A.H.C. Ng et al. (Eds.)

doi:10.3233/ATDE220126

Exploring Challenges to Design Product-Service Systems in SMEs – A Case Study

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Abstract. The transition towards a circular economy (CE) is part of the solution to reduce the global consumption of natural resources and increase resource efficiency in society. Product-Service Systems (PSS) is seen as one of the effective ways of moving towards a CE. PSS leads to an increase in product use by sharing or renting, and by extending material and product lifecycles through repair, remanufacturing, reuse and recycling. Therefore, designing PSSs have great potential to facilitate the CE transition. Many SMEs show an increased interest in a CE transition; however, they fall short in taking the right path towards designing PSS. Designing PSSs involve a rearrangement of resources, and SMEs usually do not possess the same resources as larger firms. Previous research clarifies that the transition from traditional product design to designing PSS is challenging for SMEs. This paper adds insights to the PSS literature and industrial practices through a single-case study by identifying and describing the challenges an SME may face when intending to design PSS. The data is based on interviews, workshops, and internal archive documents. The findings show that an SME faces both internal and external challenges. The internal challenges related to time constraints, the current business model, lack of financial resources, organisational structure and internal processes, dedicated employees for business and service development, and competence. The external challenges relate to SMEs position in the value chain, customer interests in PSS solutions, and handling of reversed logistics.

Keywords. PSS, Servitization, Small and medium-sized enterprises, Challenges, Circular economy

1. Introduction

Research on circular economy (CE) has gained increased attention during recent years [1] due to its potential to address the sustainability issues in society by changing the current production and consumption model [2]. The CE aims to close material cycles [3] and preserve the economic and environmental value of materials as long as possible [4]. CE is defined as *"a regenerative system in which resource input and waste, emission, and energy leakage are minimised by slowing, closing, and narrowing material and energy loops. This can be achieved through long-lasting design, maintenance, repair, reuse, remanufacturing, refurbishing, and recycling."* [5, p.759].

Although CE actions have been acknowledged as important for firms to adopt, most of the studies on CE have been conducted from a large-company perspective ([6-9]).

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Meaning there are fewer studies on the role of Small and Medium-sized Enterprises (SMEs) in the transition to CE, focusing on understanding SMEs' potential to support CE and the challenges and opportunities SMEs face in this transition. This lack of knowledge is problematic as there are about 25 million SMEs in the EU-28 (2018), representing 99,8% of all enterprises [10]; hence they are significant players in the transition towards a CE.

Integrating products and services are considered essential when developing more sustainable solutions, and offering product-service systems (PSS) can improve the circularity of businesses [11] and is therefore seen as a means to realise a circular economy [12]. PSS is defined as: "*A mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs*" [13, p. 1552]. Designing PSS aims to produce solutions rather than physical items [14] and involve designing a complete system, including both physical items and services [15, 16]. To design PSS, companies need a system approach, which requires close integration of all actors within the life cycle of the PSS [17].

Offering PSS is mentioned as a strategy for SMEs in the CE transition [8, 18], as it allows firms to build relationships with customers, enhance customer loyalty, fulfilling customer needs in an integrated way, and possibly innovate faster as they have more insights into their customers' needs [19]. However, re-designing products and services to offer PSSs involve a rearrangement of resources, and this is challenging for SMEs as they usually do not possess the same resources as larger companies [6, 20]. Besides, SMEs usually do not design their products as they are often suppliers to original equipment manufacturers (OEMs) [21], which means that they are generally not responsible for products delivered to the end-customer [8]. However, SMEs can still play a critical role when designing PSS to enable a CE transition. In particular, collaboration and transparency throughout the value chain are acknowledged as important enablers for a CE transition [22], and SMEs could fulfil this role as an intermediary to enable the required transition.

Although many product manufacturing SMEs have shown an increased interest in a CE transition [23], they fall short in taking the right path towards designing PSS [7]. There are studies on challenges SMEs experience when designing PSS. However, the majority of these studies have a quantitative perspective [e.g. 24, 25]. In addition, an extensive survey has been carried out on European SMEs focusing on CE [26], where challenges related to PSS are only addressed to a limited extent. Thus, there is a need to gain a deeper understanding of the challenges SMEs experience when designing PSS, also taking the industrial context into consideration. The purpose of the study presented in this paper is to identify and describe challenges that SMEs may face when intending to design PSS. This leads to the following research question (RQ):

RQ: What challenges are prominent for SMEs when aiming to design PSS?

To address the purpose, a case study has been performed in collaboration with an SME in the electronics industry that operates as a contract manufacturer. The study found nine challenges the SME is experiencing when designing PSS. The results will contribute to the discussion of challenges and required support for designing PSS in an SME context. The remainder of the paper is organised as follows. The next section presents the theoretical background related to SMEs characteristics, PSS design, challenges towards PSS design in SMEs, followed by a description of the research method. Thereafter, the

results are presented, and finally, the paper ends with a discussion, conclusion, and suggestions for further research.

2. Theoretical background

2.1. SMEs characteristics

SMEs are defined as "enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million" [27/361/EC]. Previous research has highlighted that SMEs are not smaller versions of larger companies [28] as their organisations differ from larger organisations [29-31]. SMEs have a short decision-making chain and a low degree of standardisation and formalisation [29], which means that their internal processes make them quicker and more flexible in deciding and acting [32]. Because of this, SMEs are considered flexible firms [29, 32] and can quickly respond and adapt to environmental and market changes [7, 29]. As SMEs have fewer formal rules and procedures, they encourage creativity and experimentation, leading to more innovative ideas. Their organisational structure and the degree of formalisation and standardisation procedures could significantly influence innovativeness, the effectiveness of innovation projects, and the speed of new product development processes [33].

2.2. PSS design

Product development is "the set of activities beginning with the perception of a market opportunity and ending in the production, sale and delivery of a product" [34, p.2]. PSS design differs from this traditional view of product development by adding a service dimension to the design activities. PSS design is both about the product offering as well as the design of the complete product-service system [15], leading to the need to combine both product design and service engineering methods [35]. Products have dimensional, aesthetical, technological and mechanical characteristics and are designed by their features [36, 37], whereas services are designed in chains of activities [38]. These different types of design require a design process with integrating procedures that can deal with both products and services [36]. Therefore, the PSS design process requires a predefined design process [38, 39] that includes a mix of design tasks that need to be performed simultaneously, requiring interdisciplinary teams [39], since there is no clear definition of a PSS designer [40]

When developing products for PSS, it is important to have a life cycle perspective [15], seeing that the product design is of great importance throughout the PSS life cycle [41], meaning that product development is essential in the PSS design process [42]. Because of this, the PSS design process needs an integrated methodology to make the combination effective [36] and to create products and services that match the criteria for CE actions such as PSS; product designers must therefore change their design thinking [43]. When offering PSS, companies should focus on designing products to extend the products lifecycle, which means that products should be easy to maintain and repair [44] by designing modular products and components[45].

Several methods for PSS design exists [40, 46-48]. However, existing PSS literature provides limited guidance to companies wishing to design PSS, and few methods have

been evaluated in an industrial context [40, 49, 50]. Although the concept of PSS was established in the mid-1990s [46], the use of PSS among practitioners is limited[51].

2.3. Challenges towards PSS design in SMEs identified in prior research

Although there are few studies on PSS design in SMEs, prior literature has revealed several challenges. Compared to larger companies, SMEs do not have the same resources [6, 20, 52]. One of the most common challenges mentioned in previous research for SMEs to design PSS is the financial challenges and the lack of financial support [6, 8]. Due to SMEs characteristics, they find it challenging to realise and design PSS offerings as it requires a new organisation, new customer relationships, new contracts and new financial models [53]. Research shows that due to their limited resources, SMEs find it challenging to develop a PSS business model [20], and due to a lack of formal business strategies, they also find it challenging to define a service strategy [54].

Developing a service culture is essential at every level for PSS design, encompassing managerial tools that need to be cross-disciplinary and the education of the final customer [55]. Replacing the value of exchange by value in use involves long-term relationships [6, 56], but SMEs have limited external contacts [29] and find it challenging to initiate partnerships and secure long-term relationships with other companies [6]. They also lack the customer support [8] needed to guide the transition towards offering PSS. SMEs also lack management commitment and vision [57] which could lead to challenges in changing mindset internally and developing a service culture [56].

SMEs also lack knowledge and competencies related to sustainability [7] and PSS design [6]. Besides, existing methods for designing PSS are too complex for SMEs [7] due to their characteristics and limited resource, meaning that they also lack methods to design PSS [6, 25]. Regulations and administrative processes are also emphasised as challenges [24].

In addition, designing PSS requires fundamental changes in the organisation, in both its strategy and structure, meaning that the company needs to innovate in multiple areas [58]. This is one reason why firms re-designing products and services are likely to perceive all challenges, such as competencies, finances, administrative procedures, and regulations, equally important [24].

3. Research method

This study is based on a case study design [59]. A case study design was considered appropriate due to prior research focusing on SMEs' challenges when designing PSS from a quantitative research approach. Hence, there is a need to explore in which industrial context the challenges appear, and a case study is preferable when a new phenomenon is to be explored [60, 61]. We employ a single in-depth case study approach to fully understand the phenomenon since a single case study generates an opportunity for significant depth of exploration [61]. The case company selected for the study was an SME in the electronics industry that operates as a contract manufacturer, with just over 50 employees. The case was selected based on the intention of the company to change its customer offering and market itself as a full-service partner. The company was thus at the beginning of designing PSS. In addition, the company is a service provider to electric vehicle batteries, where there is currently a major interest in circular business models, which makes the company an interesting case for further investigation.

The data was collected primarily through interviews and workshops. Interviews are a primary source of evidence in a case study design [60, 61], and workshops can help understand data obtained through interviews [62]. In addition to interviews and workshops, we were also provided with internal archive documents (by informants) to gain an understanding of the company's organisation and customer offerings.

Interviews and workshops took place online due to the covid-19 pandemic. Five in-depth online interviews were conducted with four senior managers at different organisational positions (i.e., Managing director, Sales and Marketing, Quality and Sustainability, and Production and Logistics), who represented central roles within the SME. As designing PSS requires changes in several parts of the organisation, it was vital to get the perspectives from different managers to cover challenges within their respective areas of responsibility. Getting an overall picture from the managing director through two in-depth interviews and additional data from the managers respectively reduced the risk of overlooking significant challenges.

The duration of the interviews was around one hour, although some interviews were longer (Table 1). The interviews were semi-structured. We draw upon theoretical concepts from the literature on SMEs and PSS design, and these were used as a base in the development of the interview guide. All interviews were recorded and transcribed verbatim. Two workshops were conducted that lasted between 60 – 90 minutes. These workshops were held with the researchers, the Managing Director, and the Sales & Marketing Manager.

A thematic analysis [63] was conducted using Nvivo 12 to organise, structure and code the data. The analysis began with reading notes from the workshops and transcriptions from the interviews to get familiarised with the data. Further, initial codes for the analysis were created based on the identified challenges found in prior research. The transcriptions were then read systematically, and additional codes emerged. These codes were then grouped into categories, which were finally divided into two overarching categories: internal and external challenges.

Table 1. Description of interviews and workshops

Informant	Interview duration	Number of interviewers
1	58 min & 1 hr 19 min	2 & 3
2	1hr 31 min	1
3	49 min	2
4	1hr 13 min	3
Workshop	**Workshop duration**	**Participants**
1	1 hr 30 min	Researchers, Managing Director, Sales & Marketing Manager
2	1 hr	Researchers, Managing Director, Sales & Marketing Manager

4. Empirical findings

This section presents the nine challenges identified in this paper, categorised into two overarching categories: internal challenges and external challenges (Table 2). The internal challenges are related to time constraints, the current business model, lack of financial resources, organisational structure and internal processes, dedicated employees

for service development, and competence. The external challenges relate to the position in the value chain, customer interests in PSS solutions, and handling of reversed logistics.

Table 2. Prominent challenges for SMEs aiming to design PSS

Internal challenges	External challenges
Time constraints	Position in the value chain
Current business model	Customer interests in PSS solutions
Financial resources	Handling of reversed logistics
Organisational structure & internal processes	
Dedicated employees for service development	
Competence	

4.1. Internal challenges

4.1.1. Time constraints

One challenge that all informants touched upon is the lack of time when shifting towards offering PSS. Time is expressed as a limited resource and is seen as one of the main challenges to designing PSS. "*I think you need to reserve some time actually to think through what you can have as a potential offer and then start working on how to bring that out for a potential market. (Informant 4)".* However, a challenge is to take time as the daily tasks are often prioritised, *"Since time is a limited resource, we just focus on what we're doing today" (Informant 1)*. Nevertheless, to design PSS, the informants see that it is crucial to devote both time and human resources to look externally for opportunities and not just focus on the internal activities.

4.1.2. Current business model

Many of the informants believe they need to design their own products to be able to design PSS and offer service agreements. However, they express difficulty transitioning from being a contract manufacturer to becoming product owners and offering PSS, both in terms of resistance from customers regarding ownership but also changing the business model. *"As long as we are within the field of being a contract manufacturer, I think it will be difficult to actually step away from that too much." (Informant 4).* Some informants were hesitant to offer PSS and change the business model. *"If we only focus on products we have, then it would be hard. But if we focus on what services others could have use of, then we might open up a bit" (Informant 1)*. Still, being open-minded and thinking in a new direction were considered necessary by the informants to be able to design PSS and become more circular. It was also expressed that if they want to be ahead of knowledge, they need to be interested in learning new things. Nevertheless, some also highlighted that they respect that building new knowledge and developing the organisation takes time, and time is seen as a limited resource and a challenge.

4.1.3. Financial resources

The financial resources are also seen as challenges when designing PSS,*" You will not be able to invest a lot of money in that unless you have some money left over to actually invest" (Informant 4).* The informants also emphasised that developing services, changing the current business models, and offering PSS must be financially justifiable.

Although some also mentioned the possibility of applying for development money through funds.

4.1.4. Organisational structure and internal processes

To offer their own products and design PSS, the informants stressed that they lack a design department, as the customers today take care of the design and R&D of products. They also mention that product development needs to be linked to the company's strategy to be able to grow as a company. The company also lacks a service development process but is hesitant that they need one to design PSS. *"We are maybe not that proactive in that type of work […]. The customer contacts us and checks if that is something that we can provide them with, but here we could definitely be more proactive." (Informant 4)*. In addition, some mentioned the need for other departments, such as a service department, to be able to repair products without affecting the ordinary production flow.

4.1.5. Dedicated employees for service development

Lack of dedicated employees and workforce is also a significant challenge to designing PSS and working with customers when developing products. *"[…] we quite rapidly and easily come in a situation, where we just haven't that amount of resources, to step into a large second project, for instance. [..] So you quite easily come to a point where the resources in total will limit you." (Informant 4)*. Besides, to be able to design PSS and at the same time change the business model, they need employees devoted to business and service development. The informants expressed demands for a clear delegation of area responsibilities for this type of development within the company, as they need to develop a service organisation and lack employees who focus entirely on service development and the aftermarket.

4.1.6. Competence

The informants disagree on the competence needed for designing PSS. *"I don't think we need more or other competence. It's more about the opening of minds and thinking in new directions" (Informant 1).* Others believe they lack technical knowledge about design features and production knowledge to be able to have solutions and technical sales discussions with customers. *"You will have parts and sections where you need to judge that with experienced persons. […] So that is really the key in this. So, without those persons, we have difficulty to contribute to those discussions." (Informant 4).*

4.2. External challenges

4.2.1. Position in the value chain

Another main challenge highlighted by the informants is being a contract manufacturer, which means that they do not own the product. Because of this, the company have difficulty influencing the product design and have little control of the product after being delivered to their customers. As a subcontractor, they need to rely on both suppliers and customers and gets involved in the product development process when the customer already has a product design. *"The design is already written in stone when it reaches us. So, I don't see that we can impact very much" (Informant 3).* They believe they need to come in earlier in the product development process to have a chance to offer expertise

and guide the customer. However, according to the informants, one of the challenges is to discuss their involvement in the development process with the customers.

Further, there is uncertainty about which actor is responsible for the aftermarket and services related to the products when designing PSS. The informants clarify that since the customer owns and designs the product, it also has the responsibility to think about the circularity and aftermarket. However, if the company is to offer services, such as repairs, there are uncertainties about which responsibilities fall on them *"It would be a question about to first make some kind of inspection […] Is that something that we should do or is that something that the customer already has done?" (Informant 4).*

4.2.2. Customer interests in PSS solutions

The company sees opportunities in contributing with expertise when working with customers developing new products and business opportunities with a potential aftermarket. Nevertheless, some informants believe the customer demand for services is low, and as they are dependent on their customers, it would be difficult to change the business model. *"We can have the discussion with them [the customers], but if there's no interest from our customer, then it becomes a bit of a hard topic to drive in some way. Then we need to find our own way of creating a business with some type of sustainable approach" (Informant 1)*. However, the company have limited internal and external discussions about what kind of services they could offer their customers. Some highlighted a need to be better at marketing themselves and informing customers about their offerings. In addition, the current customer portfolio is also seen as a challenge when designing PSS and offering expertise within many areas *"We are serving quite many different industries and different type of customers and it is bit of a challenge to actually get deep enough, within different industries, when you have such a broad offering" (Informant 4).*

4.2.3. Handling of reversed logistics

Reversed logistics is also perceived as a challenge when designing PSS. Today customers return a few products for rework, and it is often unclear what needs to be done with the product. Some informants express poor communication between the customers and the company when it comes to product returns. *"If it is not preceded by any communication, it becomes time-consuming and often inefficient" (Informant 2)* and clarifies that they need a proper service process for the reverse logistics to work if they are to offer more services. *"We live a lot on flexibility, but I think we would need to be less flexible and try to live by a set process" (Informant 2).* This is also supported by other informants saying they need to standardise their work to handle the different operations needed to bring parts back and refurbish them while at the same time manufacturing new products. Some question how to handle these operations in the same type of production process, while others mean they need two separate production flows. Some also believe that offering PSS will lead to increased goods handling and that their premises are too small to handle it.

5. Discussion, conclusion, and further research

This paper contributes to the literature on PSS by identifying and describing challenges that SMEs may face when intending to design PSS. First, one conclusion is that SMEs'

challenges can be described based on an internal and external perspective. The identified findings show that internal challenges relate to time constraints, the current business model, lack of financial resources, organisational structure and internal processes, dedicated employees for service development, and competence. The external challenges relate to the position in the value chain, customer interests in PSS solutions, and handling of reversed logistics. The findings in this study are consistent with prior research that stresses that SMEs has limited resources [6, 20]; therefore, they find it challenging designing PSS. However, this study adds to the knowledge about the challenges SMEs faces by identifying time as another challenge to be considered, as they are occupied with daily activities and are therefore unable to focus on designing PSS. Based on the findings, another conclusion is that the challenges SMEs may experience intending to design PSS are not independent of each other. The findings show that the challenges are interwoven, meaning that SMEs might find difficulties knowing what challenges they should prioritise.

Furthermore, this study also sheds light on the importance of the context when discussing challenges SMEs face when designing PSS. For example, for the studied SME, being a contract manufacturer and its position in the value chain is perceived as a challenge as they are dependent on their customers. Previous research stresses the importance of designing PSS with a life cycle perspective [16] and including all actors in the value chain. However, this is seen as a challenge as they are dependent on their customers' acceptance to design PSS, which make the studied SME question if they should design PSS with their customers or find their way of creating a business even though they experience a lack of time and other vital resources. Previous literature highlight that SMEs should strive for customer acceptance when designing PSS [8]. However, the findings show that the studied SME may not reach customer acceptance due to their position in the value chain. Hence this study shows the importance of considering the context when SMEs are to design PSS. Therefore, future studies should focus on developing the understanding of PSS design challenges while considering the context of the SMEs. There is a need for additional qualitative research on the research topic. Further research is also needed on how SMEs should handle and overcome these challenges to be able to support a CE transition.

Additionally, the study has important managerial implications for SME managers, as this study can be used as a checklist to highlight challenges managers need to consider when intending to design PSS.

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