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Procedia CIRP 64 (2017) 31 – 36

www.elsevier.com/locate/procedia

The 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems

Lifecycle management of product-service systems: a preliminary investigation of a white goods manufacturer

Thayla T. Sousa-Zomer[a*], Lucas Magalhães[b], Eduardo Zancul[bc], Paulo A. Cauchick-Miguel[b]

[a]*Post-graduate Program in Production Engineering, Federal University of Santa Catarina, Campus Universitário Trindade, Caixa Postal 476, 88040-970, Florianópolis, SC, Brazil*

[b]*Post-graduate Program in Production Engineering, University of São Paulo, Av. Prof. Almeida Prado, 128, 05508-070, São Paulo, SP, Brazil*

[c]*Production Engineering Department, University of São Paulo, Av. Prof. Almeida Prado, 128 - 05508-070, São Paulo, SP, Brazil*

* Corresponding author. Tel.: +55 48 3721-7039. *E-mail address:*thayla.ts@gmail.com

Abstract

Product-Service Systems (PSS) have been discussed as promising business strategies towards a circular economy (CE). However, PSS solutions are not necessarily more sustainable. PSS lifecycle management may play an important role to improve the offering and achieve sustainability benefits. Nevertheless, bottom-up issues for CE implementation in the industry such as lifecycle management are still little discussed in the literature. In this sense, this paper aims to explore a PSS business strategy adopted by a large white goods manufacturer that transitioned from a linear to a circular business, and the practices applied throughout the entire lifecycle that may be valuable to achieve CE requirements. A case-based approach was employed in this study and multiple sources of evidence were considered. Data were analyzed in the light of the literature, considering an inductive approach. The main preliminary findings suggest that resources consumption reduction and cost savings can be obtained through lifecycle management practices that take into consideration CE issues since the beginning of life of the PSS offering. Design practices, the adoption of different strategies at the end of life (reuse/remanufacturing or recycle), and the implementation of cleaner production practices are some of the identified practices that can contribute to achieve resource efficiency and CE requirements. This is a work in progress and further work is going to focus on a quantitative analysis of the environmental and economic performance of this PSS. In addition, as this study focused on a use-oriented PSS, future research may compare lifecycle management practices adopted by other and distinct PSS categories, and how different lifecycle management practices may contribute to achieving resource efficiency.

Peer-review under responsibility of the scientific committee of the 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems.

Keywords: sustainable product-service systems; circular business models; lifecycle management.

1. Introduction

Tackling global sustainability challenges requires a more holistic view of doing business, and new sustainable business model archetypes are emerging [1]. Business model innovation for sustainability can be defined as innovations that create positive and/or reduced negative impacts on the environment and/or society through changes in the way the organization and its value-network create, deliver value, and capture value or change their value propositions [2]. The development of more sustainable business models provides the bases for companies to better contribute to a circular economy (CE) [3]. In a circular economy system, production is circular, i.e. raw materials and products re-enter into the environment or are reused in successive production cycles [4]. Circular business models represent an opportunity for companies to profitably achieve an increase in resource productivity [5].

A concept that helps to explain value-focused, more sustainable business models is product-service systems (PSS), which may allow reducing the total environmental burden of consumption and may contribute to the more efficient use of

Peer-review under responsibility of the scientific committee of the 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems.
doi:10.1016/j.procir.2017.03.041

resources [3]. These business models allow slowing resources loops by encouraging long product life and reuse of products [6]. In fact, collaborative consumption models such as PSS are recognized as one of the best available options to shift from the present business-as-usual model towards CE [7].

PSS business strategies, however, are not intrinsically sustainable [8]. Sustainability is affected by lifecycle considerations [9]. A successful offering and realization of a PSS extends the involvement and responsibility of the provider throughout the entire lifecycle, from [10]: the design and realization (beginning of life - BoL), through the use and maintenance (middle of life - MoL), ending with the dismission (end of life - EoL). Sustainability can be improved by applying optimal BoL, MoL and EoL planning [9]. Design strategies in the BoL focused on circular economy concerns, for instance, are important to achieve environmental benefits [6]. Issues regarding disassembly, ease of distribution and return, and customer reliability in the MoL are also relevant for sustainability improvements in the context of the circular economy [7]. Indeed, the shift towards circular business models affects the design, production, use, and disposal processes [11].

PSS complete lifecycle management, in fact, may play an important role to improve the offering and achieve sustainability benefits [9]. However, bottom-up issues for CE implementation in the industry such as lifecycle management are still little discussed in the literature, and more research is needed [12]. In this context, this paper aims to investigate how lifecycle management of PSS business models may contribute to achieve environmental and economic benefits that have been highlighted in the circular business models literature (e.g. [5]) and to achieve CE requirements. Some methodological features of case-based research were applied to examine how some lifecycle management practices adopted by a large manufacturing company that implemented a new business strategy - by transitioning from the conventional sale of products towards a business model focused on satisfying consumer needs by the provision of 'functions' - may contribute to environmental and economic gains. Although circular business models have been discussed as promising, there is not yet a widespread adoption of circular business in industry [5].

In fact, the understanding of the effects of circular business and consumption models implying the selling of an integrated service and products or its leasing, refurbishment and remanufacturing has been pointed out as a research gap in CE literature [7]. Thus, this paper aims to explore a PSS business strategy adopted by a large white goods manufacturer that transitioned from a linear to a circular business. Its purpose is also to provide some insights regarding benefits that can be achieved by adopting lifecycle management practices in a business model focused on the provision of services through a leasing scheme. In addition, few studies have investigated PSS in emerging economies [13], and since the business model under analysis is located in the context of a developing country (Brazil), this study intends to make contributions in this sense as well. Indeed, sustainable business models such as PSS that focus on the reorientation of current consumption and production patterns may bring benefits for developing countries, since sustainable production and consumption is a major challenge for emerging economies, especially in fast-growing regions such as the BRIC countries [14].

The remainder of this paper is structured as follows. Section 2 presents a brief literature review on sustainable PSS business models and circular business concepts. Section 3 describes the methods applied for gathering and analyzing data. This is followed by the findings and a discussion of the PSS business under analysis anchored in the literature. Finally, concluding remarks are drawn in section 5, since this is still a work in progress, as well as the study limitations and further work.

2. Product-service systems as circular business models

In the context of circular business models, a PSS can be seen as a business strategy for slowing resources loops; the product life is extended, the product is reused, and companies can capture financial benefits from going circular, which they would not be able to achieve in a linear model [6]. The retained ownership in PSS facilitates the return flow of used products to the producer [5]. Circular businesses such as PSS allow a range of benefits, including cost savings in manufacturing, enhanced customer relations, improved customer behavior understanding, improved margins, reduced environmental impact and increased brand protection [5].

The major components of a sustainable business model are [2]: (i) value proposition, (ii) value creation, and (iii) value capture. According to the business models archetypes proposed by Bocken et al. [2], in a PSS business strategy, the value proposition focus on providing services that satisfy consumer needs without users having to own physical products. The business focus shifts from manufacturing goods to maximizing consumer use of products, reducing production throughout of materials and better aligning manufacturers' and consumers' interests. The value creation and delivery require significant changes within the firm and incentivize redesign for durability, reparability, and upgradability. The value creation also involves more direct consumer contact and consumer education to shift away from ownership. The value capture model is focused on the payment for the use of the service, not for ownership of products. This can enable consumers to access previously expensive products [2].

The management of PSS offerings lifecycle considering CE concerns may be valuable to improve their sustainability potential [9]. Design strategies for the value creation and delivery should be addressed in the BoL, when the PSS design is performed [10]. Consumer contact and education in the business model value creation should be considered in the use phase of the MoL. Production and materials consumption reduction may be achieved through maintenance and EoL strategies management (remanufacturing, reuse, and recycle).

Nevertheless, the provision of integrated products and services is not inherently more resource efficient than traditional production and consumption systems, so more research is needed to explore how trajectories of service innovations may be managed to improve resource productivity [15]. Lindahl et al. [16], for instance, have demonstrated that environmental and economic benefits can

be achieved with reuse and recyclability in integrated product service offerings. Chun and Lee [17] analyzed the environmental impacts of a use-oriented PSS in comparison with the traditional business model and demonstrated that maintenance services should be planned in order to improve the environmental performance of the offering. Although some studies have been conducted, more research regarding PSS environmental performance is still needed [18]. In fact, there is still a lot to be learned regarding circular business implementation in practice and metrics to analyze sustainable business models in the context of CE [19]. Thus, lifecycle management practices and their value to obtain environmental and economic gains in the context of circular business implementation are explored in this study. Next section outlines the research procedures to analyze the PSS business model investigated in this paper.

3. Research design

Due to its nature, this study presents some methodological characteristics of case-based research [20]. As the purpose was to explore how lifecycle management practices may be valuable to achieve sustainability benefits aligned with CE requirements, guidelines for case-based research (e.g. [20]) were considered suitable and followed.

The first step in the research design was the development of a conceptual framework. Thus, an analysis of PSS and sustainable business model literature was carried out (refer to section 2) to establish a suitable lens for the analysis. Firstly, the business model elements of the investigated PSS were analyzed, using the sustainable business model framework as proposed by Bocken et al. [2]. The analysis of the business models elements was useful to understand how CE principles are integrated into the value proposition, value creation, and value capture. Afterward, the lifecycle management practices were identified from the data collected in order to explore how practices adopted in the BoL, MoL, and EoL may be valuable to achieve environmental and economic gains, in the light of the literature.

The unit of analysis (PSS) was selected by following the information-oriented approach recommended elsewhere [21]. In this approach, units should be selected based on the expectations for the information content. As mentioned earlier, this study was conducted in an emerging economy. The investigated company is a larger manufacturer of household appliances that implemented a new circular business strategy as part of its business. This is valuable because most of the manufacturing industries still adopt the linear business model strategy [5]. For manufacturing companies the development of new innovative business models that fit the CE context is vital [12].

The business model is a use-oriented PSS (according to the categories proposed by Tukker [22]) focused on leasing appliances for filtering drinking water in households, small firms and large companies to some extent. Use-oriented PSS potentially intensify the use of material products and hence could reduce the need for materials [23], being a suitable PSS category for analysis in the context of CE. In addition, as emphasized earlier, studies of PSS solutions located in emerging and developing economies are relevant because in those regions a PSS may contribute to sustainable consumption and production goals [13]. Since this PSS has potential to present outcomes about the aspects investigated, it was selected for analysis.

Multiple techniques for collecting data were used, including primary and secondary sources. Some semi-structured interviews were conducted with managers from different functional areas (product engineering, sustainability management, production, marketing, and customer service) to gather data regarding the business model operation as well as practices of lifecycle management they adopted. Internal company reports were also accessed and examined to understand specific aspects of the business model and product development processes from a longitudinal point of view. Data were triangulated to derive the findings.

The analytic strategy involved working on the data from the ground up [20], with some concepts emerging by examining the data, using an inductive approach. The findings were analyzed anchored to the literature (no specific constructs were used in this exploratory stage of this work). An analytical description was obtained, which is outlined in the next section.

4. Results and discussion

4.1. Business model structure and context

The PSS under analysis is offered by a leading home appliance company in Latin America. The analyzed business has been in operation since 2003. This business was developed and implemented as a novel strategy for entering a new market, and it is now operated throughout the country. The introduction started with an analysis of the market, which detected some trends and opportunities. Those included the emergence of several types of services based on subscriptions in addition to a fast growth of the mineral water market in the region where the company is located. Those issues motivated the advancement of the business idea as a new business unit.

The company leases a water purifier appliance and provides product installation and maintenance services. Long-term contractual agreements are established between customers and the company. The customers are citizens or other firms (i.e. the business operates in the business-to-business - B2B - and business-to-consumer - B2C - markets). The provider retains ownership of the product, and the customer pays a monthly charge for its use. The company has the full control over the product lifecycle. It collects the product through a reverse logistics process at product end-of-life. The product can be remanufactured and reused or discontinued (and its components recycled). It is considered a pioneering concept in the Brazilian market.

Regarding the business model elements, the value proposition of this sustainable business model consists on the provision of “safe drinking water”. This is particularly important because the quality of water from the supply networks in many regions of the country is questionable. In addition, the consumption of bottled water has increased considerably in the country, which may generate

environmental impacts associated with plastic bottles consumption.

The interests of the manufacturer and customers are aligned; the former aims to offer a more sustainable solution to drinking water provision while increasing its market share in the home appliance industry. The system satisfies a population need and also may focus on reducing the environmental effects associated with bottled water consumption. A non-governmental organization (NGO) is one of the partners involved in the business and it encourages, through marketing campaigns, the reduction of water consumption in plastic and glass bottles through the adoption of filtered water in restaurants and bars (which are some of the consumers in the B2C market).

Value is created from the integrated collaboration of the service provider, consumers, suppliers, and a recycling company and associated recyclers involved in the product end-of-life. The value capture is structured in a way that affords customers access to the service provided, and it is not oriented toward product ownership. Company's practices adopted throughout PSS lifecycle that may be valuable to achieve environmental and economic gains are outlined next.

4.2. PSS lifecycle management

Some of the practices adopted by the company across lifecycle phases were identified from the collected data. They are summarized in Table 1. Fig. 1 provides an overview of the full lifecycle and the main activities involved.

Table 1. Some practices adopted along PSS lifecycle.

Lifecycle phases	Practice adopted by the provider	Environmental/economic benefits aligned with CE requirements[1]
BoL - Design	Design for maintenance and repair	Increasing of value durability of products
BoL - Design	Careful selection of materials	Increasing of value durability of products, reducing valuable materials losses, reducing input and use of natural resources
BoL - Product manufacturing	Implementation of a waste minimization program	Reducing valuable materials losses
BoL - Implementation	Assessment of the local conditions before the product is installed	Increasing of value durability of products
MoL - Maintenance	Running of mechanical, chemical and biological tests	Increasing of value durability of products, reducing valuable materials losses
EoL - Recycling	Primary recycling of components	Increasing of value durability of products, reducing valuable materials losses
EoL - Remanufacturing	Remanufacturing of components	Increasing the value durability of products, reducing input and use of natural resources

[1] Requirements to be measured in a paradigm shift towards CE involve [24]: (i) reducing input and use of natural resources, (ii) reducing emission levels, (iii) reducing valuable materials losses, (iv) increasing share of renewable and recyclable resources, (v) increasing the value durability of products.

The beginning of life involves requirements generation and analysis, the design process, product manufacturing and PSS implementation [25]. As described earlier, this business model was structured based on the need of a more sustainable way of providing drinking water. The requirements were identified through the market analysis carried out when the business was planned. Regarding the design process, the product in the system was designed to extend its utilization period in order to increase its durability and reduce the use of resources. It is designed to facilitate its maintenance and repair. The internal components that are replaced periodically (e.g. the filter) are strategically positioned allowing the easy access during the maintenance process. This allows the product life extension and slowing resource loops, corroborating with CE concerns during the design process [6]. In fact, the design of circular products needs to be 'fit for purpose' according to the chosen business model [26], and the design strategy adopted is in accordance with the value proposition strategy developed by the company.

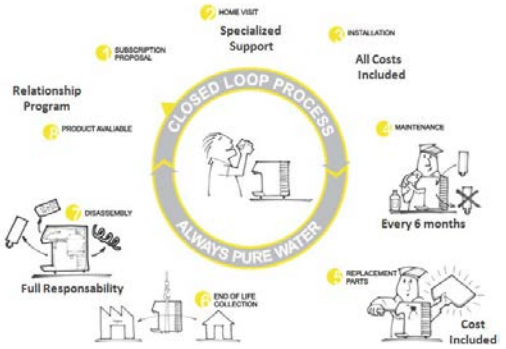

Fig. 1. Overview of lifecycle and main activities involved [27].

Moreover, the materials used in the purifier are cautiously selected during the design process to ensure the durability of the product, reducing input and use of resources, and to provide consumer safety. The materials are thoroughly analyzed concerning their resistance against corrosion and degradation. The selected materials must be resistant because during the products' life a wide range of assembly operations and maintenance services are performed. In fact, reusability puts higher requirements on quality regarding durability [16], and the correct materials selection allows increase the durability. In addition, the careful selection of material is important because in the context of CE the design strategies should include decision points to be made during the course of product design which is linked to the criticality of materials [12].

With regard to product manufacturing, the company applies cleaner production practices such as the implementation of a zero waste program in manufacturing that have contributed to reduce materials losses. According to collected data, more than 150 tons of waste from the water purifier production process was recycled so far due to the implemented waste reduction practices.

Regarding PSS implementation, the provider offers the installation services. A technician firstly visits the location

where the water purifier is going to be installed in order to conduct a preliminary assessment of the technical conditions of the place (e.g. hydraulic pressure of the supply network which may vary across the cities all over the country). This practice allows the provider to adapt the product according to the specific conditions of the place and use, and also can reduce the risks of failures in operation. This consequently contributes to increasing the product durability. After the water purifier is installed, information about the system use is delivered to the consumer. This proximity to customers is valuable to understand consumers' behavior. In fact, building and maintaining relationships with customers is one of the essential principles of the circular economy implementation [28].

The middle of life involves the use phase and maintenance services. During its operation, a PSS has to be supported to retain its functionality, availability, and operational results [22]. Preventive maintenance is performed by the provider every six months during the equipment use phase. A technician goes to the place where the water purifier is installed and performs a number of quality tests. The quality of the water filtered is verified to comply with the national health standards. If the water quality is not in accordance with the chemical and biological parameters established by a national law, the filter is replaced. In addition, the equipment is cleaned by the technician and mechanical tests are done to verify equipment components integrity. Besides enhancing consumer relations, those activities performed in the MoL allow cost saving. Since the filter is replaced only when necessary, this consequently reduces resources consumption. In fact, maintenance aspects should be carefully planned in order to improve the environmental performance [17], and the operational practice regarding maintenance adopted by the company allows reducing resource consumption by increasing the durability of the product and avoiding waste.

In addition, the mechanical tests are important to reduce the risks of failure and to extend the components' life. If some repair is necessary, the technician can perform it *in loco*, when possible. In the case of complex problems, the equipment is fully replaced, and returns to the company for examination. A complete assessment and test of equipment conditions are then conducted.

Two main strategies are adopted in the EoL. After a careful evaluation, the product and its components can be remanufactured or discontinued. If a high failure rate is detected, the equipment is discontinued. Then, the components are separated in a waste treatment center and are sent to recyclers who are partners in the business. Complex systems are disassembled and separated into single components. Although there might be considerable challenges associated with creating the required understanding and incentives for key partners [5], the stakeholders involved at the EoL in this circular business are engaged and have economic benefits with the recycling process. The provider manages the recycling process (a specialized company was established to deal with EoL recycling) and the recyclers that work as partners should provide evidence that the materials are recycled through the provision of a document certifying the components correct final destination. A primary recycling is performed, aligned with the recycling methods proposed by Bocken et al. [6], closing the resources loop. All company's subsidiaries are certified as 'zero waste' and all materials consumed in the company are recycled. This collaborative relationship between the service provider and recyclers at the EoL was observed as relevant to reduce waste and to achieve resource efficiency. Lack of channel control has been reported as a critical barrier in CE literature [5], and the right collaborative networks at the EoL and the management practices adopted by the company to ensure correct destination of materials were observed as a positive practice to obtain environmental benefits. In fact, collaboration and arrangement between various stakeholders are essential to implement new business models in support of a circular economy [11], and to obtain successful lifecycle management as well [29].

After product assessment, if the components can be reused, those are remanufactured. As pointed out by Linder and Williander [5], reuse and remanufacturing are often preferable to recycling, for economic reasons. Although remanufacturing requires considerable expertise, the company has specific remanufacturing production lines. Besides economic benefits, remanufacturing allows minimizing the consumption of resources. Therefore, as already pointed out by Goyal et al. [30], it becomes significant for the companies to design and implement the business models, which maximize the gains from the circular economy approach, not only with respect to one paradigm (reuse/remanufacturing or recycle), but also taking into consideration the combination of paradigms.

In summary, the activities performed during the lifecycle were identified as valuable to orient actions that allow environmental improvements through the reduction of resources consumption and waste generation, in addition to provide economic benefits to the provider. After presenting the findings of this work, next section highlights its main concluding points.

5. Concluding remarks

This paper investigated lifecycle practices adopted by a manufacturer that transitioned from the conventional business model of selling products towards as business model focused on the provision of services to satisfy customer needs. The company's various environmental initiatives target different parts of product's lifecycle, from design to the product's end-of-life phase. All activities performed across the PSS lifecycle are oriented and valuable to extending the product life and reducing the consumption of resources, in alignment with CE requirements. Cost savings can be obtained with the activities carried out across the lifecycle stages, although this aspect was not yet assessed, since this work is still in progress. Design strategies aligned with the business strategy are adopted. A close consumer relationship strategy during the use phase is employed, allowing performing continuous improvements in the business models. Partnerships with stakeholders at the end of life and the adoption of distinct decision paradigms (e.g. remanufacturing or recycling, depending on the product conditions) are also employed, which may also contribute to achieving resource efficiency.

This paper intends to contribute to the current body of knowledge in two different ways. Firstly, the findings suggest that activities performed across the lifecycle, i.e. the lifecycle management of a circular business may be valuable to achieve resource efficiency. Some of the identified lifecycle management practices are context related, but others such as the design, adoption of cleaner production practices in the product manufacturing phase can be applied in the lifecycle management of other circular business models. From practitioners' point of view, the findings provide an overview of some practices that may be valuable to improve environmental and economic performance, although this still needs to be assessed. Since circular business models are still little explored in practice, this investigation may provide some contributions to the current empirical body of knowledge in circular business implementation. Secondly, circular business and PSS solutions have been explored mainly in developed economies, and the literature claims for more studies in emerging markets. Thus, this paper also offers a marginal contribution in this sense.

The main limitation of this study is related to the exploration of a single unit in addition the depth of the current analysis. As a work in progress, further research will involve a more in-depth investigation by considering the transition process towards this novel sustainable business model. Further work may also explore and compare lifecycle management practices adopted by other and distinct PSS categories in the context of CE as well as to understand how different lifecycle management practices may contribute to achieve resource efficiency.

Acknowledgements

The authors thank the company that made this study possible. However, any analysis is the responsibility of the authors and, thus, it does not represent the position of the company. One of the authors is affiliated to the Federal University of Santa Catarina (UFSC) so this institution should be acknowledged as well. Finally, the authors also appreciate the Brazilian research agency CNPq for the financial support.

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