreover, the aim was to cover a variety of companies in terms of their maturity and experience with the concept of VPP so that development stages and maturity levels could be uncovered. Consequently, the VPP operators in the sample differ in the number of actors whose resources they orchestrate and in the number of years they have gained experience in operating a VPP. To avoid confounding effects rooted in divergent regulatory regimes, all VPPs in the sample are situated in Germany and Switzerland (Ferri et al., 2016; Gugler et al., 2013). In total, 22 companies operating VPPs were contacted. Of those 22 companies, nine agreed to be interviewed and to grant access to confidential information.

3.3 Data collection

Data collection occurred in two phases. The first phase focused on the case companies in their role as operators of VPPs. Seventeen interviews, either face-to-face or by telephone, were conducted, lasting between 35 and 90 minutes. The interview respondents were mostly in senior roles either supervising the strategic direction of the company or designated to lead resource-sharing activities. After a first round of coding, 23 follow-up interviews were conducted. The interview guideline was continuously updated for subsequent interviews based on novel insights gained from earlier interviews (Siggelkow, 2007). With one exception, all interviews were recorded on tape and transcribed afterwards, generating 127 pages of primary interview data. Additionally, access was granted to internal data sources (e.g., organizational charts, presentations, and memos) and further data were collected from external sources, resulting in a total of more than 160 pages of material in addition to the 127 pages of interview transcripts.

In the second phase of data collection, interviews were conducted with the actors whose resources are shared via the VPP. The authors decided to conduct subsequent interviews to validate the findings from the first round and to add additional data to the study. To obtain access to these resource providers, the nine VPP operators of the first data-collection phase were asked for their assistance in identifying such actors. Five resource providers who were identified in this way were willing to participate in an interview. To enrich the data set, additional providers of renewable energy resources were contacted via e-mail and telephone. Of the 52 providers of flexible energy production sites contacted in this step, 32 replied. From these 32 respondents, 15 were engaged in a VPP. Two of them were willing to be interviewed. Adding these two to the five willing contacts provided by the case firms yielded seven resource providers for interview (with two follow-up interviews) in addition to the nine VPP operators. Table 2 provides an overview of the case companies interviewed.

<<< Insert Table 2 around here >>>

3.4 Data analysis

The data collected were independently coded and analyzed by the authors and two research assistants (Mayring, 2007). The analysis was performed using *Atlas.ti* software. The triangulation of interview data with internal and external data alleviates recall and rationalization bias and enhances the consistency of the results (Davis and Eisenhardt, 2011). Phrases and sentences in all data sources were analyzed by means of open coding, searching for and categorizing meanings attributed to resource-sharing and orchestration activities as well as CBMs. As suggested by Siggelkow (2007), the data analysis was conducted iteratively with feedback between the data and the emerging themes (Locke, 2001; Miles and Huberman, 1984). In the beginning, the general interest tended towards the firm's perspective on resource sharing and on the roles of the actors involved. However, the topic of different resource-orchestration activities emerged very early in the analysis. Consequently, the subsequent interviews covered more specific questions on this topic. Reflecting the increasing focus, the initial coding scheme included such themes as prosumers and regulatory stakeholders, whereas the final coding scheme centered predominantly on resource-sharing and resource-orchestration activities. Every statement was paraphrased and compared to gain a better understanding of how the respondents perceived the world (Locke, 2001), and the results were compared using a cross-case analysis (Eisenhardt, 1989). This holistic and embedded approach facilitated in-depth insights into the subject and allowed general activities to be deduced (Yin, 2009).

4. RESULTS

The investigation presented in this article yields three core findings. First, the value-creation-and-delivery element of sharing-based CBMs can be configured along two main dimensions: resource modification ('no or little' vs. 'substantial') and actor interaction ('low' vs. 'high'). Second, the potential combinations of these two design choices (substantial/little resource modification and high/low actor interaction) entail four distinct implementation strategies for resource orchestration.

Third, companies can move along these four different orchestration strategies by following two paths depending on their initial set-up.

4.1 Two principal dimensions of value creation and delivery in CBMs

Geissdoerfer et al. (2018) note that "arguably [the] biggest difference between conventional business models and those designed for the CE lies in their value creation and delivery element", particularly in the coordination of the actors involved (p. 713). Hence, the value-creation-and-delivery element represents a cornerstone in developing and understanding circular BMs. The data in this study support this view, as all case companies interviewed by the authors unanimously stated that the value-creation-and-delivery element is crucial in managing the transition from linear business models to CBMs. Furthermore, the respondents indicated that they found the implementation of asset-sharing solutions and the associated alteration of the value-creation-and-delivery dimension of their BM challenging. However, many of the perceived challenges, such as reconfiguring internal processes, were alleviated by harvesting solutions from digital technologies. This is associated with different ways in which orchestrators and resource providers use digital technologies to facilitate resource sharing.

An in-depth analysis of *how* resource sharing was facilitated revealed that, for the most part, two dimensions of the value-creation-and-delivery element need to be reconfigured. On the one hand, it must be decided to what extent resources are modified before they are shared. Such differences can be classified as an *as-is* vs. a *to-be* mode of resource sharing, where the *as-is* mode implies 'no or little' resource modification and the *to-be* mode 'substantial' resource modification. On the other hand, the companies that are sharing their resources need to determine the desired pattern of human involvement and personal coordination, which can be subsumed under low or high actor interaction. The following paragraphs offer a more detailed explanation of resource modification and actor interaction. Figure 2 provides an overview of the emerging codes from the analysis.

<<Insert Figure 2 about here >>

4.1.1 Resource modification

The data in the sample infer that the extent to which resources are modified before they are shared varies considerably. *As-is* resource sharing means that the resource is not substantially modified before it is entered into the resource pool; it is taken 'as it is'. In contrast to *as-is* resource sharing, *to-be* resource sharing relies on modifying the resource substantially before sharing it. For example, changing the control unit of a power plant so that it can be remotely controlled by the VPP orchestrator represents a typical modification in the *to-be* mode.

Frequently, resource modification can be described as the digital enhancement of the resource. Digital technologies are used to digitally enable the resource to create interfaces with the orchestrator and with other resources in the resource pool. Since digitally enabling/enhancing a resource involves modification of the resource, it can be counted as *to-be* resource sharing. The data underlying the present article indicate that, overall, digital technologies tend to play a less prominent role in the *as-is* mode than in the *to-be* mode. Moreover, resource providers tend to experience lower psychological hurdles to engage in *as-is* resource sharing than in *to-be* resource sharing. However, *as-is* sharing often requires a higher level of actor interaction to coordinate the sharing of the resource.

Besides deciding whether to modify the focal resource that is shared among the different actors, the findings suggest that companies modify other resources to facilitate sharing. In this case, resource providers can choose between standardization and/or customization of their communication channels, controlling and coordination systems, contracts, technologies, and technological equipment. Standardization requires the resource providers to adapt their resources to the standards specified by the resource orchestrator. Creating such standardized interfaces between the resource provider and the orchestrator allows for an easier mode of entry to the sharing community. On the other hand, customization allows for more degrees of freedom for the resource providers, enabling them to adapt the resource sharing to their needs. Furthermore, customization creates higher entry barriers as customization requires balancing and coordinating the needs and resources of the other resource providers in the pool, which makes customization ultimately more complex.

4.1.2 Actor interaction

Interaction between the orchestrator, the resource providers, and the other actors in the resource pool mostly takes place through personal exchange. The degree of actor interaction manifests itself in the variety of communication channels used by actors in the VPP network (e.g., online platforms, e-mail, telephone, instant messaging, and face-to-face meetings) and in the number of distinct contacts between the different actors and the orchestrator (i.e., the frequency of interaction). Whereas some orchestrators stressed their desire to keep personal interaction with the resource providers to a minimum, others preferred personal exchange on a frequent basis, stating that they regularly contacted their customers via telephone.

In addition to direct interaction between actors, digital technologies can be used to facilitate the interaction, especially the communication, between the orchestrator and the resource provider. The most extreme case would be a replacement of human communication by machine-to-machine communication. As automatically controlled machine-to-machine interaction reduces human involvement, resource interaction can be a cost-efficient substitute for actor interaction in some situations. Interestingly, however, in this respect, the data show no uniform move towards more and more automated and less personal interaction. On the contrary, some orchestrators increased the level of personal interaction with resource providers over time as suggested by the findings. The orchestrator of Case D, for instance, made a switch from the initial mode of actor interaction, which took place via a web-based app, to a much more intensive mode of interaction involving regular phone calls with the actors.

Furthermore, personal interaction can lead to loyalty and a better understanding of the partner's needs and wishes. Orchestrators, in addition, stated a preference for a higher level of personal interaction over a higher level of machine-to-machine exchange if the decentralized resources were not yet able to perform the corresponding machine-to-machine exchange and the cost of enabling them would require a substantial investment. Completing the required interaction through personal instead of machine-to-machine exchange is a way of keeping the level of investment required to share resources low. Thus, the willingness to engage in more personal interaction can reduce the necessity to invest in resource modification.

4.2 Four Implementation Strategies for CBM Orchestration

The above analysis suggests a distinction between 'no or little' vs. 'substantial' resource modification (*as-is* vs. *to-be* resource sharing) and between a 'low' vs. a 'high' degree of actor interaction. A more detailed examination of how these design choices in the value-creation-and-delivery dimension are combined led to the identification of four distinct strategies for orchestrating resource sharing. The four orchestration strategies can be termed *Lean Orchestration* (no or little resource modification and low actor interaction), *Resource-Driven Orchestration* (substantial resource modification and low actor interaction), *Actor-Driven Orchestration* (no or little resource modification and high actor interaction) and *Dual Orchestration* (substantial resource modification and high actor interaction).

The data collected revealed that VPP operators and resource providers anticipated various economic and environmental benefits when they choose from the four implementation strategies and that the four implementation strategies differ in the inputs they require. Relevant resource inputs are matter and energy as well as labor (Georgescu-Roegen, 1979). With respect to economic performance, the BM literature identifies economies of scale and economies of scope as major drivers of profitability (Casadesus-Masanell and Tarzijan, 2012). The four implementation strategies are indeed likely to differ in the extents to which they entail economies of scale and economies of scope, respectively. Finally, the environmental output of the four orchestration strategies can be described in terms of the three criteria that determine whether a CE initiative results in actual decoupling. Environmental output is thus affected by the extents to which the respective strategy (1) leads to net resource (and/or impact) reduction, (2) avoids burden shifting between life cycle stages, and (3) mitigates rebound effects (Kjaer et al., 2019).

Georgesu-Roegen (1971) argued that mathematical analyses can "subserve legitimate needs of understanding" (p. 331) and impose the vice of "ignoring altogether the qualitative factors that make for endogenous variability" (p. 335). The present study therefore analyzes the potential economic and environmental impact of the four implementation strategies in qualitative terms. Georgescu-Roegen (1972) argues that such an effort should explicitly specify the starting point of the analysis (p. 256). In the present study, the DERs already exist and the analysis begins as they are becoming a part of a VPP. Table 3 provides an overview of the four implementation strategies and the analysis of their potential economic and environmental impact. Each strategy will be described in further detail in the following section.

<< Insert Table 3 about here >>

4.2.1 Lean Orchestration

Lean Orchestration enables sharing by combining little resource modification with low interaction between actors. This strategy is characterized by a small number of actors, who are typically situated in a geographically confined area. The companies interviewed repeatedly pointed out that they wanted to build showcases for which substantial resource modifications would not be required, building on the idea of a 'Minimum Viable Product' from the lean-startup methodology (Blank, 2013). This strategy principally involves solving technical issues between the partners to facilitate sharing without having to invest too much in resource modification. The personal interaction between the orchestrator and the resource providers covers several technological iterations, during which the trust between the two parties gradually increases.

This strategy is mostly pursued by companies that have no prior experience in resource-sharing activities or that wish to collaborate with resource providers with whom they have already established prior relationships from other joint activities. In this study's sample, the companies adopting this strategy were mostly small businesses that wanted to explore new options for value creation by sharing excess resources.

This strategy requires little input of energy and matter since the DERs are entered into the VPP's resource pool as they are. It also does not need a lot of input in terms of labor because the VPP network is rather small, which eases coordination. This strategy offers some economies of scope as VPP operators can leverage existing contacts they have with local customers. However, it does not offer much potential for economies of scale due to the geographically confined area in which the sharing occurs. Due to the small size of the sharing network, the net resource reduction this strategy can achieve is also quite limited. Moreover, this strategy does not possess an inherent measure against rebound effects. On the upside, this strategy avoids burden shifting to other life-cycle stages because it does not require up-front resource modification. Moreover, its local character reduces the need to install long-distance transmission infrastructure.

4.2.2 Resource-Driven Orchestration

Resource-Driven Orchestration combines substantial resource modification with low interaction between actors. The underlying characteristic of this strategy is the notion that low interaction between actors is essential if resource orchestration is to be viable in the long run. Therefore, companies turn to resource modification to foster the automation of orchestration. To determine a combination of resources that yields the highest value, companies typically engage in a pre-phase. During this phase, they seek to increase the compatibility of resources in the network, develop proprietary technological standards, and learn best practices for resource orchestration. A downside of this strategy is limited flexibility because the resources of the partners have been harmonized based on network-specific standards. In the absence of generally accepted technological standards, some companies purposefully attempt to increase the compatibility of their resource pool with the resource pools of other VPPs.

The analyzed data suggest that *Resource-Driven Orchestration* is often used by relatively big national or international players. The case companies reported that they have a history of very specialized knowledge (e.g., running nuclear power plants) and that following this strategy allows them to exploit such proprietary knowledge. These big companies have not been used to interacting extensively with external actors in the past; consequently, they prefer low levels of actor interaction.

The amount of matter and energy input required to implement this strategy is very high. Matter and energy have to be spent on the modification of resources and the automated machine-to-machine communication consumes some additional energy. However, automation restricts the amount of labor input required for orchestration. This strategy can be very attractive economically as it can be used to orchestrate large sharing networks (allowing for economies of scale) and because the VPP orchestrators opting for this strategy can typically leverage synergies with their core business (thereby realizing economies of scope). The environmental impact of *Resource-Driven Orchestration* varies substantially across cases. The matter and energy input required for the resource modification up front places *Resource-Driven Orchestration* at an initial disadvantage, which needs to be overcome subsequently for the strategy to yield environmental benefits. In other words, this strategy involves some burden shifting, where the prospect of more sustainable energy production and consumption during the operation of the VPP comes at the expense of an initial negative impact. A potential problem for the overall environmental impact can emerge when a particular resource modification is useless outside of the specific sharing network and the DER remains in the sharing network only briefly. However, in the long run, *Resource-Driven Orchestration* can result in a strong net resource reduction because of the large size of the sharing network that can be orchestrated with this strategy. Finally, this strategy, too, does not possess an inherent measure against rebound effects.

4.2.3 Actor-Driven Orchestration

Actor-Driven Orchestration combines minimal resource modification with high actor interaction. The idea of keeping entry barriers low in order to attract as many actors and resources as possible is often the driving force behind the adoption of this strategy. Therefore, it refrains from insisting on substantial resource modifications so that no significant *a priori* investment is needed to enter the resource pool. The large number of actors necessitates frequent interaction and the utilization of multiple communication channels (such as online platforms, e-mail, and telephone) to foster interaction between the orchestrator and the resource providers. Orchestrating resource sharing among many actors without adapting the resources to this end requires the orchestrator to be highly responsive and accessible.

The analyzed data indicate that the *Actor-Driven Orchestration* strategy is frequently adopted by smaller energy firms. Smaller firms seem to find it is easier to interact extensively with a variety of actors.

This strategy requires little input of energy and matter as the DERs are entered into the VPP's resource pool as they are. However, the extensive interaction of actors means that the labor input is very high. While labor costs can reduce the economic attractiveness of this strategy, it entails the potential for economies of scope and scale. Economies of scope are enabled by the great variety of value propositions that can be offered when actors interact extensively. A greater variety of value propositions typically attracts more potential customers and stimulates network effects, thereby enabling economies of scale. Network effects and a growing customer-base further fuel a higher net resource reduction. Since *Actor-Driven Orchestration* does not require substantial modification up front, it avoids burden shifting across lifecycle stages. Finally, the pronounced actor interaction can provide "social control", which may prevent rebound effects. Overall, *Actor-Driven Orchestration* is quite attractive from an environmental perspective.

4.2.4 Dual Orchestration

The most complex strategy of resource sharing that emerged from the current analysis is *Dual Orchestration*, which combines substantial resource modification with high interaction between actors. Since the orchestrator and the resource provider are willing to modify the resources, those resources can be digitally enabled/enhanced to facilitate swift orchestration. Thus, a key characteristic for such orchestration is machine-to-machine communication to facilitate sharing. At the same time, the orchestrators value the personal interaction with the parties involved because it creates user loyalty and helps the orchestrator to better understand their demands and wishes. Personal communication also allows the orchestrator and the resource owners to exchange ideas and know-how. Due to the increasing role that technology plays in this strategy, *Dual Orchestration* was viewed by most respondents as the long-term strategy around which they sought to develop their resource-sharing network. However, except for two case companies, no company has yet ventured in this ambitious direction. While no clear pattern emerged from the data regarding the types of company that prefer this type of orchestration, it can be inferred that small, local companies with limited financial resources are rather unlikely to pursue this challenging strategy because they lack legitimacy and the necessary means.

Implementing *Dual Orchestration* requires significant input of labor, energy and matter. The extensive interaction of actors is labor-intensive, while matter and energy have to be spent on the modification of resources and the automated machine-to-machine communication consumes energy. *Dual Orchestration* may imply some economies of scope as it combines the respective advantages of *Resource-Driven Orchestration* and *Actor-Driven Orchestration*. The combination of a deep understanding of customer demands and desires, enabled by extensive actor interaction, with the technology-based potential to coordinate large networks supports economies of scale. The combination of automation and actor interaction further supports the optimization of the sharing solution and the minimization of system-level inefficiencies, thereby contributing to a high net resource reduction. A large sharing network further adds to the amount of net resource reduction.

However, the initial input of matter and energy to modify the resources implies burden shifting from the operating phase to the initiation phase, which could be problematic if resources are withdrawn from the sharing network quickly. On the upside, the extensive actor interaction may provide social control that can mitigate rebound effects.

4.3 Pathways for Transitioning between CBM Strategies

The data analysis shows that companies implementing CBMs – specifically, resource-sharing business models – have frequently moved between orchestration strategies when seeking to realize the full potential of those solutions. Further data analysis illuminates such movements between strategies when implementing CBMs. The data indicate that the companies more regularly move from low-actor interaction strategies to high-actor interaction strategies. In contrast, moving from low resource modification to substantial resource modification is rather less common (see Figure 3).

<< Insert Figure 3 about here >>

4.3.1 Moving from Low Actor-Interaction Strategies to High Actor-Interaction Strategies

The analysis of the data indicates two main patterns: Companies that engaged in *Lean Orchestration* are mostly moving into *Actor-Driven Orchestration* while companies pursuing *Resource-Driven Orchestration* are more likely to move into *Dual Orchestration*.

The respondents from the case-study companies that were involved in *Lean Orchestration* predominantly saw this strategy as a means to experiment with novel technologies and novel ways to create a more sustainable value-creation-and-delivery element. Their main motivation for entering resource sharing using this strategy was to keep their investment and activities to a minimal level. However, this strategy offers very few options for scaling. Given that this experimentation-driven strategy is limited to a geographically confined area, the question surfaces as to whether the resource-sharing activities should be continued or not. Because most of the companies in this case appeared reluctant to invest heavily in resource modification, they preferred to opt for solutions that allowed them to offer their resources via a platform bundling many different offerings. Therefore, they moved or intended to move from *Lean Orchestration* to *Actor-Driven Orchestration* to scale their 'Minimum Viable Product' solutions. Furthermore, they viewed the high level of actor interaction in a positive light, because it allowed them to foster their understanding of resource orchestration.

In this study, firms adopting *Resource-Driven Orchestration* were more prone to moving to *Dual Orchestration* because this move can help them harvest the full potential of technology-heavy resource modifications and increase their financial returns from the associated investments. Increasing their interactions with other actors allows them to engage in new exploration activities around sharing.

4.3.2 Moving from Low Resource-Modification Strategies to High Resource-Modification Strategies

The results of this study emphasize that moving from low resource-modification to high resource-modification strategies is rarely employed. A principal reason is the high investment cost, which companies choosing low resource-modification strategies were trying to circumvent in the first place. Switching from *Lean Orchestration* to *Resource-Driven Orchestration* requires substantial resource modification, which was often viewed as too risky and expensive by some of the companies. Furthermore, companies adopting the *Lean Orchestration* strategy simply lacked the means to determine the technological standards and the resource modifications required. Some smaller players felt that they might be easily overruled by the bigger companies and, therefore, preferred changing strategies in a way that ensures their autonomy when it comes to asset sharing.

Some companies explained that they were thinking about moving from an *Actor-Driven Orchestration* strategy to *Dual Orchestration*. However, in line with the issues previously outlined, companies worried that too much investment would be required on their part whilst having to surrender much of their flexibility due to technological lock-in. They further feared that the coordination of actors in *Dual Orchestration* would be much more complex than in their current approach. Consequently, companies pursuing *Actor-Driven Orchestration* could only imagine switching strategies by gradually moving towards higher levels of automation.

5. DISCUSSION

Prominent political and societal stakeholders see CBMs as a pivotal ingredient in fostering a successful transition to sustainability (Geissdoerfer et al., 2018; Merli et al., 2018). Although the literature on CBMs has grown tremendously over the last few years, it still exhibits some crucial research gaps. For one thing, it has focused on the identification of relatively abstract CBMs, leading to calls for more detailed analyses of differences in implemented CBMs (e.g., Bocken et al., 2016; Brehmer et al., 2018; Bressanelli et al., 2018; Leising et al., 2018; Lewandowski, 2016; Urbinati et al., 2017). For another thing, the CE literature has largely examined CBMs from the perspective of closing resource loops, which has led to calls for more research on CBMs in relation to slowing resource loops (Merli et al., 2018). Slowing resource loops includes asset-sharing solutions (Bocken et al., 2016). Furthermore, most of the current literature has paid scant regard to B2B solutions for CBMs. By uncovering differences in the CBMs' value-creation-and-delivery element concerning asset-sharing solutions, the present study addresses several important pointers from previous research and, consequently, responds to the calls emanating from the research community. It holds several implications for the emerging CE-related academic literature and management practice.

First, it provides scholars and managers with an enhanced understanding of how to change their firm's linear BM to move to a CBM. Our research reveals important design choices in the value-creation-and-delivery element, which have been previously overlooked. These crucial choices allow firms to go beyond a 'one size fits all' CBM and to adapt it to the divergent needs of different orchestrators and clients (Matschewsky et al., 2018; Urbinati et al., 2017). Managers often face major hurdles when they try to implement CBMs (Päivärinne and Lindahl, 2016). The findings presented in this study enable managers to tackle some of these hurdles by adapting their CBMs to their specific situations. A better understanding of design alternatives – that is, substantial/little resource modification and high/low actor interaction – seems likely to stimulate a more widespread adoption of CBMs.

Second, this study provides insights into diverse implementation strategies for CBMs that were adapted by diverse orchestrators of resource-sharing solutions in the B2B context. Prior studies recognize that industrial companies need to cope with diverse sets of challenges, such as actor setup in the industry ecosystem, investment, and change management (Keupp et al., 2012; Parida et al., 2019). The case companies manage to mitigate the CBM implementation challenges by applying *Lean, Resource-Driven, Actor-Driven, and Dual Orchestration* strategies to configure resources and actors. While companies were especially careful in transitioning from successful BMs to CBMs, the four main strategies identified in this study can be taken as insights into how a CBM can be implemented.

Each strategy represents certain characteristics that individual firms should incorporate in order to realize its sustainability benefits. It was found that firms with limited resources were inclined to be more focused on *Lean Orchestration*, whereas larger firms may target long-term oriented *Dual Orchestration*. Similarly, actors with central positions within their ecosystem or network were able to pursue *Actor-Driven Orchestration* as opposed to *Resource-Driven Orchestration*. Thus, these novel findings add to the current CBM literature by highlighting the fact that implementing a CBM means making certain design choices, and that these design choices should not only be considered in isolation but also together. More specifically, the interdependencies between substantial/little resource modification and high/low actor interaction emphasize the importance of systemic thinking since the identified orchestration strategies can be defined as combinations of design choices. Hence, the study goes beyond an isolated consideration of individual design choices and points managers and scholars to noteworthy intricacies within systems of design choices.

Third, the study sheds light on transition pathways between different CBM strategies and the implications for creating economic and environmental value. It was found that the case companies associated the most complex orchestration strategy – that is, *Dual Orchestration* – with the potential to provide the greatest financial and environmental impact. Given the possibility of longitudinal insights, the data showed that companies are not locked into a certain orchestration strategy but can actually move to a different strategy such as *Dual Orchestration*. Furthermore, it was observed that companies are much better equipped for the transition to *Dual Orchestration* if they have already invested in resource modification and the digital enhancement of resources. What was not observed in this sample was the move from *Lean Orchestration* to *Dual Orchestration*. While this move is theoretically possible, it seems as if companies regarded the move from a little resource-modification/low actor-interaction strategy to a substantial resource-modification/high actor-interaction strategy as too demanding. Thus, it can be inferred that the experimental setting of *Lean Orchestration* encourages small steps rather than big leaps towards more complex CBMs.

Fourth, while this study focuses on the interdependencies between the design choices within value creation and delivery, it can be expected that multiple design options exist with respect to value propositions and value capture in CBMs as well. For example, some orchestrators of resource-sharing solutions offer advice to the resource providers on what these resource owners can do to increase the future value of their resources in the sharing network. Offering such advice is an additional design option in the value proposition domain besides marketing the functionality provided by the resources at any given moment. Future research could systematically explore such additional design options in the value proposition and value capture domains. Moreover, it could examine the implications of combining different design choices in and across the three BM domains – that is, value proposition, value creation and delivery, and value capture. As shown in the findings, firms can change their implementation strategy by altering the combination of design choices, and doing so can allow firms to move gradually to greater levels of effectiveness.

Finally, future research could seek to quantify the economic and environmental impact of the four identified implementation strategies in order to assess the degree to which the strategies contribute to the decoupling of economic growth from environmental impact. Decoupling can occur at relative and at absolute levels. Relative decoupling occurs "when resource use or some environmental pressure […] grows at a slower rate than the economic activity that is causing it [… Absolute decoupling occurs when the resource use or some environmental pressure] declines while the economic activity continues to grow" (Sanyé-Mengual et al., 2019: 2). However, CBMs in and of themselves do not necessarily decouple economic growth from environmental impact. Kjaer et al. (2019) identify three criteria that CE strategies must meet in order to lead to absolute decoupling: ensure net resource reduction, avoid burden shifting between life cycle stages, and mitigate rebound effects. Importantly, even if absolute decoupling is achieved, the levels of resource consumption and environmental impact can still exceed planetary boundaries (Sanyé-Mengual et al., 2019). Quantitative assessments of CE strategies should, therefore, go beyond determining whether absolute decoupling is achieved or not. The qualitative assessment featured in the present article provide a promising foundation for the development of 'hard' metrics and a quantitative assessment of the four implementation strategies in the future.

6. CONCLUSION

Reacting to the increasing attention of public, private, and academic interest in CBMs and the CE, this study has undertaken a detailed analysis of *how* resource sharing can be facilitated and implemented to generate economically and environmentally sustainable outcomes. An inductive case study of nine Virtual Power Plants was conducted. The results yielded important insights into the value-creation-and-delivery element of CBMs implemented by firms that orchestrate resource-sharing solutions and into the outcomes from orchestration. Observing substantial differences in the value-creation-and-delivery element across firms, three main findings can be highlighted. First, two main dimensions in the value-creation-and-delivery element need to be assessed when designing CBMs: resource modification ('no or little' vs. 'substantial') and actor interaction ('low' vs. 'high'). Second, the potential combinations of substantial/little resource modification with high/low actor interaction imply four distinct strategies for resource orchestration when implementing CBMs. Third, companies can move along these four different orchestration strategies, depending on their current set-up and their targeted gains, in order to increase economic and sustainable outcomes.

Despite the increasing amount of research on CBMs, several scholars believe that this subject ought to receive much more attention in the future (e.g., Diaz Lopez et al., 2019; Merli et al., 2018). Whereas previous work has focused on relatively abstract CBM archetypes, the present article suggests that a more detailed exploration of CBMs can be a fruitful direction for additional research. Insights into alternative design choices within a given CBM can help practitioners develop a CBM that is most appropriate to their specific situation. The study of CBMs provides several opportunities for subsequent research. First, future efforts could further examine the conditions under which a given strategy outperforms the others in order to provide managers with some research-based guidance on when to choose which strategy. In addition to environmental conditions, future efforts may want to investigate the influence of firm-level characteristics that make the adoption of a given CBM more favorable than any other. Second, since the present paper has focused on design choices in the value-creation-and-delivery domain, future research could explore which design choices exist in the value proposition and value capture domains of CBMs and how they are or should be combined. In particular, the combination of design choices across the CBM domains represents an intriguing path for future research because such combinations can paint a holistic picture of CBMs. Third, scholars could analyze design choices in CBMs that incorporate CE thinking but are unrelated to sharing. The analysis of differences in the CBM for orchestrating resource-sharing solutions featured in this current article is just one step on the path to a better understanding of CBMs and the transition to a CE.

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Table 1: Overview of orchestrator case companies

Case	Main business	Revenue in Million EURO	Total # of employees (# related to VPP)	VPP activities since	# of interviews + follow-ups
Case A	Renewable Energies, Energy Trading, VPP	273	120 (100)	2010	3+5
Case B	Local Utility	140	260 (4)	2012	2+1
Case C	Local Utility	80	150 (5)	2004	2+2
Case D	National Utility	6,600	8,850 (12)	2010	4+2
Case E	Local Utility	290	510 (3)	2014	1+3
Case F	Renewable Energies, VPP	n. a.	n. a.	2015	1+1
Case G	Multi-National Utility, Transmission Grid Operator	6,700	8,350 (50)	2010	2+4
Case H	Multi-National Utility	116,000	56,500 (70)	2014	1+3
Case I	Technology Provider	75,600	348,000 (n.a.)	2009	1+2

Table 2: Overview of interviewed actors that provide their DER to a VPP (covered in addition to the case companies)

Note: DER ~ Distributed Energy Resource

Resource provider	Type	Affiliation	Size of production site in kW_{el}	DER owner since	Joined VPP in	# of interviews + follow-ups
Resource provider 1	Owner DER	Case A	75	2002	2013	1
Resource provider 2	Owner DER	Case A	80	1999	2015	1 +1
Resource provider 3	Cooperative DER	Case A	150	2005	2014	1
Resource provider 4	Cooperative DER	Case B	260	2006	2012	1
Resource provider 5	Owner DER	Case B	150	2006	2013	1 +1
Resource provider 6	Owner DER	-	80	2003	2013	1
Resource provider 7	Owner DER	-	120	2004	2012	1

Table 3. Qualitative assessment of the four orchestration strategies

	Lean Orchestration	Resource-Driven Orchestration	Actor-Driven Orchestration	Dual Orchestration
Input				
Matter and energy	(-) No resource modification required	(+) Resource modification requires material and energy input (+) Automated machine-to-machine communication consumes some energy	(-) No resource modification required	(+) Resource modification requires material and energy input (+) Automated machine-to-machine communication consumes some energy
Labor	(-) Small size of network eases coordination	(-) Low due to automated orchestration	(+) High due to significant actor interaction	(+) High due to significant actor interaction
Output – Economic				
Economies of scope	(+) Leverage existing contacts with local customers	(+) Leverage synergies with core business	(+) Likely due to the great variety of offerings	(+) Possibility to combine the respective advantages of Resource-Driven Orchestration and Actor-Driven Orchestration
Economies of scale	(-) Limited due to local focus	(+) Likely due to size of sharing network	(+) Likely due to network effects and growing customer base	(+) Deep understanding of customer demands and wishes can support scaling (+) Potentially fostered by large size of sharing network
Output – Environmental				
Net resource reduction	(-) Limited due to small size of sharing network	(+) If material and energy input for resource modification and automated communication reasonable, potentially	(+) Potentially substantial due to network effects and growing customer base	(+) If material and energy input for resource modification and automated communication reasonable, potentially

		substantial due size of sharing network		substantial due size of sharing network (+) Combination of automation and actor interaction supports optimization of sharing solution and minimization of system-level inefficiencies
Avoidance of burden shifting across lifecycle stages	(+) Local solutions reduce need for long-distance transmission infrastructure (+) No substantial resource modification required up front	(-) Resource modification requires some material and energy input up front which may be useless outside of the specific asset sharing network	(+) No substantial resource modification required up front	(-) Resource modification requires some material and energy input up front which may be useless outside of the specific asset sharing network
Mitigation of rebound effects	(-) No inherent mitigation of rebound effects	(-) No inherent mitigation of rebound effects	(+) Significant actor interaction can provide "social control", which may prevent rebound effects	(+) Significant actor interaction can provide "social control", which may prevent rebound effects

Figure 1: ReSOLVE Framework

Note: Based on Ellen MacArthur Foundation (2015) and Manninen et al. (2018)

Circular Economy Practice	Description
Regenerate	• Shift to renewable energy and materials • Reclaim, retain and regenerate health of ecosystems • Return recovered biological resources to the biosphere
Share	• Maximize utilization of products by sharing them among users • Reuse products throughout their technical lifetime (including second-hand use) • Prolong life through maintenance, repair, design for durability, upgradability
Optimize	• Increase performance/efficiency of product • Remove waste in production and the supply chain • Leverage big data, automation, remote sensing and steering
Loop	• Remanufacture product/components • Recycle materials • Digest anaerobically, extract biochemicals from organic waste
Virtualize	• Dematerialize directly (e.g., books, CDs, DVDs, travel) • Dematerialize indirectly (e.g., online shopping)
Exchange	• Replace old with advanced non-renewable materials • Apply new technologies (e.g., 3D printing) • Choose new product/service (e.g., multimodal transport)

Figure 2: Emerging Codes from the Qualitative Analysis: Resource Modification and Actor Interaction

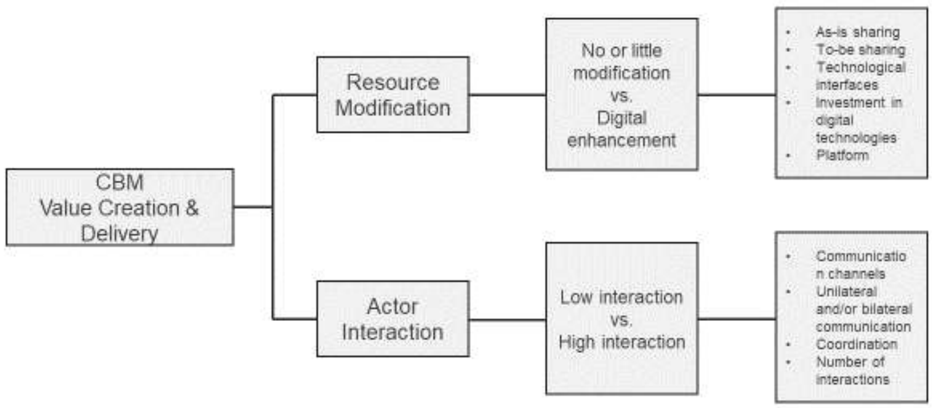

Figure 3: Pathways for the Transition between CBM Orchestration Strategies

Note: Black arrows indicate common/planned movements between orchestration strategies. Dashed arrows indicate uncommon/unplanned movements between orchestration strategies. 'MVP' means 'minimum viable product'.