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How the characteristics of small and medium-sized enterprises influence product-service systems design challenges

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Abstract: Manufacturing companies can contribute to a resource-efficient society by designing product-service systems (PSS). Despite the increased importance of PSS for the manufacturing industry in their efforts to become sustainable, few studies focus on small and medium-sized enterprises (SMEs). The study presented in this article aims to add knowledge on how the characteristics of SMEs influence the challenges SMEs experience when designing PSS. It employs a multiple case study design where data are based on interviews, workshops, and internal archive documents from three contract manufacturing SMEs. The analysis suggests that nine SME characteristics

influence the challenges SMEs experience when designing PSS. It also shows that SMEs' different characteristics influence one or more challenges, and that SMEs have a short-term horizon and a reactive business approach which influences the overall challenge of designing PSS.

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Keywords: product-service systems; PSS; servitisation; small and medium-sized enterprises; SME; firm characteristics; challenges; sustainability; manufacturing companies; contract manufacturing.

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1 Introduction

The manufacturing industry has a considerable impact on the environment (Garetti and Taisch, 2012), and improving sustainability in manufacturing companies has become one of the critical factors for survival and long-term business success (Oncioiu et al., 2018; Yang et al., 2017). Scholars suggest that one way for manufacturing companies to become more sustainable is through product-service systems (PSS), which implies combining products and services to create closed material cycles and reducing consumption and product usage (e.g., Kjaer et al., 2019; Mont, 2002; Tukker, 2015). The concept of PSS can be defined as “a mix of tangible products and intangible services designed and combined so that they are jointly capable of fulfilling final customer needs” [Tukker and Tischner, (2006), p.1552].

Although the literature provides evidence regarding PSS’s potential to facilitate sustainability and circular economy in manufacturing companies (Kjaer et al., 2019; Micheli et al., 2017; Tukker, 2015), most previous studies have focused on large manufacturing companies (Bassi and Dias, 2019; de Jesus Pacheco et al., 2019; Dey et al., 2020; Hernandez-Pardo et al., 2013) and have a limited focus on a small and medium-sized enterprise (SME) manufacturing perspective. SMEs play a crucial role in economic development and the manufacturing industry in combating sustainability issues (de Jesus Pacheco et al., 2019; Dey et al., 2020; Garetti and Taisch, 2012; Prieto-Sandoval et al., 2019).

Although manufacturing SMEs have shown interest in adopting PSS to become more sustainable and competitive, they experience challenges when designing PSS (de Jesus Pacheco et al., 2019; García-Quevedo et al., 2020; Hernandez-Pardo et al., 2013; Åkesson et al., 2022). Prior studies have suggested that to design PSS successfully, companies need to be able, for example, to re-arrange resources and organisation structures. However, this is a complex task for SMEs as they suffer from resource deprivation and do not possess the same resources as large companies (Adrodegari et al., 2017; Bassi and Dias, 2019; de Jesus Pacheco et al., 2019; Pesce et al., 2020). According to previous studies, SMEs and large companies have significant differences in firm characteristics (e.g., different sizes, structures, and financial arrangements) that affect their organisations, processes, and performance (Ates et al., 2013; Bos-Brouwers, 2010; Ghobadian and Gallea, 1996; O’Dwyer and Ledwith, 2010). Consequently, there is a need to provide design support that purposefully addresses specific needs, as large companies and SMEs may need different support due to their characteristics (Brambila-Macias and Sakao, 2021).

Studies have presented several challenges for SMEs when designing PSS (de Jesus Pacheco et al., 2019; Hernandez-Pardo et al., 2013) and have shown the specific characteristics of SMEs (Bos-Brouwers, 2010; Ghobadian and Gallea, 1996), yet research focusing on the relationship between the challenges and characteristics of SMEs related to PSS design is limited. Nevertheless, research has indicated that some challenges for SMEs designing PSS are related to SMEs’ characteristics (Bassi and Dias, 2019; de Jesus Pacheco et al., 2019); however, such challenges are only briefly discussed in a few studies (e.g., Besch, 2005; de Jesus Pacheco et al., 2019; Hallstedt et al., 2020). Therefore, the study presented in this article addresses the research gap by exploring SMEs’ characteristics and their influence on the challenges SMEs experience when designing PSS. The research question (RQ) is formulated as follows:

RQ How do the characteristics of SMEs influence the challenges when designing PSS?

The article is organised as follows. The next section presents the theoretical background related to PSS design, the characteristics of SMEs, and the challenges towards PSS design in SMEs. Then the research method is described, followed by the findings from three case companies related to SME characteristics and PSS design challenges. After the discussion and conclusions, limitations and suggestions for further research are presented.

2 Theoretical background

2.1 SMEs' characteristics

A distinct difference between SMEs and larger companies is the number of employees. 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” (European Union, 2003/361/EC). In addition, within the SME definition, a small enterprise is defined as one that employs fewer than 50 persons, where the annual turnover and/or annual balance sheet total does not exceed EUR 10 million (European Union, 2003). Previous research has highlighted that SMEs are not smaller versions of larger companies (Storey, 2016) as they differ from such companies (Ates et al., 2013; O’Dwyer and Ledwith, 2010). SMEs are characterised by limited resources (Garetti and Taisch, 2012), such as limited capital, time, knowledge, and skilled personnel (Bos-Brouwers, 2010). In addition, SMEs differ regarding strategic orientation and innovativeness. Although large firms generally focus on market and product innovations and search for new opportunities, SMEs focus on their existing businesses, avoid unnecessary risks, and only make changes and adapt when environmental pressures force them (Kumar et al., 2012). A lack of formal risk management concerning business planning in SMEs leads to difficulties in identifying uncertainty and risks that threaten their survival (Brambila-Macias and Sakao, 2021). Studies also show that SMEs are generally reactive to environmental practices (Brammer and Pavelin, 2008; Williamson and Lynch-Wood, 2001) and see environmental issues as threats instead of opportunities (Greenan et al., 1997). Furthermore, limited resources encourage SMEs to settle for what is available and focus on short-term success (Berends et al., 2014), leading to a short-term vision, compared to larger companies that focus more on the mid to long term (Bos-Brouwers, 2010).

Research has also suggested that it is harder for SMEs to obtain external funding (Freel, 2007). In addition, the division of activities is limited and unclear in SMEs with a low degree of specialisation (Ghobadian and Gallea, 1996). SMEs have a short decision-making chain and a lower degree of standardisation and formalisation than larger companies (Bos-Brouwers, 2010; Ghobadian and Gallea, 1996), meaning that their internal processes make them quicker and more flexible in deciding and acting (Cristo-Andrade and Franco, 2019). Consequently, SMEs are considered flexible firms (Brambila-Macias and Sakao, 2021; Cristo-Andrade and Franco, 2019), which is regarded as one of their most vital advantages (Fiegenbaum and Karnani, 1991) as they can quickly respond and adapt to environmental and market changes when needed (Cristo-Andrade and Franco, 2019; Ghobadian and Gallea, 1996). As SMEs have fewer formal rules and procedures, they encourage creativity and experimentation, leading to

more innovative ideas (Heunks, 1998; Schilling, 2005). However, SMEs 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 (Schilling, 2005), as they often rely on informal design processes compared to large companies (Brambila-Macias and Sakao, 2021).

Although SMEs are considered essential for the manufacturing industry as they employ nearly 70% of the European workforce and produce almost 60 % of the overall turnover from manufacturing and services (Calogirou et al., 2010), they are generally integrated into supply chains as manufacturers of parts and components (Garetti and Taisch, 2012). As a result, SMEs have a greater local and regional focus and are more strongly attached to their customers than larger companies (Bos-Brouwers, 2010), which leads to them being more dependent on their customers in the innovation process (Tödtling and Kaufmann, 2001). Some SMEs are product owners, but SMEs are often suppliers of goods and services to original equipment manufacturers (OEMs) and usually do not design their products (Cristoni and Tonelli, 2018; Ghobadian and Gallea, 1996) and are generally not responsible for the products delivered to the end customer (Dey et al., 2020). In addition, as suppliers, SMEs need to deal with asymmetrical relationships (Flanckegård et al., 2021) as the SME's position entails a power imbalance where another company uses the SME's resources but not the other way around (Casciaro and Piskorski, 2005).

2.2 *PSS design*

PSS involve product use by sharing or renting and by extending material and product life-cycles through repair, remanufacturing, reuse, and recycling (Barquet et al., 2016; Camilleri, 2019). PSS differs from the traditional product development view (c.f. Ulrich and Eppinger, 2020) by adding a service dimension to the design activities. PSS design is about both the product offering and the design of the complete PSS (Sundin et al., 2009), leading to the need to combine product design and service engineering methods (Sakao and Lindahl, 2009). Products have dimensional, aesthetic, technological and mechanical characteristics and are designed to satisfy customers through their features (Kimita et al., 2009; Roy and Cheruvu, 2009), whereas services are designed in chains of activities (Morelli, 2006). These different types of design require a design process with integrated procedures that can deal with both products and services (Kimita et al., 2009). Therefore, the PSS design process requires a predefined design process (Aurich et al., 2006; Morelli, 2006) that includes a mix of design tasks that must be performed simultaneously, requiring interdisciplinary teams (Aurich et al., 2006).

When designing PSS, it is essential to have a life-cycle perspective (Sundin et al., 2009) when it comes to the design of the product as well as the system (Geum and Park, 2011). Thus, the PSS design process needs an integrated methodology to make the combination effective (Kimita et al., 2009) and create products and services matching the criteria for circular economy actions such as PSS; product designers must therefore change their way of designing products (Andrews, 2015). When offering PSS, companies should focus on designing products to extend the product's life-cycle, which means that products should be easy to maintain and repair (Adrodegari and Saccani, 2020) by designing modular products and components (Mont et al., 2006).

Several methods for PSS design exist (Clayton et al., 2012; Da Costa Fernandes et al., 2020; Tukker, 2015; Vasantha et al., 2012), but only a few methods have been evaluated in an industrial context (Baines et al., 2007; Joore and Brezet, 2015; Vasantha et al., 2012). Although the concept of PSS was established in the mid-1990s (Tukker, 2015), the use of PSS among practitioners is limited (Baines et al., 2017). In addition, research on PSS design provides many context-specific cases, so results are yet to be generalised. Because PSS design is complex and heavily dependent on the context, standardisation is hard to achieve (Brissaud et al., 2022).

2.3 Challenges towards PSS design in SMEs identified in prior research

Although few studies have focused on PSS design in SMEs, prior literature has revealed several challenges. Compared to larger companies, SMEs do not have the same resources (Adrodegari et al., 2017; Ahmad et al., 2019; de Jesus Pacheco et al., 2019). Two of the most common challenges mentioned in previous research on SMEs designing PSS are the financial challenges (de Jesus Pacheco et al., 2019) and the lack of financial support (de Jesus Pacheco et al., 2019; Dey et al., 2020). Due to their characteristics, SMEs find it challenging to realise and design PSS offerings, which require a proper organisation, new customer relationships, new contracts, and new business models (Garetti and Taisch, 2012). Due to their limited resources (Ahmad et al., 2019), such as limited time and lack of dedicated employees for service development (Åkesson et al., 2022), SMEs find it challenging to develop a PSS business model (Adrodegari et al., 2017). In addition, their lack of formal business strategies makes it challenging to define a service strategy (Hernandez-Pardo et al., 2013; Hernández Pardo et al., 2012).

Developing a service culture is essential for PSS design, encompassing managerial tools that need to be cross-disciplinary and the education of the final customer (Mura et al., 2020). Replacing the value of exchange with value in use involves long-term relationships (de Jesus Pacheco et al., 2019; Neely, 2008) and the co-creation of value across the supply chain is essential for PSS design (Lelah et al., 2012). However, SMEs have limited external contacts (Ghobadian and Gallea, 1996) and find it challenging to initiate partnerships and secure long-term relationships with other companies (de Jesus Pacheco et al., 2019). SMEs' position in the value chain is also perceived as a challenge as SMEs are dependent on their customers and face challenges related to customer interest in PSS solutions (Dmitrijeva et al., 2020; Åkesson et al., 2022), in addition to lacking the customer support (Dey et al., 2020) needed to guide the transition towards offering PSS. SMEs also lack management commitment and vision (Sharma et al., 2020), which could lead to internal challenges in changing their mindset and developing a service culture (Neely, 2008).

SMEs also lack knowledge and competencies related to sustainability (Hernandez-Pardo et al., 2013) and PSS design (de Jesus Pacheco et al., 2019). Furthermore, existing methods for designing PSS are too complex for SMEs (Hernandez-Pardo et al., 2013) due to their characteristics and limited resource, meaning that they also lack methods to design PSS (de Jesus Pacheco et al., 2019; Garcés-Ayerbe et al., 2019). Regulations and administrative processes are also challenging (Garcés-Ayerbe et al., 2019; García-Quevedo et al., 2020). In addition, SMEs face challenges related to their organisational structure (Ahmad et al., 2019) and internal processes (Åkesson et al., 2022), as designing PSS requires fundamental changes in the organisation's strategy and structure, meaning that the company needs to innovate in

multiple areas (Vihma and Moora, 2020). For instance, to offer PSS, SMEs need to manage the end-of-use and end-of-life of products, and these reverse logistics are seen as challenging (Åkesson et al., 2022). The need to innovate in multiple areas is why firms re-designing products and services are likely to perceive all challenges, such as competencies, finances, administrative procedures, and regulations, as equally important (García-Quevedo et al., 2020).

3 Research method

This study is based on a multiple case study (Yin, 2018) as it supports efforts to understand the challenges SMEs experience when designing PSS due to their characteristics. The multiple case study is also considered an appropriate design for this study as it allows one to explore several cases deeply and carry out a cross-case analysis (Eisenhardt, 1989). The design was considered an appropriate choice as this study seeks to complement prior research on SMEs' challenges when designing PSS, which has foremost been conducted based on a quantitative research approach.

Three case companies were purposively selected for theoretical reasons (Eisenhardt, 1989), making it possible to contribute to the existing theory. The selection was based on three criteria. The first criterion is that the case companies meet the requirements for being defined as SMEs. The included case companies were categorised as small-sized firms according to the SME definition, employing between 24 and just under 50 employees and having a turnover between 4 M euros and 8 M euros. The second criterion was for the companies to belong to the manufacturing industry. The case companies were contract manufacturers located in Sweden. Finally, the third criterion is that the companies were in the transition to design PSS. In addition, a multiple-case study design is suitable for determining if the contextual conditions of various SMEs influence the outcome, i.e., PSS design (Yin, 2018). Thus, the three SMEs represent different types of products (e.g., polymer, metal, and electronic components) that target different customer segments (e.g., heavy vehicle industry, medical technology, and commercial kitchen). The companies also differ in terms of PSS design maturity. One company is in the early stages of exploring possibilities of designing PSS, whereas one is recently reorganised and rebranded itself as a full-service partner. The third company offers PSS for a limited number of products but wants to expand its offering and offer PSS for more components.

Data were mainly collected through semi-structured interviews and internal archive documents provided by informants on an as-needed basis. The interviews with senior managers were held remotely via face-to-face meetings online due to the COVID-19 pandemic. The senior managers had different organisational positions (see Table 1). As designing PSS requires the involvement of different competencies in several parts of the organisation, it was vital for the study to get the perspectives of different managers to cover challenges within their respective areas of responsibility and reduce the risk of overlooking significant challenges. Some informants had several areas of responsibility or had experience as former managers in other company areas. For instance, the managing director of case company A was also the production manager, and the technical and key account manager of case company C was also the former production and logistics manager. Thus, they covered crucial competencies in several areas, which are key for organisational transformations such as PSS design. Ten semi-structured

interviews were conducted with nine senior managers, accounting for approximately 12 hours of interview time. The interviews were conducted individually with each manager, but one was performed as a group interview to fulfil the request of two of the senior managers. An individual follow-up interview was conducted with one of these managers as the other manager had limited time to attend an individual follow-up interview.

Table 1 Description of interviews

| <i>Interview number</i> | <i>Informant title</i> | <i>Type of interview</i> | <i>Case company</i> | <i>Interview duration</i> |
|-------------------------|--|--------------------------|---------------------|---------------------------|
| 1 | Managing director | Individual | A | 1 hr 26 min |
| 2 | Technical manager | Individual | A | 1 hr 25 min |
| 3 | Managing director | Individual | B | 58 min |
| 4 | Managing director | Follow-up individual | B | 1 hr 19 min |
| 5 | Sales and marketing manager | Individual | B | 1 hr 13 min |
| 6 | Quality and sustainability manager | Individual | B | 49 min |
| 7 | Production and logistics manager | Individual | B | 1 hr 31 min |
| 8 | Managing director | Individual | C | 1 hr 21 min |
| 9 | Communication and marketing manager technical and key account manager | Group | C | 58 min |
| 10 | Communication and marketing manager | Follow-up individual | C | 45 min |

The interviews lasted between 45 minutes and 91 minutes (see Table 1). We drew upon theoretical concepts from the literature on SMEs and PSS design, and these were used as the basis for developing the interview guide. All interviews were recorded and transcribed verbatim. In addition to the interviews, two workshops were held with case company B, which helped understand the data obtained through the interviews (Säfsten and Gustavsson, 2020). The workshops, which lasted between 60 and 90 minutes, were held with the researchers, the managing director, and the sales and marketing manager from case company B (see Table 2). The research process started with case company B as a single case study and was later expanded to include two additional cases, case companies A and C, where the companies did not have the opportunity for workshops due to their lack of time.

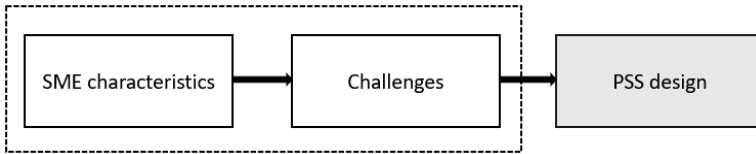
Table 2 Description of workshops

| <i>Workshop</i> | <i>Participants</i> | <i>Case company</i> | <i>Workshop duration</i> |
|-----------------|--|---------------------|--------------------------|
| 1 | Researchers, managing director, sales and marketing manager | B | 1 hr 30 min |
| 2 | Researchers, managing director, sales and marketing manager | B | 1 hr |

We performed a thematic analysis using NVivo 12 to organise, structure and code the data. Four of the 10 interviews were conducted in English. The interviews in Swedish were translated into English using a back-translation technique (Regmi et al., 2010). The analysis began with reading transcriptions from the interviews, notes from the

workshops, and internal archive documents to become familiar with the data. The analysis continued by identifying SMEs’ characteristics and related challenges in the data; see Figure 1 for the model used to guide the analysis. This coding was supported by and viewed through the theoretical framework of SMEs’ characteristics and challenges described in the theoretical background (see Section 2). The next step involved comparing the identified SMEs’ characteristics and challenges among the case companies to identify similarities and dissimilarities. Occasionally, blurred boundaries between the identified SMEs’ characteristics and challenges emerged; these blurred boundaries were discussed among the researchers to agree on the coding.

Figure 1 The analysis model

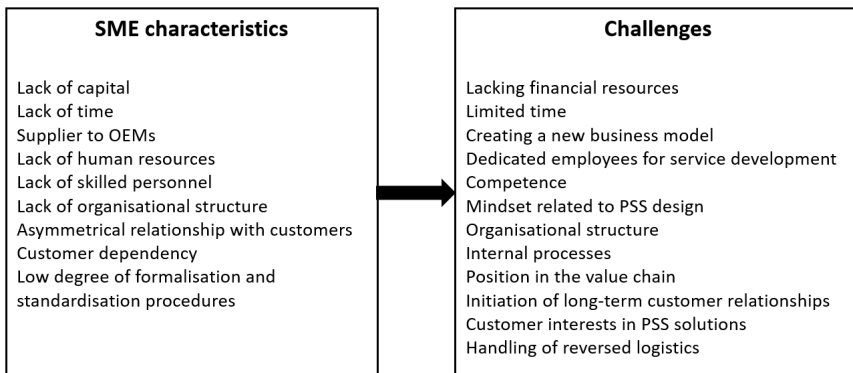


Notes: The analysis model illustrates a path between the influence of SME characteristics on challenges that SMEs experience, shown as the first and second boxes in the model. Even though SMEs’ challenges influence the PSS design, as illustrated as the last box in the model, the study was limited to the first path in the model, as indicated by the dotted line.

4 Findings

This section presents the SME characteristics that influence the challenges when designing PSS. The study identified nine SME characteristics common to all three companies, influencing twelve PSS design challenges (see Figure 2), presented in detail in the following sections.

Figure 2 SMEs characteristics influencing the challenges of designing PSS



4.1 Lack of capital

The empirical findings show that SMEs' characteristics related to the lack of capital make it difficult to invest in designing PSS. Financial resources are seen as one of the main challenges when designing PSS. The informants highlighted that they need capital to design PSS as; "You will not be able to invest a lot of money in that unless you have some money left over to actually invest" (Informant B-4). All companies expressed that the lack of financial resources is a common problem in smaller companies. "[...] small businesses barely have their heads above water" (Informant C-1). Another informant explained "That's probably how it is in this industry we have with small and medium-sized companies. You don't have those gigantic surpluses to play with. You can cope with everyday life, but not much more" (Informant A-1). 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.

4.2 Lack of time

The empirical findings show that SME characteristics in the form of time limitations create constraints when designing PSS. Informants from all three companies expressed that it is time-consuming when shifting to shift toward offering PSS. However, time is described as a limited resource and is seen as one of the main challenges to designing PSS. Informants from company C clarified that designing PSS takes time. "It has also cost us quite a lot, both time and money, to develop this" (Information C-1). However, a challenge is to find the time for such efforts as the daily tasks are often prioritised in the studied SMEs. "SMEs are all busy, struggling with many practical problems [...]" (Informant A-1). Informants from company B supported these comments. "Since time is a limited resource, we just focus on what we're doing today" (Informant B-1). Nevertheless, to design PSS, informants from all companies noted that it is crucial to devote both time and human resources to look externally for opportunities. "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 B-4).

4.3 Supplier to OEMs

The empirical findings also show that being a supplier to OEMs influences the challenge of creating a PSS business model. Informants from all three companies commented that it is a challenge to design PSS as a supplying contract manufacturer and believe it would be easier if they own the products to be able to create a PSS business model. "These contract manufacturing products will be completely tied to just delivering and getting paid" (Informant A-1). As another informant explained that "the design is already written in stone when it reaches us, so I don't see that we can impact very much" (Informant B-3). However, informants expressed difficulty transitioning from being a contract manufacturer to becoming product owners and offering PSS, in terms of both customer resistance regarding ownership and 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 B-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 B-1). Another concern related to changing the business model and going from traditional product sales to offering PSS is that more capital is required: “It requires a lot of liquidity for me to create rental models instead of selling directly” (Informant C-1). In addition, the large customer portfolio that the companies have as suppliers influences the challenge of creating a new business model as it requires expertise in multiple areas. “We are serving quite many different industries and different types of customers, and it is a bit of a challenge to actually get deep enough, within different industries, when you have such a broad offering” (Informant B-4).

4.4 Lack of human resources

SMEs experience a lack of human resources and have a limited number of employees. Based on the empirical findings, this SME characteristic influences the challenge of obtaining dedicated employees for service development. The lack of dedicated employees and workforce is also a significant challenge to designing PSS and working with customers when developing products. According to Informant B-4, “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”. In addition, to be able to design PSS and simultaneously change the business model, they need employees devoted to business and service development. The informants see the lack of workforce as a challenge when designing and offering PSS and emphasise that it is a disadvantage compared to larger companies. “I don’t have any [human] resources to spend on research and development. We are running an ongoing business. So, all our resources, in general, should go to developing new products [...] (Informant C-1). Although informants believe they need to employ more people to design PSS, they also see it as a challenge. “You have to have a couple of millions to play with, to employ four people, that’s 2 million in one year. The availability of that kind of capital is a limitation” (Informant A-1). In addition to the challenge of having a shortage of human resources, an informant from one company highlighted that it is not just a matter of having staff, but of having the right staff: “If we squeezed in 10 people who only think about circular solutions, we’d probably get a lot further, but it’s not just about the process. It’s about getting the right people in too” (Informant C-1). Some informants expressed demands for a clear delegation of area responsibilities for this type of development within the companies, as they need to develop a service organisation and lack employees who focus entirely on service development and the aftermarket.

4.5 Lack of skilled personnel

One of the SME characteristics is the lack of skilled personnel. According to the empirical findings, a discrepancy emerged among the informants concerning whether competence is a challenge. One informant from company B stated, “I don’t think we need more or other competence” (Informant B-1). Another informant from company C also mentioned that competence is important but that it is something they already have: “We have an excellent and broad competence in-house” (Informant C-3). However, other informants from companies A and B stressed that competence is a challenge for the companies, and there was no consensus among these informants concerning what

competence is needed. For example, some 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 contributing to those discussions” (Informant B-4). Others mentioned that they instead lacked in sales competence. “We are traditionally a contract manufacturer that really only responds to the needs of our customers, and we don’t have a lot of tradition and experience in selling” (Informant A-1). In addition, one informant stated that they already had competence in-house for designing PSS and described that the SME’s characteristics concerning skilled personnel instead influenced the challenge of developing a mindset to design PSS: “It’s more about the opening of minds and thinking in new directions” (Informant B-1). In general, the informants considered being open-minded and thinking in a new direction were necessary for designing PSS. Informants explained that they are required to keep learning if they desire to develop their knowledge.

4.6 Lack of organisational structure

Another SME characteristic that influences challenges when designing PSS is the lack of organisational structure, meaning departments having the authority and responsibility to develop products and services. This characteristic influences challenges related to the organisational structure and formal processes supporting PSS design. As the customers today take care of the design and R&D of products, the companies have limited human resources for product development. To offer their own products and design PSS, the companies believe they need a proper design department. One of the case companies lacks a design department, while the other two have one or two people working on product design and development. However, the people within product development are already overloaded with work. “You’d think we’d have a whole department just for product development, but in fact, it’s one or two people doing this, and they’re very stretched” (Informant A-1). Furthermore, none of the companies has a service department nor a service development process, but the informants were hesitant about needing one to design PSS as they believe they can create a process on demand due to them being flexible. “We don’t need to be that stubborn or square-minded that we need to first create a process and then work the process. We can create a process while we’re at it and be a bit more flexible [...]. That’s a big difference between big companies and entrepreneurial smaller companies. That is actually a negative side that you try to build processes for everything” (Informant B-1). Another informant from company C stated, “I believe more in the creative and a bit ad-hoc” (Informant C-1). Even if they do not have or think they need a service development process, they still believe they can become better at finding and developing service offers by being more proactive instead of just reactive. “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 B- 4).

4.7 Asymmetrical relationship with customers

SME characteristics of having asymmetrical relationships with customers influence their position in the value chain creating challenges when initiating long-term customer

relationships and partnerships for designing PSS. The informants expressed that their companies' position in the chain is seen as a challenge, both when it comes to being a small company in relation to their large customers and also because they are small contract manufacturers. "It's a pretty tough day to be a contract manufacturer, especially for these [...] customers. They are big and strong and like to be in charge" (Informant A-1). Another informant stated, "I would say that the biggest barrier I can see is to get that cooperation with the customer, since we are a contract manufacturer. We don't have a product which is ours. So, we need in some way to get together in a partnership with our customers" (Informant B-1). Their small size makes it difficult for them to be heard by their customers. "[...] We have a very small voice in the public sphere" (Informant C-3). However, the informants mentioned that they want to build long-term relationships with customers and partners but find it difficult due to their position. "Unfortunately, these [...] customers are not very interested in building a relationship with us. They change their purchasing agents basically every year, and they are kind of allergic to close contact, you could say. It's not easy for us to knock on there and say, 'hey we have another product to promote now. We have a service here you can buy.' It's tough. We just get scolded when we make mistakes or can't deliver. We very rarely get praise when we do something well" (Informant A-1). Still, they see the possibility of securing contracts by designing PSS and reducing the risk of being replaced. "But we see, as a small company, that we like to connect with the customer in the longer term. We do that through contracts. We fight for the big wholesalers who have the whole market. They are not so reliable, and they can throw us out if they get a better offer and think they should work with someone else" (Informant C-3). However, the informants are aware that securing contracts is difficult because they are small suppliers, "No customer, I would say, would like to get in that type of situation, where you are stuck with a supplier. They want to challenge you for price and performance, and capacity, basically. So it will be very hard for someone to sign a 20-year contract and being 'stuck' with you [...] no one wants you really! [...]. So that, I think, is some very big hurdles in that case" (Informant B-1).

4.8 *Customer dependency*

SMEs depend on their customers, which influences the challenges of handling the customers' interest in PSS solutions and offerings. Due to customer dependency SMEs find it difficult to inform and educate their customers about PSS. A major challenge that informants at all companies talked about is customers' interest in PSS solutions. "It's the customer who is in charge, if they say 'no, but this is not interesting', no, but then it's so" (Informant C-3). Some informants believe the customer demand for services is low; as they are dependent on their customers, it would be difficult to change to a more sustainable approach. "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 B-1). Informants from two of the three companies see opportunities in contributing expertise when working with customers and developing new products and business opportunities with a potential aftermarket. Informants from the third company also believe they can offer suggestions on production adjustments that make the product cheaper for all parties, but they were doubtful that there is a demand for services related to sustainability: "Unfortunately, the demand is too low, and customers

are unwilling to pay for it, not at the moment anyway” (Informant A-1). Nevertheless, informants from all companies mentioned that they need to spend more time marketing themselves and informing customers about their potential offerings. However, companies A and B have engaged in limited internal and external discussions about what kinds of services they could offer their customers. Meanwhile, company C has invested heavily in marketing, but informants still see getting the market interested as one of the main challenges. “It’s working with the market, getting the market to follow and understand what we’re saying. I would say that’s the big challenge” (Informant C-1).

4.9 Low degree of formalisation and standardisation procedures

The empirical findings show that being flexible is not always desirable as SME characteristics of having a low degree of formalisation and standardisation procedures influence challenges when handling reversed logistics. Reversed logistics is perceived by informants at all companies as a challenge when designing PSS. This includes the internal logistics and processes and working with customers and other partners to bring back the products. “The biggest obstacle when I talk to our customers is ‘What is the obstacle to going circular?’. Then logistics is usually a concern, who is going to handle this, who will handle the returns, where is the material going to be stored, that sort of thing [...]. We are pretty small, we work with some of Sweden’s wholesalers who have a turnover of billions, but they can’t be responsible for a pallet of plates to be returned” (Informant C-3). One informant expressed 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 B-2). This informant further clarified 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 B-2). Other informants supported this as well, saying they need to standardise their work to handle the different operations needed to support the reversed logistics. “How are we going to take care of them? How will they be scrapped? Will they be recycled? Can we sell them? (Informant A-1). According to another informant, “our internal logistics, [...] if it increases, there’s a bit to handle, so we have to get better at that” (Informant C-2).

5 Discussion

This study identifies nine SME characteristics influencing twelve PSS design challenges (see Figure 2). Our findings show that SMEs’ characteristic of having a lack of capital influences challenges such as obtaining the financing needed to design PSS. This finding is consistent with prior research that stresses that most SMEs have limited access to capital for investments (Bos-Brouwers, 2010) and therefore find it challenging to design PSS (Adrodegari et al., 2017; de Jesus Pacheco et al., 2019). The question is whether this financial resource limitation is because it is more difficult for SMEs to obtain external funding, which aligns with what Freel (2007) suggests, or because they require human resources and time to apply for external funding. Either way, the findings indicate that SMEs’ lack of capital influences their possibility to make dedicated investments.

Furthermore, SMEs’ small organisational size means they depend on a few employees (European Union, 2003). Our findings show that SMEs’ limited staff is

required to complete tasks related to their regular business (i.e., produce and sell) rather than working on designing PSS. Thus, SMEs' characteristics of being relatively small influence challenges related to SMEs not having the required staff to design PSS or the opportunity to give their employees time to develop their knowledge and skill set to design PSS. Notably, regarding the skilled personnel, the findings show a disagreement concerning the specific competence SMEs staff needs to possess to design PSS successfully.

SMEs' size and the characteristics of being a contract manufacturer and supplier to larger OEMs also influence challenges in creating a PSS business model. The findings show that the studied SMEs rely deeply on their existing large customers' knowledge and interest in designing PSS. According to the informants, the OEMs seem to not have acknowledged the importance of designing PSS. This is problematic as the SMEs lack the possibility to enlighten their customers and increase their interest in PSS due to their position in the value chain. The findings indicate that the asymmetrical relationship between small and large firms in the value chains, where the larger company holds the power, challenges SMEs' ability to communicate their PSS offerings and initiate partnerships to design PSS.

According to the literature (e.g., Brambila-Macias and Sakao, 2021; Cristo-Andrade and Franco, 2019), SMEs are more flexible than larger companies, which is usually perceived as a strength as they can change and adapt quickly. Our findings suggest that being flexible and having a low degree of formalisation and standardisation procedures are not always strengths as these characteristics creates challenges with the reversed logistics. The studied SMEs need a proper service process and standardise their work to manage the reverse logistics, which is much needed when designing PSS (e.g., obtaining circularity when renting out products).

Our findings suggest that the SMEs, because of their characteristics, are focused on their daily business to survive rather than to be proactive in securing their long-term success in the market by designing PSS. This finding supports the literature on SMEs characteristics that stresses that SMEs focus on short-term success rather than being proactive (Cristo-Andrade and Franco, 2019; Ghobadian and Gallear, 1996; Heunks, 1998; Schilling, 2005). Our finding may be explained, in part, by the fact that PSS is still perceived as a new business logic and strategy for contracting manufacturing SMEs.

6 Conclusions and implications

Based on the findings, it can be concluded that SMEs' characteristics influence the challenges when they design PSS. It can also be concluded that SMEs' different characteristics influence multiple challenges, i.e., overlaps exist between the SME characteristics and the challenges of designing PSS. Another conclusion is that SMEs' characteristics, that they are small companies with limited resources, promote a short-term horizon and a more reactive business approach, influencing the overall challenge of designing PSS.

This study adds to existing PSS design literature by presenting a first analysis of the relationships between the characteristics of SMEs and the challenges of designing PSS, as prior research has mainly focused on larger companies (de Jesus Pacheco et al., 2019; Hernandez-Pardo et al., 2013). The study shows that the characteristics of SMEs must be considered when SMEs face challenges designing PSS, as SMEs differ in several areas

compared to large companies (Brambila-Macias and Sakao, 2021), which contributes to an increased understanding of PSS design in an SME context. This study also provides managerial implications because insights regarding the characteristics that influence PSS design can help managers to better prepare SMEs for PSS design.

7 Limitations and future research

These findings should be interpreted considering the limitation of the study, specifically the number of case companies. Although the present study included three SME case companies who are contract manufacturers, it would be of value to study a greater number of SME case companies with different types of collaboration forms with OEMs to strengthen the generalisation of the findings. Although the three case companies are all SMEs, it is not certain they exhibit all SME characteristics presented in the studied literature. Furthermore, the study has focused on exploring SMEs' characteristics and their influence on the challenges SMEs experience when designing PSS. Therefore, further exploring possible hierarchies and identifying multiple linkages would be interesting. Moreover, this study includes case companies that are SMEs but are characterised as small companies according to the definition set by the European Union (2003). Thus, the study does not include medium-sized companies, and it would be fruitful to include such SMEs in future studies. Moreover, this study focuses on PSS challenges; research on PSS would benefit from focusing on what enables companies to overcome PSS challenges. We suggest including SMEs and large manufacturing companies to make possible comparisons.

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