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Enabling circular strategies with different types of product/service-systems

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Abstract

To be successfully implemented, circular economy requires the design of innovative business models that can enable multiple value creation mechanisms. One way to achieve this is by means of product/service-systems. Nevertheless, there is still limited consideration in the literature regarding the effect of applying different circular strategies – or resource productivity or resource efficiency strategies - in the development of alternative business models for different product/service-system types. By means of retrospective case studies, this article discusses how different types of product/service-systems and their business models are related to or enable different circular strategies. Insights and future research opportunities are outlined.

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Keywords: product/service-system; circular economy; business model; resource productivity; resource efficiency

1. Introduction

The need to respect planetary boundaries and mitigate future economic risks has gained larger recognition and reached different spheres of society in the last years. Calls to change the current ‘take-make-use-dispose’ economic system have been voiced by several governmental and international organizations, business, consultancies and scholars [1–4]. Circular economy (CE) is viewed as an important approach to enable a significant change in the economic system while contributing to the development of a more sustainable society [1,3,4]. CE has the potential to establish multiple value creation mechanisms that enable decoupling business success and growth from the consumption of virgin and finite resources [5].

Despite the fact that the conceptual foundations of CE (such as biomimicry, cradle-to-cradle, industrial ecology, performance economy, blue economy and others) existed previously [6,7], the implementation of circular strategies for resource productivity (here treated as comprising resource efficiency as well as resource effective solutions) in a synergistic and systemic way remains a challenge. Much has

yet to be understood regarding the successful implementation of combinations of such strategies as well as how to stimulate their adoption on the scale of industrial and economic systems.

The development of innovative business models to enable multiple value creation opportunities and mechanisms is one of the keys to implementing circular principles [4,8,9]. Some tools have been proposed for the design of circular business models (e.g., the Framework for Sustainable Business Model Innovation [10]; the Business Cycle Canvas [11]; the Circular Business Model Framework [12]), but there is limited consideration of the effect of different circular strategies for resource productivity in the business models’ dimensions.

Product/service-systems (PSS) are often outlined as enablers for enhancing business’ circularity [4,13,14]. However, PSS offerings are not necessarily more sustainable or circular. The design and implementation of resource efficient PSS solutions is still a challenge [15,16]. Furthermore, different types of PSS (i.e. product-oriented, use-oriented, and result-oriented [17]) present different combinations of business models’ elements. Previous work [18] has explored the relationship of CE strategies with circular business model

dimensions on a conceptual level, but empirical investigation is still required. To expand the current literature, this study explores nine cases to understand how different types of PSS and their business models relate to or enable different circular strategies.

The research methodology is presented in section 2. Subsequently, the selected case studies are described in section 3. Section 4 analyses the patterns in the case studies and discusses how different circular strategies affect the business models for different PSS types. Lastly, section 5 outlines conclusions and suggestions for further work.

2. Research methodology

Retrospective case studies were conducted to explore and understand how different types of PSS enable a number of circular strategies for resource productivity. The design of the retrospective case study envisioned three parts: (1) *case selection*; (2) *data collection*; and (3) *exploratory analysis* [19].

2.1. Cases selection

Case companies that have adopted CE principles in the Nordic region were identified through official reports funded by the Nordic Council of Ministers [20–22] and in databases of industry associations (e.g.: Technology Industries of Finland, Innovation Center Iceland). This was supplemented by desk research. This effort was undertaken in the context of the CIRCit project (<http://circitnord.com/>), with the aim to compile a database showcasing business benefits of CE; the wide applicability of the concept in terms of sectors; and the various business areas that can contribute to increased circularity (ranging from material selection and product design, to capturing end-of-life/use materials and the ability to generate value from waste).

The case companies included in this article were part of the first iteration of this database, which contained 45 cases. All the cases that involved PSS approaches (i.e. 9 companies) were selected from the database (Table 1).

Table 1. Sample of case studies

Company	Sector	Country	Reference
Martela	Furniture	Finland	[22,23]
Konecranes	(heavy) Machinery	Finland	[24,25]
UniCarriers	(heavy) Machinery	Sweden	[26]
Danelec Marine	Electronics	Denmark	[27]
Svenska Retursystem	Packaging	Sweden	[28]
RePack	Packaging	Finland	[29]
Bergans	Textile & fashion	Norway	[30]
Vigga	Textile & fashion	Denmark	[31]
Bycyklen	Transport	Denmark	[32]

2.2. Data collection

Data was gathered on the nature of the circular initiatives, the details of the offering, customer segments, the value proposition, benefits achieved, and key implementation aspects. Data collected from secondary sources was supplemented with primary sources, such as company websites, reports and brochures. Short (paragraph-length) case descriptions were collated and verified with the companies.

2.3. Exploratory analysis of selected cases and data

Techniques based on content analysis [33] were applied on the collected material to cluster information that was further compiled and organized according to a coding framework. The coding dimensions of this framework were developed deductively, based on a preliminary literature review. The framework contains two main categories: (1) *Circular strategies* and (2) *Type of product/service-system*.

The first category encompasses the full range of resource productivity strategies. The strategy typology is based on Plotting et al. [34], which considers both resource efficiency and resource effectiveness approaches. Three sub-categories are distinguished in: (i) smarter product use and manufacture; (ii) extended lifespan of products and parts; and (iii) useful application of materials.

The second category comprises the full range of business model configurations for PSS according to Tukker [17] (i.e. product-oriented, use-oriented and result-oriented and their sub-types). See Figure 1 for an overview of the main and sub-categories used.

3. Case study descriptions

Martela specializes in furniture for public spaces, businesses and schools. The Finnish company offers rental and leasing, as well as repair and refurbishment services. End-of-use furniture can be returned to Martela to be dismantled. Reusable parts are placed in new assemblies and wood, metal and plastic recyclables are reclaimed as secondary raw materials or used in energy production. The company also offers consultancy services that ensures customers only order what they really need. In 2014, Martela received ±3,000 tons of used furniture: over 20,000 pieces were cleaned, refurbished and given a new use [22,23].

Konecranes provides lifting equipment all over the world for process industries, shipyards, ports and terminals. Konecranes offers complimentary services aimed at maximizing the productivity of uptime and minimizing the cost of downtime. By doing this, they enable the extension of the equipment lifetime. For example, the Lifecycle Care programme provides spare parts, maintenance and retrofits. With the Lifecycle Care in Real Time programme, which uses remote sensing and big data, crane usage data are collected in real-time. This provides insight into running time, motor starts, work cycles and emergency stops, which are used to detect overloads and overheats, to plan predictive maintenance [24,25]. Konecranes is also scaling up leasing (such as the RENTALL service

bundle for cranes) and activity management PSS offerings (such as the Agilion warehouse management service) [35].

The multinational *UniCarriers*, with European headquarters in Sweden, provides a range of industrial trucks. Across their buy, lease and rental offerings, UniCarriers extends the life of its products. When a rental contract ends, for example, trucks can continue to be used: a truck will last 10-15 years, where a typical contract lasts 5-7 years. UniCarriers renovates these trucks, which can be done efficiently due to a large degree of standardization of parts across its product range. After this, the trucks are sold or leased again. Following its second renovation cycle, the trucks become part of a product cascade: they are used in applications that are less demanding compared to the previous applications [26].

Danelec Marine redesigned its Electronic Chart Display & Information System (ECDIS) increasing reliability through modularization and parts reduction whilst facilitating repair and future compatibility. If quick on-board repair is not possible, modular design allows the ship's software module to be removed from the faulty unit and placed into a new one. This way, the ship can continue, whilst the ECDIS is repaired on-shore. An extensive partner network allows for speedy and skilled installation, repair and support services, all over the world. More reliable navigation and reduced ship downtime constitute Danelec's value proposition to its customers [27].

Svenska Retursystem is a Swedish company that offers a reusable transit packaging system. The system consists of sturdy stackable crates and pallets in various sizes, and supporting operations. Svenska Retursystem delivers the units to the manufacturers where they are filled. Via wholesalers, the units arrive at the retailers, where they are emptied. Through the same chain, they are eventually returned to Svenska Retursystem, where the crates are checked and washed, after which they are ready to be used again. Most of Sweden's food manufacturers rely on this system. At the end-of-life, the crates are recycled into new crates. According to the company, the carbon footprint of this solution is up to 74% lower when compared to disposable packaging. Furthermore, Svenska Retursystem's pallets are up to 10 kg lighter, which reduces fuel consumption in transportation [28].

RePack is a Finnish solution of reusable packaging for online retail, initially focused on clothing. At check-out in webstores, customers are offered the option to use RePack, for which a small deposit is charged. After having received their order, customers can return the RePack free of charge through the regular postal system. When the company receives the RePack, shoppers receive their deposit back in the form of an email voucher for the next purchase from any webstore that uses RePack. According to RePack, this generates a positive rebound effect as their users buy more often and spend up to 30% more than the average webstore customer. RePack users are also loyal customers: up to 60% of RePack vouchers are claimed. RePack is designed to be used up to 20 times. According to the company, the carbon footprint is up to 80% less compared with disposable bags [29].

Bergans provides a range of outdoor apparel as well as tents, canoes and backpacks. Bergans has seen the potential for the extension of product life, and has implemented, for example, a rental scheme for backpacks, tents and skiwear. In addition to

this, in its flagship store in Oslo, the company offers repair services and the option for customers to return no longer in use clothing to be resold. Customers can get a 20% discount on a new item that is bought at the same time that they return used clothing items. To facilitate returning an item via the post, special mailing bags can be ordered via text or online. Products that can no longer be repaired or resold are turned into redesigned or 'upcycled' items or donated to charity for reuse or recycling into insulation or filler materials. Bergans has also undertaken a range of efforts in the area of responsible sourcing, such as the implementation of standards for the responsible production of down and wool, and other initiatives such as the use of recycled materials in new products and finding non-toxic alternatives for water-repellant coatings [30].

Vigga is a Danish maternity and baby clothing company that offers access to their clothes through a renting system. According to Vigga, their business model is 80% less wasteful in terms of resources, as multiple customers reuse these otherwise short-lived items of clothing. Customers also benefit, since they do not have the up-front cost of investing in clothing they only use a short while. Instead, they pay a subscription fee that totals as less than buying the clothes new from a high-street low-cost fast-fashion brand. To implement their solution, Vigga had to work with suppliers to ensure access to high-grade, long-lasting as well as organic materials with a time-less look. Clothing that cannot be reused any longer is recycled. Vigga is currently growing, and offering increased flexibility in rentals with different sizes of clothing packs. The company is expanding its product range and its rental platform. Examples of this are the collaboration with other brands such as Patagonia for outerwear, and Angulus for baby shoes [31].

Bycyklen is a public, electrical bike-sharing system for citizens and tourists provided by the By & Pendlercykel Fonden in collaboration with the municipality of Copenhagen and other partners. It was founded in 2014 with the intention to be a "fourth leg" in the public transportation opportunities, both reducing traffic congestion and promoting a healthier and greener transport form of biking. The company's electric smart bikes equipped with GPS tablets and the many docking stations throughout the city are the backbone of this system. Users can create an account online or directly on the bike's tablet and log into a bike on the tablet. When the trip is completed, the bikes can be returned to any docking station where the bike will charge to be ready for the next user. By sharing the bikes instead of owning them individually, the bikes can be used more intensively. They are designed to require little maintenance and, when in need of repair, users can send an error report directly from the bike tablet to alert Bycyklen. Collaboration with local authorities was fundamental to establishing the system and fit it in with the existing city and transport infrastructure [32].

A summary of the PSS-related offerings, customer segments and key values for customers for all cases is presented in Table 2.

Table 2. Customer value proposition and interface aspects of the business models (obs.: references are listed in Table 1).

Company	PSS-related offerings	Customer segments	Values for the customers
Martela	Access to furniture by rental or lease system	Municipalities and business	Convenience, money savings, well being
Konecranes	Services for crane operation, access to cranes by means of leasing, and warehouse management solutions	Process industries, shipyards, ports and terminals	Reduced operational risks, money savings
UniCarriers	Access to industrial trucks by means of rental, leasing or acquisition	Industries with material handling needs	Flexibility, savings (time & money)
Danelec Marine	Availability of marine fleet navigation system by subscription service	Maritime companies worldwide	Reduced operational risks, savings (time & money)
Svenska Retursystem	Access to reusable crates and pallets services	Producers, wholesalers of goods	Savings (time & money)
RePack	Reusable packaging system for clothing e-commerce in a service system	Retailers	Social meaning, savings, new revenues
Bergans	Access to large backpacks, tents and ski wear under a rental scheme	Consumers interested in sportswear apparel	Flexibility, money savings, convenience
Vigga	Access to organic maternity and children's wear in a renting system	Pregnant women or families with babies	Social meaning, affordability, convenience, flexibility
Bycyklen	Urban mobility with public electrical bike-sharing system	Copenhagen citizens, commuters and tourists	Affordability, convenience, flexibility

4. Patterns of circular strategies for resource productivity with different types of product/service-systems

The resulting compilation of the case studies in the framework of analysis is presented in Figure 1. Some trends and points for discussion may be outlined as follows:

1. The most recurrent PSS types adopted to enable circular strategies are the *product renting/sharing*, *lease* and *product related service*. The majority of companies are using two or more of the eight PSS types across their offerings and applying four or more circular strategies. Companies tend to combine at least two PSS categories, which are mainly the product- and use-oriented (i.e. *Martela*, *Unicarriers Europe*, *Danelec Marine*, *Svenska Retursystem* and *Bergan*). However, in the case of *Konecranes* all three PSS types are combined.

2. Some *use-oriented* PSS cases presented a narrow coverage of circular strategies. Some of the cases – e.g. *Bycyklen*, *RePack* – are more focused on single strategies related to extending lifespan of products and parts by reuse or repair and maintenance. There is an opportunity for better applying strategies during the PSS operation or use-phase, such as refurbish and remanufacture, or for the end-of-life, such as recycling or recovering.
3. Only one case of the sample provided evidence of *result-oriented* PSS solution (*Konecranes*). Result-oriented PSS, especially the *functional result type*, is often associated with the highest decoupling potential, due to the highest degree of incentives for the provider to implement circular strategies (i.e. all material and energy used to deliver the agreed results become cost factors for the provider) [16,17,36]. Due to the striking marginal representation of this PSS type in our data set, there is not enough evidence to confirm or contradict this point. This leaves an opportunity for further investigating circular solutions based on this PSS configuration to verify to what extend result-oriented PSS can contribute for enhancing circularity.
4. The frequency of strategies for *smarter product use and operation* and *manufacture and logistics* is low. These strategies are related to preventative actions or efficiency measures to reduce the amount of resource consumption since the beginning of-life and they may be important to start the process with less consumption of virgin resources. Interestingly, some cases presenting the preventative strategies managed to combine them with strategies for extending the product life or closing the loop of materials. For instance, *Martela* provides solutions to extend the life of the furniture and materials (e.g.: reuse, remanufacture, recycling, recover) with a preventative strategy based on ecodesign practices for producing smart offices (using up to 50% less space than before and generating savings in rental and energy consumption in the offices). *Bycyklen*, rethinks urban mobility by proposing a sharing system relying on a multifunctional product (bicycles are equipped with GPS system). Similarly, *Vigga* had to source organic and time-less look materials in order to make the renting model feasible. Some lines of thought in CE have positioned efficiency and effectiveness as competing solutions [37]. Nevertheless, some of the cases identified here and previous literature work, such as Niero et al. [38], indicate that combining is possible.

This paper illustrated one way to analyse the relationships between PSS and circular strategies. Summarizing the discussion, PSS appears to offer opportunities for the concomitant application of circular strategies (i.e. the synergistic application of circular strategies in parallel or in sequence, depending on the life cycle stage they are applied in).

However, the cases presented a shortcoming of *result-oriented* PSS type, which might be related with high risks for operationalization of such models [17], and of some circular

Company Name	Types of PSS							Circular Strategies														
	Product-oriented		Use-oriented		Result-oriented			Smarter product use and manufacture					Extend lifespan of products and parts				Useful application of materials					
	Product related service	Product related advice	Product lease	Product renting/ sharing	Product pooling	Pay-per-service unit	Activity management / outsourcing	Functional result	Refuse	Rethink	Reduce											
								Abandoning product function - without replacement of function	Same function, radically different product/technology - e.g. virtualization	More intense use of product capacity - e.g. sharing, multifunctional products	Raw materials and sourcing - e.g. efficiency measures, lightweighting	Manufacturing and logistics - e.g. efficiency measures	Product use and operation - e.g. more efficient energy-in-use, reduced cleaning	Upgrade - improving product function in respect to previous versions	Re-use - product in good condition; used in original function by new user	Repair and Maintenance - correct faulty component to return it to its original function	Refurbish - Return worn part or product to satisfactory working condition	Remanufacture - return worn part or product to original specifications	Repurpose - use of part of product in a new product with a different function	Recycle - closed or open loop recycling, cascading	Recover - Energy or material recovery - e.g. combustion or biodegradation	
Martela																						
Konecranes																						
Unicarriers Europe																						
Danelec Marine																						
Svenska Retursystem																						
RePack																						
Bergans																						
Vigga																						
Bycyklen																						

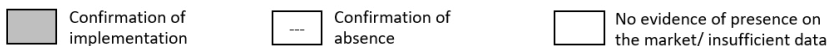


Fig. 1 – Framework for analysing the relationship of circular strategies for resource productivity and product/service-system types (adapted from [17,24])

strategies such as *refuse*, *rethink*, *reduce* (in manufacturing/logistic and product use/operation), *refurbishment* and *remanufacturing*.

5. Final remarks and suggestions for further work

This paper explored how different PSS types can enable a number of circular strategies for resource productivity. The main contributions of the paper are: the compilation of case studies for CE involving PSS in the Nordic industry and the identification of trends and opportunities for future research in circular business modelling based on PSS. The main trends are:

- PSS appears to be conducive to the synergistic application of multiple circular strategies;
- Combining resource efficiency strategies (preventative) with resource effective strategies (for extending products/materials life) seems to be a trend in companies implementing PSS;
- Circular solutions based on the result-oriented PSS are less frequent, although the potentials for energy savings and resource decoupling are claimed to higher [17];
- Companies have room to improve the application of more diversified CE strategies such as new technology paradigms (refuse), rethinking value propositions and offerings’ fulfillment (rethink), and extending lifespan of products through refurbishment and remanufacturing.

The conceptual study described in this article will serve as one of the foundations for the proposition of a dynamic tool for sustainable circular business modelling, which is being developed by the main author of this research. The

patterns/links between different types of service-oriented business models and resource productivity strategies identified in the cases will support the development of a morphologic matrix for circular business model configuration.

The main limitations of this study are related to the methods applied for the retrospective case study. The process was based mainly on content analysis of primary (companies’ websites, reports and brochures) and secondary sources (sustainability or CE reports developed by the Nordic countries or national industry associations) of information. As a good practice for case studies, triangulation with other methods (e.g. interviews and observation) is frequently applied, and could be incorporated as next steps. Furthermore, more data could be gathered on all cases for a more accurate picture, which was not possible due to constraints of access and time. Another limitation is related to the limited number of case studies, which do not enable statistical analysis.

Regarding future research, in general, there is opportunity for better exploring the specifics of business model configurations and what conditions favour synergistic combinations versus those that favour trade-offs. What has to be further investigated is what conditions favor the circular combinations without generating inconsistencies (e.g.: making a product more durable for lasting along several life-cycles may hinder resource efficiency in the design, however it may generate a positive net value considering the complete life-cycle) and how to balance and choose the possible combination of strategies. Furthermore, some challenges are related to assigning circular strategies and cases to the eight PSS types proposed by Tukker [17]. This typology is easier to apply for

manufacturing providers of equipment and consumer goods and when the provider's perspective is the reference for analysis. Systemic solutions involving multiple stakeholders such as returnable packaging systems – i.e.: *RePack* and *Svenska Retursystem* – require new classifications. This indicates a need for expanding or exploring new PSS typologies for resource and energy productivity purposes. These two last aspects are in our opinion top challenges in PSS resource efficiency research and practice.

Additionally, it is important to explore how circular strategies affect or are affected by the internal dimensions of a business model, or its value network, and how value is generated in multiple ways and in the multiple interfaces of value chain collaboration [13]. Although it was possible to identify the values provided to the customers in the cases, it was not straightforward to do the same for internal stakeholders such as suppliers or the provider. This topic is a gap in literature and not well reflected in the company's reports and websites.

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