

Bake, John Sakwe; Pessôa, Marcus Vinicius Pereira; Sipke, Hoekstra

Article

Mapping challenges and methodologies for providing PSS - a thematic and descriptive analysis

Cogent Business & Management

Provided in Cooperation with:

Taylor & Francis Group

Suggested Citation: Bake, John Sakwe; Pessôa, Marcus Vinicius Pereira; Sipke, Hoekstra (2020) : Mapping challenges and methodologies for providing PSS - a thematic and descriptive analysis, Cogent Business & Management, ISSN 2331-1975, Taylor & Francis, Abingdon, Vol. 7, Iss. 1, pp. 1-27,
<https://doi.org/10.1080/23311975.2020.1809945>

This Version is available at:

<https://hdl.handle.net/10419/244928>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by/4.0/>

Mapping challenges and methodologies for providing PSS - a thematic and descriptive analysis

John Sakwe Bake, Marcus Vinicius Pereira Pessôa & Hoekstra Sipke |

To cite this article: John Sakwe Bake, Marcus Vinicius Pereira Pessôa & Hoekstra Sipke | (2020) Mapping challenges and methodologies for providing PSS - a thematic and descriptive analysis, Cogent Business & Management, 7:1, 1809945, DOI: [10.1080/23311975.2020.1809945](https://doi.org/10.1080/23311975.2020.1809945)

To link to this article: <https://doi.org/10.1080/23311975.2020.1809945>



© 2020 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.



Published online: 06 Sep 2020.



Submit your article to this journal [↗](#)



Article views: 450



View related articles [↗](#)



View Crossmark data [↗](#)



Received: 06 May 2020
Accepted: 10 July 2020

*Corresponding author: John Sakwe Bake, University of Twente, Enschede, 7522 NB, Nederland
E-mail: j.b.sakwe@utwente.nl

Reviewing editor:
Pantea Foroudi, MBT, Middlesex University, UNITED KINGDOM

Additional information is available at the end of the article

MANAGEMENT | REVIEW ARTICLE

Mapping challenges and methodologies for providing PSS - a thematic and descriptive analysis

John Sakwe Bake^{1*}, Marcus Vinicius Pereira Pessôa¹ and Hoekstra Sipke¹

Abstract: Product service systems (PSS) are seen as a viable option for enhancing the competitiveness of organizations that produce stand-alone products and services. Although there are various opportunities associated with PSS, research evidence shows that product manufacturers face challenges in successfully deploying PSS strategies. While the methods addressing PSS challenges have attracted much interest from both academia and practice, the literature provides limited knowledge about PSS development methods and challenges related to specific assets or products. This limitation hinders the development of successful strategies for both developing products to PSS and converting existing products to PSS. This study clarifies the contribution of the literature by proposing a mapping of PSS development methods capable of tackling the PSS business models that offer challenges. The mapping of challenges and methods presented can support organisations in their strategic decision-making about providing PSS, thus mitigating risks and improving business performance. Finally, analysing the extension of this coverage makes it possible to understand the method's limitations and determine opportunities for further research. A specific focus is placed on the asset or product development industry.

ABOUT THE AUTHOR

John Sakwe Bake is a Business Process Improvement and Supply Chain lecturer at Fontys University of Applied Sciences in the Netherlands. He holds a master's degree in International Business, with a practical background in companies like Xerox and PHILIPS. His interests are business process improvement, including lean manufacturing and Six Sigma management, as well as supply chain management. He is currently earning a PhD in asset management at the University of Twente in the Netherlands.

With today's growing demands in manufacturing competitiveness and sustainability, one way to achieve these goals is to expand from product-based to service-based business models. Thus, his project focuses on supporting industrial asset production companies in this large commercial process of service migration, and especially leveraging the opportunities of the digital technologies of Industry 4.0.

PUBLIC INTEREST STATEMENT

With the growing interest in environmental sustainability as well as competitive pressures, manufacturing companies are seeking better ways to efficiently develop products both to improve profitability and address diverse customer needs. As a result, these companies are increasingly expanding to provide a seamless combination of products and services. The benefits of this combination are increased product performance, increased profit, reduced production volumes, closer and increased product and customer knowledge, and a reduced environmental burden.

Subjects: Manufacturing Engineering; Supply Chain Management; Operations Management; Engineering Management; Customer Relationship Management; CRM; Supply Chain Management; Operations Management; Strategic Management; Strategic Management; Operations Management

Keywords: product service systems; PSS challenges; PSS development methods; systematic literature Review; business models

1. Introduction

Manufacturing companies have devoted strong efforts to design, develop, and produce physical products that meet market demands (Aurich et al., 2009). Today, increasing competition, an increasing need for closer and longer lasting relationships with customers, and a greater need to decrease costs are examples of trends that are forcing companies to explore other competitive strategies (Lindahl et al., 2009). One approach proposed in the literature to address these problems is the adoption of a product service system (PSS) business model (Isaksson et al., 2009; Lindahl et al., 2009; Sakao et al., 2013; Sundin et al., 2009a).

PSS models offer opportunities for better control and knowledge of the product being used and consequently, better customer understanding Lindahl et al. (2009), increased profit, a long term return on investment, stable cash flow, and cost reduction (e.g. Isaksson et al., 2009; Neely, 2008). As reiterated by Goedkoop et al. (1999), Tukker (2004, 2015), PSS models offer advantages for environmental sustainability, such as through reduced production volume (Minguez et al., 2012).

Despite these business and environmental benefits, migrating from conventional product manufacturing to offering PSS constitute a major managerial challenge (Brax & Gustafsson, 2005; Meier et al., 2010a; Oliva & Kallenberg, 2003; Reim et al., 2014, 2015). For instance, while Oliva and Kallenberg (2003) argues that one of the issues is that services require different organisational principles, processes, and structures that are not well understood by product manufacturers, Brax and Gustafsson (2005) points out that some customers find the maintenance strategy for PSS and the information systems and technology adopted to be inflexible. J. C. Aurich et al. (2010) note that manufacturers are challenged by the specific methodologies and tools for PSS implementation.

Since these challenges or barriers are diverse and largely situation dependent, manufacturers find it difficult to have a complete understanding of the broader issues associated with developing and offering PSS. This lack of knowledge can hinder their ability to successfully expand to providing PSS. Thus, knowledge of the challenges Zhang and Banerji (2017) and methods Bertoni et al. (2016) have attracted the attention of both academia and practice. This knowledge is crucial for achieving manufacturers' expansion goals for sustained competitiveness.

There is limited research in terms of combining PSS challenges and methods, and studies that do concentrate on the barriers and methods applied for specific industries (Mahut et al., 2017). This fragmented approach leads to limited representation of the wider issues and available solutions to support organisations' transformation to PSS, which can hinder realisation of the expected benefits of PSS expansion.

The aim of this study is to support decision-making processes for product-oriented organisations shifting to PSS. A mapping of challenges and methods is presented to provide such support. From a practical point of view, the study's contribution is enabling these organizations to identify the challenges they will most likely face during this transition and the approaches that may be used to address them. From a theoretical point of view, this study adds to the topic of PSS; in particular, it presents scholarly arguments and viewpoints in relation to PSS challenges and methods and opens a future research agenda.

The rest of the paper is organised as follows. Section 2 presents the research background, where related research on challenges and methods is explored. Section 3 discusses the approach for reviewing the challenges and methods, and section 4 analyses and outlines the challenges. Section 5 presents the methods proposed for addressing the challenges. Section 6 discusses the findings, including the mapping of PSS challenges and methods; conclusions are drawn, and future research is outlined.

2. Background

This section is guided by the following research question: What are the challenges and methodologies for developing and offering PSS? The section is not intended to present an exhaustive state of the art review of PSS, but rather an overview of the topics related to the PSS challenges identified in previous studies, along with the methods proposed.

The concept of PSS was conceived by Goedkoop et al. (1999) in their paper titled 'Products Service Systems-Economic and Ecological Basics'. The authors define PSS as 'A system of products, services, infrastructure, and networks that strives to be competitive, satisfies customer needs, and results in a lower environmental impact than a traditional business model'. With emphasis on PSS research regarding challenges, the collection of data in the methodology section of this paper uncovers some studies that discuss challenges. These studies were analysed with the goal of identifying these challenges and methodologies.

The results of the analysis show that various investigation perspectives are proposed, resulting in different classifications of the challenges. For instance, based on a single case study the challenges are investigated from a change process perspective and classified as, culture, customer relationships, strategic alignment, internal processes and capacity, and integrated supply (Martinez et al., 2010). With a focus on the automotive industry, Mahut et al. (2017) review PSS definitions, opportunities, and obstacles that present challenges, as well as some methodologies for its application. They summarised the following categories as barriers or challenges for PSS implementation: lack of support from laws and regulation, lack of awareness related to PSS, and an increased load related to maintenance service systems. Similarly, T. S. Baines et al. (2009) use a case study to present another classification of challenges that comprise the following aspects: organisational transformation, integrated delivery systems, designing product and service systems, value dimension of integrated products and services, and the language of services. Through a systematic literature review, Zhang and Banerji (2017) identify the following challenges: organisational structure, business model, development process, customer and risk management, and relationships, as well as the relationships between these challenges and their impact on business performance. Brax and Gustafsson (2005) also employs a case study and classifies the challenges as communication, production, marketing, product design, supply, and relationships. Through workshops with several Swedish manufacturers, Sundin et al. (2009c) investigate PSS challenges and suggest the following classifications for large companies: how to market the PSS, how to develop the PSS, how to set the price, how to use new technology, and how to benefit from the environmental potential. For small and medium size enterprises, the challenges found were categorised as how to capture value, how to develop business models, how to segment markets for PSS geographically and by product, how to deliver PSS, how to use new technology for service delivery, how to market the PSS internally, and how to organise for PSS development (Sundin et al., 2009c).

With regard to methods supporting PSS implementation, various contributions are proposed to support the expansion of manufacturing firms to PSS. In Mahut et al. (2017), some of the methods include the methodology for PSS development, service engineering, functional product development, architecture for service engineering, and property driven design methodology.

Based on this background, it can be argued that the challenges presented are rather fragmented and thus still leave room for a more comprehensive investigation that includes several industries and assets. This study uses a systematic literature review comprising four steps to investigate the challenges and methods for developing and offering PSS, with a focus on industrial product or asset development industries in the business-to-business (B2B) sector.

3. Research approach for reviewing the literature

A systematic literature review according to the requirements of Tranfield et al. (2003) was conducted with the goal of answering the following research question: What are the challenges and methods for developing and offering PSS? To answer this question rigorously, a five-stage systematic review process was adopted to search, analyse, and synthesize research on PSS associated challenges and development methods. Systematic reviews enhance research rigour by adopting replicable, scientific, and transparent processes (Tranfield et al., 2003). The steps used in the present study are as follows:

- (1) Create the search query. The search query was created based on existing terminology, as shown in Table 1;
- (2) Create the inclusion and exclusion criteria;
- (3) Search for articles in the Scopus data base, and select relevant articles based on the inclusion and exclusion criteria; and
- (4) Analyse the results through descriptive and thematic analysis.

The literature search was performed in the Scopus database, which according to Tukker (2015) and Falagas et al. (2008) has been proven the best for electronic literature searches, mainly due to its wider subject and journal range. The literature search was based on peer-reviewed conference proceedings and journals. To widely cover the topic, various terms referring to PSS were used in the search query. Table 1 shows some of the most commonly used terminology.

3.1. Creating the search query

As shown in Figure 1, the search query was created based on terminology interchangeably used by various authors to refer to PSS. The search query's first section is a combination of keywords used by other researchers. The second section is to help understand PSS development and challenges and guarantees that product manufacturing-related papers are included. The search resulted in 278 potential articles that were then screened in the next round.

3.2. Creating the inclusion and exclusion criteria

To select the search results from the Scopus database, we focus on articles that are central and relevant to the field of PSS within the wider manufacturing context and that are written in English. It has also been argued that PSS is more applicable to industrial products and in the B2B sector because consumers are not excited about ownerless consumption (e.g. see (Li et al., 2020; Tukker, 2015)). Based on this argument, we limited the search to articles that discuss the challenges and methods found in the asset development industry in the B2B sector. The following inclusion criteria were used to identify articles:

Table 1. Key words and authors

Terminology	Literature
Servitisation	(T. S. Baines et al., 2009), (Vandermerwe & Rada, 1988)
Product service systems	(Tukker, 2004)
Industrial product service systems	(Meier et al., 2010)
Integrated product offering and functional sales	(Lindahl et al., 2006)
Integrated product service engineering	(Lindahl et al., 2009)
Integrated solutions	(Johansson et al., 2003)
Functional product	(Alonso-Rasgado et al., 2004)
Functional sales	(Sundin & Bras, 2005)
Service offering	(Kohtamäki et al., 2013)
Service dominant logic	(Vargo et al., 2010)

Figure 1. Search query for the systematic literature review.

Scopus	("integrated solution" OR "industrial Product Service Systems" OR "integrated product" OR "service offering" OR "product-service system" OR "servitization" OR "functional product" OR "integrated product service engineering" OR "integrated product service offering" OR "Functional Product Development" OR "Service-Dominant logic" "Servicification" OR "Service Transition" OR "Product Bundling" OR "Functional sales") AND (challenges AND methods AND assets)
--------	---

- (1) Written in English;
- (2) Discuss PSS challenges from the perspective of products or assets and a challenge is at least explicitly or implicitly identified;
- (3) Focus on B2B, that is, products or assets; and
- (4) Implicitly or explicitly consider methods or frameworks with cases in the B2B sector.

3.3. Searching articles

As depicted in Figure 2, this stage involved a series of steps. In the first step, the search query was typed into the Scopus database, which resulted in 278 potential articles. The titles and abstracts of all 278 articles were screened and read, taking into account the inclusion criteria, and this resulted in 65 relevant articles that formed the foundation of the literature review. While reading these 65 articles in detail, 20 additional articles were found that were relevant; these were also included, resulting in 85 articles. Therefore, the literature review is based on 85 articles emphasizing the challenges of PSS and methodologies and focusing on the asset or product development industry.

3.4. Analysis of articles

The articles were first analysed descriptively and then thematically.

4. Classification of papers reviewed

The challenges of PSS were thematically analysed. The descriptive analysis was performed using a deductive approach with predefined criteria, including publication source, type of PSS, and industry. Table 2 is an overview of the industries that were cited in the articles, and shows that PSS expansion has been common with the defence and manufacturers' of industrial equipment.

The articles were analysed thematically using categories consistent with those used by other PSS researchers (e.g. (Meier et al., 2010a) and (Parida et al., 2014; Reim et al., 2015)), as follows (Figure 3).

Figure 2. Sample size generation for literature search.

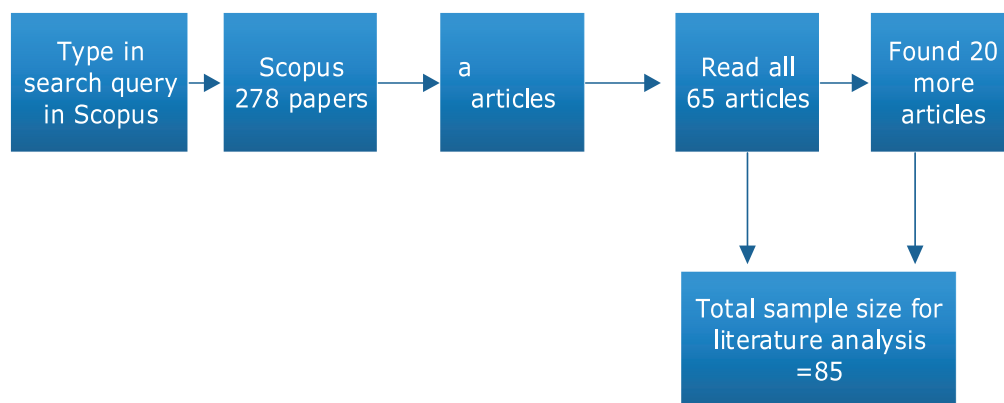


Table 2. Most frequently cited journals

Journals	count
Journal of Cleaner Production	10
CIRP Journal of Manufacturing Science and Technology	9
Industrial Marketing Management	7
Journal of Manufacturing Technology Management	6
CIRP Proceedings/Procedia	6
Journal of Operations and Production Management	5
Journal of Engineering Design	5
International Journal of Production Research	4
CIRP ANNALS	3
Journal of Engineering Manufacture	3
International Journal of Production Economics	3
Computers in Industry	2
European Management Journal	2
System Science and System Engineering	2
CIRP Annals—Manufacturing Technology	2
IFIP International Conference	1
Research Technology Management	1
Managing Service Quality-An International Journal	1
International Journal of Service Industry Management	1
Journal of Computer Integrated Manufacturing	1
Journal of the Academy of Marketing Science	1
Journal of Marketing	1
International Journal of Internet Manufacturing	1
International CINet Conference	1
Business Strategy and the Environment	1
Operations Management Research	1
CIRP Annals Manufacturing Technology	1
European Journal of Marketing	1
Journal of Service Theory Practice	1
Journal of Purchasing and Supply Management	1
Production Planning & Control	1

- seamless combination of product service development;
- supply network involving manufacturers, customers, and suppliers that support the PSS development and offering;
- contracts that regulate the relationship between PSS providers and PSS users;
- specificities from customers and markets;
- company business model and organisation required to support a PSS.

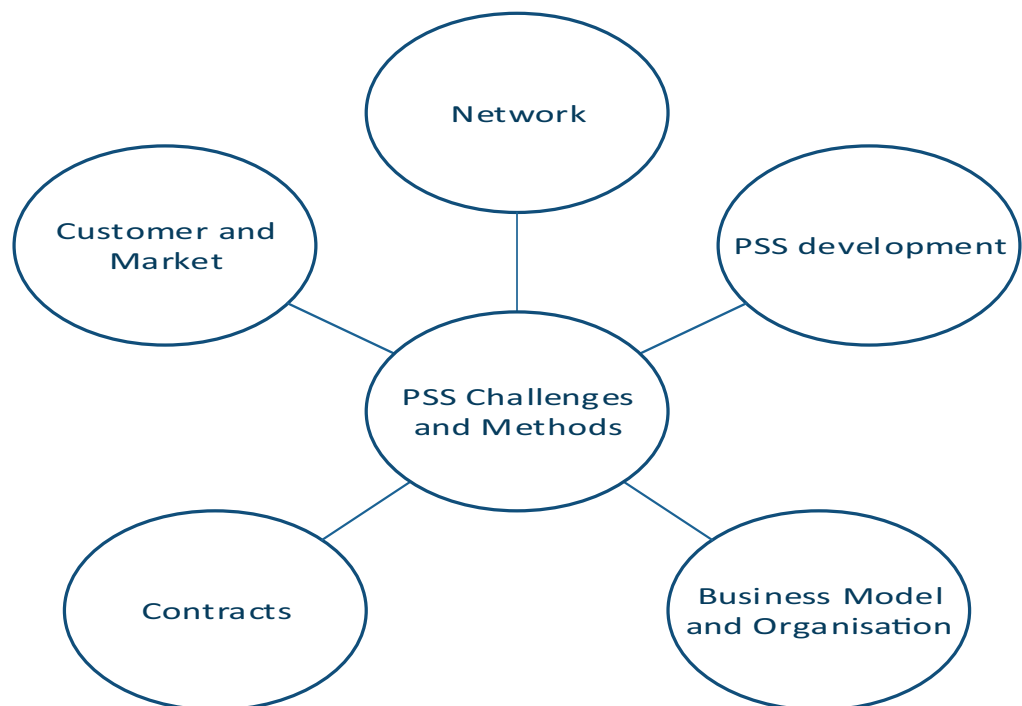
Each of the themes identified above were later analysed to determine how the PSS topic is evolving, and which PSS types are gaining in popularity. According to Tukker's classification, PSS types are product-oriented, use-oriented, and performance- or result-oriented (Tukker, 2004).

Use-oriented: The PSS provider retains product ownership and product usage; services such as maintenance, repair, upgrades, and failure prediction are made available to customers (Azarenko

Table 3. Main industries or product types

Industries Represented	Authors
Automobile/transport	(Ardolino et al., 2018), (Ziaee Bigdeli et al., 2018), (Schenkl et al., 2014b), (Schenkl et al., 2014a), (Williams, 2006), (Maxwell & Van Der Vorst, 2003)
Defence/Aerospace	(Settanni et al., 2014), (Erkoyuncu et al., 2009), (Datta & Roy, 2010), (T. S. Baines et al., 2009), (Wallin et al., 2015), (Ng et al., 2009), (Priya datta et al., 2011), (Johnstone et al., 2009), (Kleemann & Essig, 2013)
Industrial equipment	(Meier et al., 2010a), (Adrodegari et al., 2017), (Ng et al., 2009), (Durugbo, 2013), (Visnjic et al., 2017), (Sundin & Bras, 2005), (Windahl & Lakemond, 2006), (Sundin et al., 2009a), (Coreynen et al., 2018)
Machine tools	(Meier et al., 2010a), (Meier & Massberg, 2004), (Meier et al., 2010b), (Barquet et al., 2013), (Kamp et al., 2017)
Elevators	(Sakao & Shimomura, 2007), (Hara et al., 2009), (Song & Sakao, 2017)
Capital goods	(Aurich et al., 2009), (Aurich et al., 2010), (Aurich et al., 2006a), (Brax & Gustafsson, 2005), (T. S. Baines et al., 2009)

Figure 3. Conceptual framework of PSS challenges and methods.



et al., 2009). Selling the use or availability of a product that is not owned by a customer are typical examples of these models (Aurich et al., 2010). The commonly cited examples are product leasing, renting, and sharing (Tukker, 2004).

Performance-oriented: In this business model, the provider sells equipment performance, competency, or results to a customer instead of products; the provider retains product ownership. Common services in this business model are outsourcing or activity management. Examples including selling washed cloths instead of washing machines, printing companies that charge their customers according to the number of prints made instead of selling the printing machines, and offering a specified pleasant climate in offices rather than gas or cooling equipment (Tukker,

2004). To retain equipment ownership, the provider retains the propriety rights of product ownership, and the results or performance of product usage are offered as a service to customers.

Product-oriented: The PSS provider sells the product and offers after-sales services to ensure the functionality and durability of the product owned by the customer. Examples of these services include maintenance, repair, upgrades, and tool and consumables management (Azarenko et al., 2009). After the use phase of the product, refurbishing, remanufacturing, take back, dismantling, and disposal are also possible. In addition, the provider also offers advice and consulting services to customers to ensure the most efficient use of the product (Tukker, 2004). Depending on the customers' wishes, the provider offers e-maintenance.

Figure 4 is a distribution of PSS types and evolution in publications. Even though there is variation in publications over the years, generally there have been more scientific contributions post 2008 than before. Furthermore, it is difficult to conclude which PSS type has gained popularity.

5. PSS challenges

The challenges identified were classified according to the five themes presented. Table 4 depicts the challenges and respective references.

5.1. Business model and organization

PSS business models include product-oriented, use-oriented and result- or performance- oriented models (T. Baines et al., 2007). Migrating to a business model that offers PSS from a traditional product business model constitutes a major managerial challenge, in terms of both adjusting the organisational structure and the cost and revenue structure (Coreynen et al., 2018).

One challenge is **how to transform the organisation** into a successful product service system organization (Item 1). Providing PSS may require changes in the organisational structure of the providing company to accommodate the involvement of customers and other suppliers and partners (T. Baines et al., 2007).

Inability to understand the **capabilities** required to offer PSS can hinder a company's performance (Parida et al., 2014). These capabilities should be in line with the various services that make up the PSS value proposition (Raja et al., 2017). It is important for manufacturers to balance product and service innovation, while developing a distinct and balanced product and service culture (Story et al., 2017).

Another challenge is **recognising changes** in the company's business model (3). Recognising these changes, such as changes in the value proposition, helps the company understand how to interact with customers; the capabilities required to deliver, create, and capture; and how to acquire the competencies required to deliver value (Kowalkowski, 2011; Storbacka et al., 2013). These changes can turn into obstacles, which, if not addressed, can prevent the company from

Figure 4. Distribution of PSS publications and PSS types.

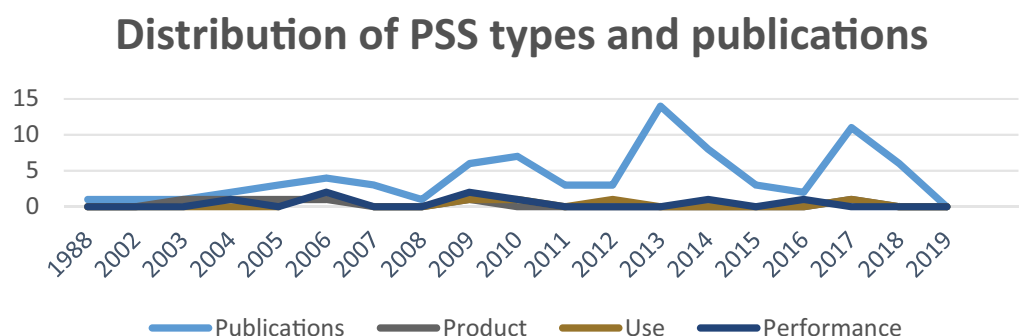


Table 4. Thematic analysis of challenges and methods

Themes	Challenges		Literature
Business Model and Organisation	1	How to transform the organisation	(Coreynen et al., 2018), (Martinez et al., 2018), (Zhang & Banerji, 2017), (Baines et al., 2017), (Neely, 2008), (Oliva & Kallenberg, 2003), (T. Baines et al., 2007), (Beuren et al., 2013)
	2	Capabilities required for services	(Wallin et al., 2015), (Story et al., 2017), (Ullaga & Reinartz, 2011), (Parida et al., 2014), (Raja et al., 2017), (Oliva & Kallenberg, 2003)
	3	Recognising changes in business model	(Adrodegari et al., 2017), (Barquet et al., 2013), (Parida et al., 2014), (Storbacka et al., 2013), (Pessôa & Becker, 2017)
	4	Implementing business models	(Reim et al., 2015), (Parida et al., 2014)
	5	Managing goods and service business logics	(Visintin, 2012)
	6	Designing business model	(Parida et al., 2014), (Meier & Massberg, 2004), (Nudurupati et al., 2016)
Customer and Market	7	Managing relationships with customers	(Zhang & Banerji, 2017), (W. Reim et al., 2015), (Wallin et al., 2015), (W. Reim et al., 2018), (T. S. Baines et al., 2009), (Brax & Gustafsson, 2005), (Deleon & Chatterjee, 2017), (Kamp et al., 2017), (Martinez et al., 2010), (Visintin, 2012)
	8	Customer acceptance	(Story et al., 2017), (Schenkl et al., 2014a), (Alonso-Rasgado et al., 2004), (Alonso-Rasgado & Thompson, 2006)
	9	Meeting high customer expectation	(Alonso-Rasgado & Thompson, 2006), (Kamp et al., 2017), (Schenkl et al., 2014b), (Brax & Gustafsson, 2005), (Raja et al., 2017), (Ullaga & Reinartz, 2011)
	10	Communicating value	(E. Sundin et al., 2010), (Kowalkowski, 2011), (Nudurupati et al., 2016), (Brax & Gustafsson, 2005), (W. Reim et al., 2015), (Ullaga & Reinartz, 2011), (T. S. Baines et al., 2009)
Contract	11	Trust	(Durugbo, 2013), (Reim et al., 2014), (W. Reim et al., 2018), (Wallin et al., 2015)
	12	Managing risks, e.g. service costs estimation	(Erkoyuncu et al., 2009), (Isaksson et al., 2009), (Settanni et al., 2014), (Datta & Roy, 2010)
	13	Risks, e.g. dealing with dynamic changes in long-term contracts	(Richter et al., 2010a)
Network	14	Delivering performance commitment of service contract	(Priya Datta et al., 2011), (Ng et al., 2010), (Ng et al., 2009), (Visnjic et al., 2017), (Ullaga & Reinartz, 2011), (Teixeira et al., 2013), (Sakao et al., 2013), (Lagemann & Meier, 2014), (Sakao et al., 2013)
	15	Managing relationship with suppliers	(Weigel & Hadwisch, 2018), (Brady et al., 2005), (Åhlström & Nordin, 2006), (Möller & Halinen, 1999), (Saccani et al., 2014), (Parida et al., 2014), (Reim et al., 2015), (Martinez et al., 2010), (Ziaee Bigdeli et al., 2018), (Gebauer et al., 2013), (Windahl & Lakemond, 2006), (Kleemann & Essig, 2013)
	16	Complexity in managing PSS delivery network	(Möller et al., 2005), (Gebauer et al., 2013), (Parida et al., 2014), (Meier & Massberg, 2004), (Meier et al., 2010), (Eloranta & Turunen, 2016)

(Continued)

Table 4. (Continued)

Themes	Challenges	Literature
Product Service Development	17 Integrating product and services to create added value for customers	(Isaksson et al., 2009), (Johnstone et al., 2009), (Ulaga & Reinartz, 2011), (Wallin et al., 2015), (T. S. Baines et al., 2009), (Parida et al., 2014), (Trevisan & Brissaud, 2016), (Aurich et al., 2006), (Alonso-Rasgado & Thompson, 2006), (Maussang et al., 2009), (Hara et al., 2009), (Zhang & Banerji, 2017), (Sundin et al., 2009), (Nudurupati et al., 2016, (Meier & Massberg, 2004), (Pezzotta et al., 2018), (Lindahl et al., 2009), (Vandermerwe & Rada, 1988)
	18 Develop the product for PSS	(Sundin et al., 2009b), (Aurich et al., 2006a), (Brax & Gustafsson, 2005)
	19 Develop the service for PSS	(Pezzotta et al., 2016), (Isaksson et al., 2009), (Alonso-Rasgado & Thompson, 2006)
	20 Customization	(Song & Sako, 2017), (Song et al., 2013)
	21 Managing product data or knowledge	(Baxter et al., 2009), (Johnstone et al., 2009)
	22 Developing sustainable PSS and Remanufacturing	(Garretti et al., 2012), (Song et al., 2013), (Sundin et al., 2009), (Vandermerwe & Rada, 1988), (Williams, 2006), (Maxwell & Van der Vorst, 2003)
	23 Modelling PSS	(Trevisan & Brissaud, 2016), (Isaksson et al., 2009), (Cavallieri & Pezzotta, 2012), (Becker et al., 2010), (Cavallieri & Pezzotta, 2012)
	24 Configuring PSS	(Aurich et al., 2009)
	25 Maintenance strategy design including relevant information systems and technology supporting solution	(Brax & Gustafsson, 2005), (Lightfoot et al., 2011)

upscaling to PSS (Pessôa & Becker, 2017). One option is to adopt the Canvas business model to uncover the obstacles and changes that can potentially prevent companies from successfully expanding to offer PSS.

Implementing PSS Business models (4) is still a challenge. These researchers have proposed tactics to enable manufacturing firms to implement various PSS business models. The authors argue that firms need to develop specific tactics encompassing networks, sustainability, contracts, marketing, and product service design (W. Reim et al., 2015).

Furthermore, some researchers argue that, in practice, organisations seldom provide PSS as their sole means of capturing and providing value; they have to combine both goods and PSS logic. **Managing goods and service business logic is a challenge** (5) (Nudurupati Et Al., 2016). Some authors found that **designing business models** represents a challenge for manufacturers transforming to offering PSS (6).

5.2. Customer and market

A key feature of PSS is customer centricity (T. S. Baines et al., 2009). Customer and market constructs concern the difficulties getting customers to accept the offer Raja et al. (2017) and actually managing them (Zhang & Banerji, 2017).

Several authors point out that manufacturers find it challenging to **establish long-term relationships with their customers** (7). A relationship represents the degree of interaction between two parties, for example, the customer and supplier (Brady et al., 2005; Deleon & Chatterjee, 2017). Relationship challenges are caused by the resources of the providing firms in terms of the providers' knowledge and opportunistic behaviour (Brax & Gustafsson, 2005). For product-oriented PSS, the interaction between the customer and provider is regular or on-demand; however, for use-oriented and performance-oriented PSS, the interaction is frequent and based on trust (W. Reim et al., 2015).

Customer acceptance (8) is a challenge for manufacturers who transition to offering PSS. One of the reasons is that customers may expect superior performance in terms of cost, quality and time (Schenkl et al., 2014a). The use of resources is a key enabler; for example, adequate training of sales personnel will help convince customers to engage in long-term service agreements (Story et al., 2017).

According to the PSS literature, **meeting customer expectations** (9) is a challenge for service-oriented organisations, especially in making sure the performance commitments made to customers are met profitably. Some authors affirm that resources are key enablers; however, the challenge is how to use them to meet customers' expectations (Schenkl et al., 2014b; Ulaga & Reinartz, 2011). One such resource is digital technology, but the real issue is how to use technology to meet high customer expectations regarding cost and quality (Schenkl et al., 2014b).

Some authors highlight the relevance of communication (Meier et al., 2010a; E. Sundin et al., 2010). **The challenge is how to communicate value to customers** (10). Communication is also crucial during product development, where the manufacturer needs to interact with stakeholders in a co-creation process, thus making sure needs are captured (Alonso-Rasgado & Thompson, 2006).

Another challenge discussed is **how to establish trust between customers and PSS providers** (11). These authors argue that trust is a key issue and is necessary to enhance relationships (Durugbo, 2013; W. Reim et al., 2018, 2014; Wallin et al., 2015). Trust is manifested in various ways, for instance, inadequate customer behaviour W. Reim et al. (2018), e.g. acting opportunistically to maximise their advantage. Furthermore, ambiguity of roles in the co-creation process could create issues (Rönnerberg Sjödin et al., 2016). For results-oriented PSS, W. Reim et al. (2018) believe that trust, monitoring, and sharing are agency mechanisms that can address the relationship challenges. Kamp et al. (2017) argue that the use of smart technologies is a plausible technique for addressing trustworthy

relationships, especially in advance services. The authors believe equipping machinery with sensors, microprocessors, controllers, telemetering, and transmission devices is a way forward.

5.3. Contracts

PSS contracts are agreements between providers and customers whose goal is to mitigate risks by defining each party's responsibilities and providing input into determining cost and price (Meier et al., 2010a). In PSS, the contractual relationship shifts from transactional to relational (W. Reim et al., 2018). Long service contracts provide manufacturers with opportunities to strengthen customer relationships, solidify their customer base, and gather customer knowledge (Brax et al., 2009).

One of the challenges of implementing PSS is how to **manage risks related to contracts (12)**, such as difficulty estimating the cost to deliver a contract (Erkoyuncu et al., 2009). Risks generally increase from product-oriented to result-oriented, but not for all PSS types (W. Reim et al., 2015; Richter et al., 2010). Some of these risks in PSS include: (1) technical risks, such as breakdowns and information monitoring and sharing problems; (2) customer behavioural risks like careless and opportunistic customer behaviour; and (3) delivery competence risks, including lack of competences and resources, complex supply chains, and inappropriate organisation structures (W. Reim et al., 2016).

Another example of such risks is **dealing with dynamic changes in long-term contracts (13)** (Richter et al., 2010). For use-oriented PSS, the authors believe one way to mitigate risks is to ensure flexibility in equipment design. Managing these risks is a key capability and is challenging (Visnjic et al., 2017). The level of operational risks and complexity is typical of such contracts (Datta & Christopher, 2011). However, these risks can be addressed by using various operation strategies to deliver contracts Priya Datta et al. (2011), using condition monitoring Ulaga and Reinartz (2011), Teixeira et al. (2013), Sakao et al. (2013), and capacity management for field service engineers during delivery of these contracts (Lagemann & Meier, 2014; Ng et al., 2010).

The literature reiterates that organisations find it challenging to **deliver the service contract's performance commitment (14)**. This is especially the case in outcome-based contracts (Ng et al., 2009; Visnjic et al., 2017). Under these contracts, the firm is responsible for delivering at a level where the customer is partly responsible for service delivery (Ng et al., 2009). In reality, the buyer purchases the results of the product, that is, service utilization or performance outcomes, and not the product itself. The provider bears the operating costs, which encompass maintenance, repairs, engineers, spare parts, and downtimes and they receive income by delivering performance (Priya Datta et al., 2011; Sakao et al., 2013). In outcome contracts Ng et al. (2009) point out that both parties need to come together to achieve effective value co-creation and co-production.

5.4. Network management

To deliver the agreements made with customers, offering PSS requires additional capabilities, competencies, or resources that might not be available internally. The manufacturer sub-contracts or outsources these capabilities to suppliers to deliver the required value to customers (Gebauer et al., 2013), (Ziaee Bigdeli et al., 2018). Such capabilities emanate from various partners, including suppliers, distributors, and in some cases, new partners that can undertake on-site maintenance and repair operations (Parida et al., 2014; W. Reim et al., 2015). This requires a higher level of cooperation or collaboration between providers and their supporting networks (Windahl & Lakemond, 2006).

Researchers assert that manufacturers find it challenging to **establish good relationships within their networks (15)**. Relationships enable organisations to cope with their increasing technological dependence on others and the need to develop and tailor offerings to more specific requirements (Åhlström & Nordin., 2006; Håkansson & Ford, 2002). In performance-based contracting, the relationship should be based on trust, customer interaction, and mutual commitments (Kleemann & Essig, 2013).

Effective communication is one way to address this relationship challenge (Meier et al., 2010a, 2010b; WEIGEL & HADWICH, 2018). A flexible organizational structure and an advanced information system can enhance communications within a service network and service-oriented relationship capabilities (Gebauer et al., 2013). Such capabilities may vary according to the type of PSS (Brax et al., 2009; W. Reim et al., 2015; Saccani et al., 2014).

Complexity in managing a PSS delivery network (16) has been flagged by many as challenging and might damage relationships with suppliers (Möller & Halinen, 1999). One way to address this complexity in network management is to use platforms to share, connect, and integrate with the network, while ensuring transparency and control over value creation and innovation (Eloranta & Turunen, 2016). (Meier et al., 2010b) argue that a suitable and robust information and communication system is required to solve this issue, as it can enable delivery performance in terms of availability and results. Furthermore, adapting the organisational structure, for example, from functional to process-oriented, is essential. This helps create transparency and thus, better communications between the networks of service delivery partners. They also recommend using a modular organisational concept, based on a modular organisational unit that links the PSS product module with existing resources. Linking processes with resources creates flexibility at low cost.

5.5. Product service design

To provide customer value and meet contractual agreements, product and service design is crucial (Richter et al., 2010). The PSS design and development construct refers to the challenges associated with designing and developing products and services to create customer value.

The literature argues that **integrating product and service development processes to create customer value** is challenging (17). One of the reasons is a shift in customer value from a focus on products to a focus on functionality Meier et al. (2010), Isaksson et al. (2009) that emanates from both product and service components, instead of only products. Consequently, the design process changes from short term to long term, embracing a total life cycle perspective in line with the contract period j. C. Aurich et al. (2006a), Isaksson et al. (2009), and Modelling (Aurich et al., 2009; Becker et al., 2010; Cavalieri & Pezzotta, 2012; Johnstone et al., 2009; Sundin & Bras, 2005; Sundin et al., 2009b).

Manufacturers **are challenged to develop products for PSS** (18). E. Sundin et al. (2009b) outline that one way to develop products for PSS and create customer value is to upgrade the development and management of the physical product using a life cycle perspective. In this case, the manufacturer ensures the required functionality is provided J. C. Aurich et al. (2006a), William (2006) while making sure the product is easier to maintain and reuse.

It is argued that **developing services for PSS is a challenge** (19). When providing a function instead of a product, PSS providers assume complete responsibility for life cycle cost (Alonso-Rasgado & Thompson, 2006; Alonso-Rasgado et al., 2004; Isaksson et al., 2009). The provider ensures that product requirements such as easy maintenance and upgrade are well aligned with service contract requirements (Isaksson et al., 2009). In fact, to ensure that providers meet their contractual agreements, they need to ensure flexibility during system design to mitigate uncertainties related to product use (Richter et al., 2010).

For result or performance PSS, life cycle implications are important (J. C. Aurich et al., 2006a). In this context, it becomes crucial to define the properties governing behaviour during the product's life cycle (ISAKSSON et al., 2009). It also becomes necessary to model, define, and simulate properties of downstream processes, such as manufacturing and maintenance, in other words, understanding how the functional product will fulfil customer needs (Isaksson et al., 2009). J. C. Aurich et al. (2006a) argues that in designing PSS, manufacturers should focus on product functionality, while considering ease of repair and maintenance.

Customization in PSS (20) is challenging. One way to create customer value in PSS is through customization (Song & Sakao, 2017), (Song et al., 2013). The authors argue that it is a challenge for PSS providers to manage various customer requirements during product development. Customization, which enhances long-term customer relationships, is lower for product-oriented PSS, but slightly higher for some customers of use-oriented PSS and performance-oriented PSS (W. Reim et al., 2015).

Brax et al. (2009) argue that **managing product data or knowledge is a challenge** (21). One way to manage product data is by monitoring products using information technology. **Developing sustainable PSS and remanufacturing** (22), modelling PSS (23), and configuring PSS (24) are challenges for companies that switch to PSS (Aurich et al., 2009).

Brax And Gustafsson (2005) found that designing PSS solutions requires designing a solution maintenance strategy that is tailored to customer requirements. The challenge is the design of the solution maintenance strategy (25), as well as choosing the right information systems and technology to support the solution (Brax & Gustafsson, 2005; Lightfoot et al., 2011).

6. Methods addressing PSS challenges

The previous section reveals that organisations transforming to PSS offerings face various challenges. The process of transforming to PSS requires support in terms of methods to address these challenges (Trevisan & Brissaud, 2016). Vasantha et al. (2012) argue that organisations need assistance in developing systems ready to deliver offerings over extended periods. Various methods to address the identified challenges are presented in this section. The articles describing these methods were read, and the overriding theme of each method was highlighted as displayed in Table 5. These categories are: organisation, product design, service design, PSS design, product/service design, and contracts.

6.1. Method 1

To solve the challenges associated with understanding changes in PSS business models Adrodegari et al. (2017) provide a Canvas framework to enable asset manufacturers' migration towards a results-oriented PSS business model and recognise the changes required to offer PSS. The authors specify critical success factors when changing business models. They adopted the Canvas business model to describe a systematic approach to supporting and understanding the changes in a PSS business model for an industrial equipment manufacturer producing industrial robots.

6.2. Method 2

Barquet et al. (2013) assert that manufacturers seeking to offer PSS face the challenge of understanding what type of PSS business model to offer as a means for their service expansion strategy. They propose a three-step method using the Canvas business model concept to analyse four PSS scenarios, which include a product-oriented PSS for existing products, use-oriented services PSS for existing products, performance-oriented PSS for existing products, and performance-oriented services PSS for new products and services. The Canvas model is later adopted to characterise various aspects of the alternative chosen. Their method addresses the challenges of recognising changes and implementing business models and was applied at a machine tool manufacturer seeking to adopt use-oriented PSS for a new business.

6.3. Method 3

Visintin (2012) argues that manufacturers find it challenging to operate PSS and the product sale business model. They introduce a generic method to enable manufacturers to deliver goods logic and an integrated solutions business model. To succeed in solving this problem, organisations need to adopt different delivery approaches targeting various customers. Their method focuses on the delivery process to ensure components that have already been designed are integrated and customised to meet various customers' requirements. Implemented in the printing industry, the framework consists of software, hardware, and service components, a generic delivery process, and four main delivery approaches, allowing development of capabilities alongside a process to manage these two logics.

Table 5. Categorisation of Methods

Numbering	Literature	Product-oriented (PO)	Use-oriented (UO)	Results or Performance-oriented (RO)	Not specified	Category of method
1	Adrodegari et al., 2017		✓			Organisation
2	Barquet et al., 2013				None	
3	Visintin, 2012				Not clear	
4	Meier & Massberg, 2004		✓			Organisation and service design
5	(Schenkl et al., 2014b				None	Product design
6	Alonso-Rasgado et al., 2004, Alonso-Rasgado & Thompson, 2006		✓			Service design
7	Maxwell & Van Der Vorst, 2003	✓				Product design
8	Aurich et al., 2006a	✓				Technical product and or service design
9	William, 2006	✓				Product Design
10	Ng et al., 2009			✓		PSS design
11	Shimomura et al. 2009					Service design
12	Baxter et al., 2009		✓			Product Design
13	Aurich et al., 2009			✓		Technical product and service design
14	Hara et al., 2009			✓		Service design
15	Sundin et al., 2009	✓				Product design
16	Datta & Roy, 2010			✓		Contract
17	Settanni et al., 2014			✓		
18	Isaksson et al., 2009			✓		Product design
19	(Song & Sakao, 2017	✓				Product design
20	Pezzotta et al., 2016				None	Service design
21	Sassanelli et al., 2017				✓	Product design

6.4. Method 4

Meier and Massberg (2004) provide a systematic procedure for developing services and a business model. They reiterate that development of a modular service product portfolio is required for a successful service strategy. An internet-based service configurator was developed and used to integrate component suppliers and outside service providers, which was realised via a portal. The portal supports the design and maintenance of service modules, administration of access authorisation, and selection mechanisms for automatic configuration of the appropriate service modules in terms of quality, cost, and resource criteria. Manufacturers can use their approach to design availability business models and customer-based services through modularization.

6.5. Method 5

Schenkl et al. (2014b) provide a technology centred model that specifies how organisations can develop products that are better aligned with higher customer value and higher revenue and are competitive, thus gaining market acceptance. Their approach specifies a three-step guideline to reach these goals. Their framework, which is applied in the automotive industry, discusses how specific PSS goals can be realised by identifying technology bottlenecks in both products and service, as well as in the support infrastructure. Identification of these bottlenecks is then addressed by appropriate technology that improves product and service performance.

6.6. Method 6

Alonso-Rasgado et al. (2004) and Alonso-Rasgado & Thompson (2006) proposed the 'Total Care' method for developing the concepts of a service support system. Their five-stage method with two sections—architecture and business—provide a procedure through which service support systems can be designed and integrated with existing or new hardware. The business aspects comprise markets, risks, partnership agreements, and sales and distribution, while the architectural aspects include hardware and service support systems. Suppliers of total care products are responsible for supporting the hardware in operation and offer customers a guarantee of availability.

6.7. Method 7

Settanni et al. (2014) provide a through-life costing methodology for advanced services delivered through PSS. They provide a four-step method for cost estimation in service contracts. The authors adopted input-output-analysis (IOA) of activities contained in a system through an integrated definition of system modelling (IDEF0) to compute these activities and the costs associated with performing them over time. The authors believe that IDEF0 helps depict the sustaining operations structure to deliver availability of the system in terms of means-ends or supply-demand. Application of their method is limited to military aircraft platforms and sub-systems and requires a certain level of mathematical knowledge.

6.8. Method 8

Datta & Roy (2010) provide a five-stage method for executing service cost estimation for result-oriented or performance contracts. They adopt an analogue method that spans three stages of the equipment life cycle: design, delivery, and adaptation. The main cost categories considered include recurring costs, non-recurring costs, overhead, and hidden costs. According to the authors, hidden costs tend to increase; these include relationship management costs, communication costs, detailed level data costs, reverse logistics and flexible response costs, and cultural change or change management costs. Their model can be used by managers that must invest in the right type of cost estimation at different stages of the PSS life cycle. Implemented in a defence industry, their framework provides a guide as to which cost ownership structures managers face when providing complex engineering services.

6.9. Method 9

The methodology for functional product development (FPD) extends the actual product design process to include modelling hardware, electronics, software, and services while considering the behaviour of the use and end of life phases, such as ease of maintenance, repair, and upgrade,

with build-in sensors fostering collaboration between the stakeholders (Isaksson et al., 2009). They propose a functional product development process that starts with identifying customer needs and requirements, followed by modelling and simulation.

6.10. Method 10

The systematic design of product-related technical service from a life cycle perspective is proposed by (J. C. Aurich et al., 2006a, 2006b). Their systematic process is a modification of the conventional product design approach, which they integrate with service design from a life cycle perspective. This method is suitable for capital goods like construction machines where major parts of the products and services developed are realized by an extended network of suppliers throughout the life cycle. They propose an integrated process model based on modularization that applies processes from a library shared with service network partners. Because of the potential impact on technical services across the entire product life cycle, they recommend using life cycle engineering techniques, for example, a design for X in combination with service design methods.

6.11. Method 11

Sassanelli et al. (2017) propose a design for a product service system supportability (DfPSSu) method based on the design for X approach. This method can address issues regarding integrated development of products and services aimed at providing the required functionality, addressing changing customer requirements, and increasing demand for new technologies. They propose a five-stage procedure with operational design guidelines that manufacturers can adopt at the conceptual stage to meet system functional requirements as well as design rules to improve life cycle performance of some systems' critical components.

6.12. Method 12

Shimomura et al. (2009) develop extended service blueprint (ESB) methodology to integrate product and service processes to maximise customer value. Their method provides a unified service methodology for developing services in general (e.g. see (Sakao & Shimomura, 2007)). With the goal of creating customer value, this method matches service activities with relevant and corresponding physical product components considering the desired function, using extended service blueprint (ESB). Their three-stage method embodies customer needs, designing service contents, and, finally, designing service activities using extended service blueprinting.

6.13. Method 13

Hara et al. (2009) proposed a service development method called service explorer (SE), which uses service blueprinting to integrate both product and service delivery activities and processes and aims at maximising customer value. Their method begins with an understanding of the receiver's state parameters (RSP), also known as customer wishes, value, and needs. These needs are then linked to a view model that represents the relevant product structure, which is then coupled with service activities through extended service blueprinting. The extended service blueprint helps model product behaviour and human activities. The method integrates products and service activities and is applied to elevators.

6.14. Method 14

MaussaNg et al. (2009) develop a PSS development methodology that provides designers with guidelines to determine engineering product criteria through a functional analysis system technique (FAST). Their method enables PSS engineering designers to realise technical engineering specifications in relation to the whole system's requirements to develop the physical objects involved in the system. They use a graph of interactors and functional block diagrams (FBD) to model and analyse PSS structures. To migrate from needs to solutions, they propose using SADT to describe functioning scenarios, which clarifies the activities performed in the system.

6.15. Method 15

E. Sundin et al. (2009b) find that one way to improve a product for PSS is to develop it from a life cycle perspective. The product's life cycle phases—manufacturing, maintenance, and end-of-life treatment—need to be considered. Their work exemplifies that design for X approaches, where X stands for a particular life cycle phase representing the aim of the methodology, is essential. In their case of Swedish firms, they apply design for remanufacture (DFRem) where they identify the process of remanufacturing for forklift trucks. For each process activity, guidelines are provided regarding specific product properties such as ease of access and wear resistance, which will eventually result in overall product and service improvement in terms of time and costs (E. Sundin et al., 2009b).

6.16. Method 16

Pezzotta et al. (2016) develop service engineering methodology (SEEM) to address the challenge of developing services for PSS and the performance of the service delivery process from the perspective of the PSS provider and customer. SEEM improves the value of service offerings by enhancing service conception, service delivery, and service consumption using appropriate engineering models, for example, quality function deployment (QFD), service blueprinting, discrete event simulation (DES), and service requirement trees (SRTs). Their four-stage approach moves from identifying the PSS that can meet customers' needs and required performance to designing the service delivery process, and finally, simulating and implementing it.

6.17. Method 17

Song and Sakao (2017) argue that one of the issues in PSS design activities is the high level of customization. Their work provides a customization method aimed at addressing customization challenges in PSS. In their five-stage process, they used a rough analytical hierarchical process (rough AHP) and industrial customer activity analysis (ICAA) to prioritise customer requirements. They then adopt house of quality to prioritise technical attributes (TA) that include functions. They identify conflicts in the technical attributes that are later standardised using the theory of inventive problem solving (TRIZ).

6.18. Method 18

Baxter et al. (2009) propose a data management method to support PSS design. With their method, organisations providing PSS can address the **challenge of managing product data and knowledge** to support product development. They apply the product process and resources (PPR) model across the product life cycle to manage data. Sources of knowledge include process knowledge, product knowledge, and task knowledge. Their three-stage method is composed of design knowledge, manufacturing capability knowledge, and service knowledge.

6.19. Method 19

Aurich et al. (2009) develop a framework for modelling or configuring a result-oriented PSS. They present the concept of a life cycle oriented configuration of PSS, combining physical and non-physical components to meet both customer and provider objectives. They discuss that modelling a result-oriented PSS is mainly based on the product rather than the solution character of PSS. Services in such cases mainly aim at enhancing the product's functional and economic performance. Their framework depicts seven elementary steps spread across three sections, and they note that their case study with a cultivator was successful.

6.20. Method 20

Williams (2006) provides a method for a micro retail factory (MRF). Their approach details how automobile manufacturers can empirically develop a PSS that addresses sustainability concerns. Their method is useful for manufacturers that provide product-oriented PSS and helps managers who seek to solve the economic and environmental sustainability challenges facing their organizations. The authors believe that by using modularity and upgradability in the design process, individual components or modules can be regularly replaced, repaired, or upgraded as part of an ongoing contract between provider and customer. In doing so, they argue that the need for higher product volumes becomes obsolete, which will result in significant costs savings while meeting sustainability demands.

6.21. Method 21

To tackle the sustainability challenge for PSS Maxwell and Van der Vorst (2003) develop a sustainable product service development (SPSD) method across a product's entire life cycle. Their approach describes a four-stage procedure through which manufacturing companies can decrease the environmental impact of their product at the concept stage of development. According to the authors, SPSD can produce products/services that are sustainable and achieve their required functionality, meet customer requirements, and are cost effective. They particularly stress that their approach adopts a life cycle assessment method, while integrating environmental performance improvement systems (EMS).

7. Discussion

The aim of this paper was to investigate the challenges facing product manufacturers who transform to offering PSS and the methods available to support them. Providing PSS is motivated by enhancing organisation competitiveness, increased customer value, long-term improved return on investment, stable cash flow, low environmental impact, and waste and cost reduction (Isaksson et al., 2009). However, the literature reiterates that migrating from asset manufacturing to offering PSS constitutes a major managerial challenge (Martinez et al., 2010; Meier et al., 2010a; Oliva & Kallenberg, 2003; E. Sundin et al., 2009c). These challenges present substantial risks for business success (e.g. see (Gebauer et al., 2005; Neely, 2008; Zhang & Banerji, 2017), such as in terms of profitability. Despite the business relevance of understanding the challenges and methods for offering PSS, previous research has paid little attention to providing a holistic approach by mapping challenges and methodologies (e.g. see (Martinez et al., 2010) (Brax & Gustafsson, 2005; Isaksson et al., 2009; Mahut et al., 2017; Nudurupati et al., 2016; T. S. Baines et al., 2009; E. Sundin et al., 2009c; Zhang & Banerji, 2017)).

Because of the scarcity in the literature on challenges and methods, this paper contributes by providing a comprehensive mapping of challenges and methods. In practical terms, this mapping provides support for manufacturers in migrating to offering PSS by making them aware of potential risks and their solutions. Theoretically, this mapping opens up new opportunities for future research in PSS. Table 6 maps these challenges and methods. The coloured boxes indicate challenges addressed and the overriding theme of the proposed method. The table shows that several methods are proposed to address a number of the challenges related to PSS implementation. This matrix allows organisations to quickly see which of the challenges are typical in their specific context and then choose the available solutions to address that particular issue.

This mapping shows that methods are still needed to address a wide range of challenges (e.g. see challenges 1, 2, 4, 7, 10, 11, 12, 14, and 15 in the white spaces of Table 6). As depicted in Table 4, these methods can cover a wide spectrum, including product design methods, service design methods, organisational methods, PSS design methods, contracts, and product/service design methods.

This mapping shows that even though several methods are proposed to upscale from asset manufacturing to PSS, the prevailing methods are dominated by design, ignoring aspects related to risks in service contracts. The current methods do not analyse the viability of the assets in relation to the PSS contract requirements, thus leaving open questions about whether the PSS provider can actually deliver the performance commitments required to ensure long-term relationships with their customers. Such methods will provide extensive support for manufacturers before they pursue a PSS journey.

8. Conclusion

We can conclude that asset manufacturers face several challenges in providing PSS, and several methods already exist to tackle some of these challenges. These challenges encompass business models and organisational, customer, market, contract, network, and product service development issues. With regard to business models and organisation, in transforming to offering PSS, asset producing companies struggle to re-organise their organisations and often face difficulties understanding the changes in their business models. Such changes include their value proposition, cost structure, customer segment, networks, key activities, resources, key partners, and revenue model. In terms of customers and markets, research shows that

Table 6. Mapping of PSS methods and challenges

Themes	Challenges	Methods				
		Product Design (Method 5,7,12,15,19,21)	Service Design (Method 6,11,14,18,20,4)	Contracts (Method 16,17)	Organisation (Method 1, 2, 3,4)	Product and/or Service Design (Method 8, 13)
Business Model and Organisation	1					
	2					
	3					
	4					
	5					
	6					
Customer and Market	7					
	8					
	9					
	10					
	11					
	12					
Contract	13					
	14					
Network	15					
	16					

(Continued)

Table 6. (Continued)		Methods					
Themes	Challenges	Product Design (Method 5,7,12,15,19,21)	Service Design (Method 6,11,14,18,20,4)	Contracts (Method 16,17)	Organisation (Method 1, 2, 3,4)	Product and/or Service Design (Method 8, 13)	PSS Design (Method 10)
Product Service development	17						
	18						
	19						
	20						
	21						
	22						
	23						
	24						
	25						

production companies that switch to offering PSS face the challenge of establishing long-term relationships with their customers; one reason is adverse customer behaviour in using the product as well as the provider's inability to deliver the performance agreements in contracts. Asset or product manufacturing firms migrating to PSS struggle to develop the product, service, and product service system. Since they are more used to designing the physical artefact, they find it difficult to understand the notion of a life cycle perspective. Research also shows that asset manufacturers are challenged to manage their networks for effective and efficient delivery of the services. Even though several methods exist for addressing these challenges, Table 6 shows that more methods are required to address challenges 1, 2, 4, 7, 10, 11, 12, 14, 15, 24, and 25. As shown in Table 6, such methods include aspects related to product design, service design, organisation, contracts, PSS design, and product or service design.

Future research can investigate these challenges in the context of a business model's specific services. Such research can enable an in-depth understanding of the issues a particular business model faces when a specific service type is offered. For example, these could be challenges related to offering process-oriented or customer-oriented services for specific industries. Research is also required to identify challenges specific to certain industries. Mahut et al. (2017) has already established a good foundation for such research by focusing specifically on the automotive industry.

Furthermore, as depicted on Table 6, more methodologies focus on the technical aspects of PSS, while ignoring the managerial aspects. Therefore, further research should be conducted to also investigate the managerial aspects, such as environmental sustainability. This is also consistent with the systematic review conducted by (Beuren et al., 2013).

The use of smart technologies to support manufacturers' expansion to PSS should also be further investigated, as this constitutes an opportunity, but also a significant challenge, especially in terms of enhancing customer-supplier relationships (Kamp et al., 2017). The role played by knowledge of new technologies and their effective use has been highlighted as a promising area to support service expansion (Ziaee Bigdeli et al., 2018), (Ardolino et al., 2018), (Teixeira et al., 2013). Further research should develop methods that integrate new technologies to support the implementation of PSS.

Finally, this research was limited to the use of Scopus as the only database searched for relevant articles. Although scholarly arguments have emerged on the coverage of Scopus in scientific research, we might have missed some articles that could have extended the lists of challenges or barriers and methodologies.

Author details

John Sakwe Bake¹

E-mail: j.b.sakwe@utwente.nl

Marcus Vinicius Pereira Pessôa¹

E-mail: m.v.pereirapessoa@utwente.nl

Hoekstra Sipke¹

E-mail: s.hoekstra@utwente.nl

¹ University of Twente, Enschede, 7522 NB, Nederland.

Citation information

Cite this article as: Mapping challenges and methodologies for providing PSS - a thematic and descriptive analysis, John Sakwe Bake, Marcus Vinicius Pereira Pessôa & Hoekstra Sipke, *Cogent Business & Management* (2020), 7: 1809945.

ReferenceReference

Adrodegari, F., Saccani, N., Kowalkowski, C., & Vilo, J. (2017). PSS business model conceptualization and application*. *Production Planning & Control*, 28(1), 1251–1263. <https://doi.org/10.1080/09537287.2017.1363924>

Åhlström, P., & Nordin, F. (2006). Problems of establishing service supply relationships: Evidence from a high-tech manufacturing company. *Journal of Purchasing Supply Management*, 12(2), 75–89. <https://doi.org/10.1016/j.pursup.2006.05.002>

Alonso-Rasgado, T., & Thompson, G. (2006). A rapid design process for total care product creation. *Journal of Engineering Design*, 17(6), 509–531. doi:10.1080/09544820600750579

Alonso-Rasgado, T., Thompson, G., & Elfström, B.-O. E. (2004). The design of functional (total care) products. *Journal of Engineering Design*, 15(6), 515–540. doi:10.1080/09544820412331271176

Ardolino, M., Rapaccini, M., Saccani, N., Gaiardelli, P., Crespi, G., & Ruggeri, C. (2018). The role of digital technologies for the service transformation of industrial companies. *International Journal of Production Research*, 56(6), 2116–2132. doi:10.1080/00207543.2017.1324224

Aurich, J. C., Fuchs, C., & Wagenknecht, C. (2006a). Life cycle oriented design of technical Product-Service Systems. *Journal of Cleaner Production*, 14(17), 1480–1494. doi:10.1016/j.jclepro.2006.01.019

- Aurich, J. C., Fuchs, C., & Wagenknecht, C. (2006b). Modular design of technical product-service systems. *Innovation in life cycle engineering and sustainable development* (pp. 303–320). Springer. https://doi.org/10.1007/1-4020-4617-0_21
- Aurich, J. C., Mannweiler, C., & Schweitzer, E. (2010). How to design and offer services successfully. *CIRP Journal of Manufacturing Science and Technology*, 2(3), 136–143. doi:10.1016/j.cirpj.2010.03.002
- Aurich, J. C., Wolf, N., Siener, M., & Schweitzer, E. (2009). Configuration of product-service systems. *Journal of Manufacturing Technology Management*, 20(5), 591–605. <https://doi.org/10.1108/17410380910961000>
- Azarenko, A., Roy, R., Shehab, E., Tiwari, A., & Roy, R. (2009). Technical product-service systems: Some implications for the machine tool industry. *Journal of Manufacturing Technology Management*, 20(5), 700–722. doi:10.1108/17410380910961064
- Baines, T., Lightfoot, H. W., Evans, S., Neely, A., Greenough, R., Peppard, J., Roy, R., Shehab, E., Braganza, A., Tiwari, A., Alcock, J. R., Angus, J. P., Bastl, M., Cousens, A., Irving, P., Johnson, M., Kingston, J., Lockett, H., Martinez, V., Michele, P., ... Wilson, H. (2007). State-of-the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 221(10), 1543–1552. doi:10.1243/09544054JEM858
- Baines, T., Ziaee Bigdeli, A., Bustanza, O. F., Shi, V. G., Baldwin, J., & Ridgway, K. (2017). Servitization: Revisiting the state-of-the-art and research priorities. *International Journal of Operations and Production Management*, 37(2), 256–278. <https://doi.org/10.1108/IJOPM-06-2015-0312>
- Baines, T. S., Lightfoot, H. W., & Kay, J. M. (2009). Servitized manufacture: Practical challenges of delivering integrated products and services. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, 223(9), 1207–1215. doi:10.1243/09544054JEM1552
- Barquet, A. P. B., de Oliveira, M. G., Amigo, C. R., Cunha, V. P., & Rozenfeld, H. (2013). Employing the business model concept to support the adoption of product-service systems (PSS). *Industrial Marketing Management*, 42(5), 693–704. <https://doi.org/10.1016/j.indmarman.2013.05.003>
- Baxter, D., Roy, R., Doultsinou, A., Gao, J., & Kalta, M. (2009). A knowledge management framework to support product-service systems design. *International Journal of Computer Integrated Manufacturing*, 22(12), 1073–1088. <https://doi.org/10.1080/09511920903207464>
- Becker, J., Beverungen, D. F., & Knackstedt, R. (2010). The challenge of conceptual modeling for product-service systems: Status-quo and perspectives for reference models and modeling languages. *Information Systems and e-Business Management*, 8(1), 33–66. doi:10.1007/s10257-008-0108-y
- Bertoni, A., Bertoni, M., Panarotto, M., Johansson, C., & Larsson, T. C. (2016). Value-driven product service systems development: Methods and industrial applications. *CIRP Journal of Manufacturing Science and Technology*, 15, 42–55. <https://doi.org/10.1016/j.cirpj.2016.04.008>
- Beuren, F. H., Gomes Ferreira, M. G., & Cauchick Miguel, P. A. (2013). Product-service systems: A literature review on integrated products and services. *Journal of cleaner production*, 47, 222–231. <https://doi.org/10.1016/j.jclepro.2012.12.028>
- Brady, T., Davies, A., & Gann, D. M. (2005). Creating value by delivering integrated solutions. *International Journal of Project Management*, 23(5), 360–365. doi:10.1016/j.jiproman.2005.01.001
- Brax, S., & Gustafsson, A. (2005). A manufacturer becoming service provider—challenges and a paradox. *Managing Service Quality: An International Journal*, 15(2), 142–155. doi:10.1108/09604520510585334
- Brax, S. A., Jonsson, K., & Wilkinson, A. (2009). Developing integrated solution offerings for remote diagnostics: A comparative case study of two manufacturers. *International Journal of Operations & Production Management*, 29(5), 539–560. doi:10.1108/01443570910953621
- Cavaliere, S., & Pezzotta, G. (2012). Product-Service Systems Engineering: State of the art and research challenges. *Computers in Industry*, 63(4), 278–288. doi:10.1016/j.compind.2012.02.006
- Coreynen, W., Matthyssens, P., De Rijck, R., & Dewit, I. (2018). Internal levers for servitization: How product-oriented manufacturers can upscale product-service systems. *International Journal of Production Research*, 56(6), 2184–2198. doi:10.1080/00207543.2017.1343504
- Datta, P. P., & Christopher, M. G. (2011). Information sharing and coordination mechanisms for managing uncertainty in supply chains: A simulation study. *International Journal of Production Research*, 49(3), 765–803. doi:10.1080/00207540903460216
- Datta, P. P., & Roy, R. (2010). Cost modelling techniques for availability type service support contracts: A literature review and empirical study. *CIRP Journal of Manufacturing Science and Technology*, 3(2), 142–157. <https://doi.org/10.1016/j.cirpj.2010.07.003>
- Deleon, A. J., & Chatterjee, S. C. (2017). B2B relationship calculus: Quantifying resource effects in service-dominant logic. *Journal of the Academy of Marketing Science*, 45(3), 402–427. doi:10.1007/s11747-015-0467-0
- Durugbo, C. (2013). Competitive product-service systems: Lessons from a multicase study. *International Journal of Production Research*, 51(19), 5671–5682. doi:10.1080/00207543.2013.775526
- Eloranta, V., & Turunen, T. (2016). Platforms in service-driven manufacturing: Leveraging complexity by connecting, sharing, and integrating. *Industrial Marketing Management*, 55, 178–186. <https://doi.org/10.1016/j.indmarman.2015.10.003>
- Erkoyuncu, J. A., Roy, R., Shehab, E., & Wardle, P. (2009). Uncertainty challenges in service cost estimation for product-service systems in the aerospace and defence industries. *Proceedings of the 19th CIRP Design Conference—Competitive Design*, Cranfield University Press.
- Falagas, M. E., Pitsouni, E. I., Malietzis, G. A., & Pappas, G. (2008). Comparison of PubMed, scopus, web of science, and google scholar: Strengths and weaknesses. *FASEB Journal*, 22(2), 338–342. <https://doi.org/10.1096/fj.07-9492LSF>
- Garetti, M., Rosa, P., & Terzi, S. (2012). Life cycle simulation for the design of product-service systems. *Computers in Industry*, 63(4), 361–369. <https://doi.org/10.1016/j.compind.2012.02.007>
- Gebauer, H., Fleisch, E., & Friedli, T. (2005). Overcoming the service paradox in manufacturing companies. *European Management Journal*, 23(1), 14–26. <https://doi.org/10.1016/j.emj.2004.12.006>
- Gebauer, H., Paiola, M., & Saccani, N. (2013). Characterizing service networks for moving from products to solutions. *Industrial Marketing Management*, 42(1), 31–46. doi:10.1016/j.indmarman.2012.11.002

- Goedkoop, M., van Halen, C., te Riele, H., & Rommens, P. J. E. A. (1999). Product service systems, ecological and economic basics report for Dutch Ministries of Environment (VROM) and Economic Affairs (EZ), 1999. *Economic Affairs*.
- Håkansson, H., & Ford, D. (2002). How should companies interact in business networks?. *Journal of business research*, 55(2), 133–139. doi:10.1016/S0148-2963(00)00148-X
- Hara, T., Arai, T., Shimomura, Y., & Sakao, T. (2009). Service CAD system to integrate product and human activity for total value. *CIRP Journal of Manufacturing Science and Technology*, 1(4), 262–271. <https://doi.org/10.1016/j.cirpj.2009.06.002>
- Isaksson, O., Larsson, T. C., & Rönnbäck, A. Ö. (2009). Development of product-service systems: Challenges and opportunities for the manufacturing firm. *Journal of Engineering Design*, 20(4), 329–348. doi:10.1080/09544820903152663
- Johansson, J. E., Krishnamurthy, C., & Schlissberg, H. E. J. M. q. (2003). Solving the solutions problem. *Mckinsey Quarterly*, (3), 116–125.
- Johnstone, S., Dainty, A., Wilkinson, A., & Wilkinson, A.. (2009). Integrating products and services through life: An aerospace experience. *International Journal of Operations & Production Management*, 29(5), 520–538. doi:10.1108/01443570910953612
- Kamp, B., Ochoa, A., & Diaz, J. (2017). Smart servitization within the context of industrial user-supplier relationships: Contingencies according to a machine tool manufacturer. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, 11(3), 651–663. doi:10.1007/s12008-016-0345-0
- Kleemann, F. C., & Essig, M. (2013). A providers' perspective on supplier relationships in performance-based contracting. *Journal of Purchasing and Supply Management*, 19(3), 185–198. doi:10.1016/j.pursup.2013.03.001
- Kohtamäki, M., Partanen, J., Parida, V., & Wincent, J. (2013). Non-linear relationship between industrial service offering and sales growth: The moderating role of network capabilities. *Industrial Marketing Management*, 42(8), 1374–1385. <https://doi.org/10.1016/j.indmarman.2013.07.018>
- Kowalkowski, C. (2011). Dynamics of value propositions: Insights from service-dominant logic. *European Journal of Marketing*, 45(1/2), 277–294. doi:10.1108/03090561111095702
- Lagemann, H., & MEIER, H. (2014). Robust capacity planning for the delivery of industrial product-service systems. *Procedia CIRP*, 19(C), 99–104. <https://doi.org/10.1016/j.procir.2014.05.021>
- Li, A. Q., Kumar, M., Claes, B., & Found, P. (2020). The state-of-the-art of the theory on Product-Service Systems. *International Journal of Production Economics*, 222. <https://doi.org/10.1016/j.ijpe.2019.09.012>
- Lightfoot, H., Baines, T., & Smart, P. (2011). Examining the information and communication technologies enabling servitized manufacture. *Journal of Engineering Manufacture*, 225(10), 1964–1968. doi:10.1177/0954405411399019
- Lindahl, M., Sakao, T., Sundin, E., & Shimomura, Y. (2009). Product/service systems experiences: An international survey of Swedish, Japanese, Italian and German manufacturing companies. 1st CIRP Industrial Product-Service Systems (IP52) Conference, Cranfield University UK, 1–2 April 2009, Cranfield University Press, 74–81.
- Lindahl, M., Sundin, E., Öhrwall Rönnbäck, A., Öhlund Sandström, G., & Östlin, J. (2006, April 20–21). *Integrated product and service engineering-the ipse project*. Paper presented at the Workshop of the Sustainable Consumption Research Exchange (SCORE!), Copenhagen, Denmark.
- Mahut, F., Daaboul, J., Bricogne, M., & Eynard, B. (2017). Product-Service Systems for servitization of the automotive industry: A literature review. *International Journal of Production Research*, 55(7), 2102–2120. doi:10.1080/00207543.2016.1252864
- Martinez, V., Bastl, M., Kingston, J., Evans, S., & Leseure, M. (2010). Challenges in transforming manufacturing organisations into product-service providers. *Journal of manufacturing technology management*, 21(4), 449–469. doi:10.1108/17410381011046571
- Maxwell, D., & Van der Vorst, R. (2003). Developing sustainable products and services. *Journal of Cleaner Production*, 11(8 SPEC.), 883–895. [https://doi.org/10.1016/S0959-6526\(02\)00164-6](https://doi.org/10.1016/S0959-6526(02)00164-6)
- Meier, H., & Massberg, W. (2004). Life cycle-based service design for innovative business models. *CIRP Annals - Manufacturing Technology*, 53(1), 393–396. [https://doi.org/10.1016/S0007-8506\(07\)60724-0](https://doi.org/10.1016/S0007-8506(07)60724-0)
- Meier, H., Roy, R., & Seliger, G. (2010a). Industrial Product-Service Systems—IPS 2. *CIRP Annals - Manufacturing Technology*, 59(2), 607–627. doi:10.1016/j.cirp.2010.05.004
- Meier, H., Uhlmann, E., Krug, C., Völker, O., Geisert, C., & Stelzer, C. (2010b). Dynamic IPS2 networks and operations based on software agents. *CIRP Journal of Manufacturing Science and Technology*, 3(2), 165–173. doi:10.1016/j.cirpj.2010.04.001
- Minguez, J., Baureis, D., & Neumann, D. (2012). A reference architecture for agile product-service systems. *CIRP Journal of Manufacturing Science and Technology*, 5(4), 319–327. doi:10.1016/j.cirpj.2012.09.007
- Möller, K., Rajala, A., & Svahn, S. (2005). Strategic business nets - Their type and management. *Journal of Business Research*, 58(9 SPEC. ISS.), 1274–1284. <https://doi.org/10.1016/j.jbusres.2003.05.002>
- Möller, K. K., & Halinen, A. (1999). Business relationships and networks: Managerial challenge of network era. *Industrial marketing management*, 28(5), 413–427. doi:10.1016/S0019-8501(99)00086-3
- Neely, A. (2008). Exploring the financial consequences of the servitization of manufacturing. *Operations Management Research*, 1(2), 103–118. <https://doi.org/10.1007/s12063-009-0015-5>
- Ng, I. C., Maull, R., & Yip, N. J. E. M. J. (2009). Outcome-based contracts as a driver for systems thinking and service-dominant logic in service science: Evidence from the defence industry. *European management journal*, 27(6), 377–387. doi:10.1016/j.emj.2009.05.002
- Ng, I. C., Nudurupati, S. S., & Gustafsson, A.. (2010). Outcome-based service contracts in the defence industry-mitigating the challenges. *Journal of Service Management*, 21(5), 656–674. doi:10.1108/09564231011079084
- Nudurupati, S. S., Lascelles, D., Wright, G., & YIP, N. (2016). Eight challenges of servitisation for the configuration, measurement and management of organisations. *Journal of Service Theory and Practice*, 26(6), 745–763. doi:10.1108/JSTP-02-2015-0045
- Oliva, R., & Kallenberg, R. (2003). Managing the transition from products to services. *International journal of service industry management*, 14(2), 160–172. doi:10.1108/09564230310474138
- Parida, V., Sjödin, D. R., Wincent, J., & Kohtamäki, M. (2014). Mastering the transition to product-service provision: Insights into business models, learning

- activities, and capabilities. *Research Technology Management*, 57(3), 44–52. <https://doi.org/10.5437/08956308X5703227>
- Pessôa, M. V. P., & Becker, J. M. J. (2017). Overcoming the product-service model adoption obstacles. *Procedia CIRP*, 64, 163–168. <https://doi.org/10.1016/j.procir.2017.03.062>
- Pezzotta, G., Pirola, F., Rondini, A., Pinto, R., & Ouertani, M. (2016). Towards a methodology to engineer industrial product-service system – Evidence from power and automation industry. *CIRP Journal of Manufacturing Science and Technology*, 15, 19–32. <https://doi.org/10.1016/j.cirpj.2016.04.00>
- Pezzotta, G., Sassanelli, C., Pirola, F., Sala, R., Rossi, M., Fotia, S., et al. (2018). The product service system lean design methodology (PSSLDLM): Integrating product and service components along the whole PSS lifecycle. *Journal of Manufacturing Technology Management*, 29(8), 1270–1295. <https://doi.org/10.1108/JMTM-06-2017-0132>
- Priya Datta, P., Roy, R., & Demeter, K. (2011). Operations strategy for the effective delivery of integrated industrial product-service offerings: Two exploratory defence industry case studies. *International Journal of Operations & Production Management*, 31(5), 579–603. doi:10.1108/01443571111126337
- Raja, J. Z., Frandsen, T., & Mouritsen, J. (2017). Exploring the managerial dilemmas encountered by advanced analytical equipment providers in developing service-led growth strategies. *International Journal of Production Economics*, 192, 120–132. <https://doi.org/10.1016/j.ijpe.2016.12.034>
- Reim, W., Parida, V., & Örtqvist, D. (2015). Product-service systems (PSS) business models and tactics – A systematic literature review. *Journal of Cleaner Production*, 97, 61–75. <https://doi.org/10.1016/j.jclepro.2014.07.003>
- Reim, W., Parida, V., & Sjödin, D. R. (2016). Risk management for product-service system operation. *International Journal of Operations & Production Management*, 36(6), 665–686. doi:10.1108/IJOPM-10-2014-0498
- Reim, W., Sjödin, D., & Parida, V. (2018). Mitigating adverse customer behaviour for product-service system provision: An agency theory perspective. *Industrial Marketing Management*, 74, 150–161. <https://doi.org/10.1016/j.indmarman.2018.04.004>
- Reim, W., Sjödin, D. R., & Parida, V. (2014). Trust or Control: How to Manage Behavioural Uncertainty for Industrial Product-Service System Provision? International CINet Conference: Operating Innovation-Innovating Operations 07/09/2014–09/09/2014.
- Richter, A., Sadek, T., & Steven, M. (2010). Flexibility in industrial product-service systems and use-oriented business models. *CIRP Journal of Manufacturing Science and Technology*, 3(2), 128–134. doi:10.1016/j.cirpj.2010.06.003
- Rönnerberg Sjödin, D., Parida, V., & Wincent, J. (2016). Value co-creation process of integrated product-services: Effect of role ambiguities and relational coping strategies. *Industrial marketing management*, 56, 108–119. <https://doi.org/10.1016/j.indmarman.2016.03.013>
- Saccani, N., Visintin, F., & Rapaccini, M. (2014). Investigating the linkages between service types and supplier relationships in servitized environments. *International Journal of Production Economics*, 149, 226–238. <https://doi.org/10.1016/j.ijpe.2013.10.001>
- Sakao, T., Rönnerbäck, A. Ö., Sandström, G. Ö., & Engineering, S. (2013). Uncovering benefits and risks of integrated product service offerings—Using a case of technology encapsulation. *Journal of Systems Science and Systems Engineering*, 22(4), 421–439. doi:10.1007/s11518-013-5233-6
- Sakao, T., & Shimomura, Y. (2007). Service Engineering: A novel engineering discipline for producers to increase value combining service and product. *Journal of Cleaner Production*, 15(6), 590–604. doi:10.1016/j.jclepro.2006.05.015
- Sassanelli, C., Pezzotta, G., Sala, R., Correia, A., & Terzi, S. (2017). Testing the Methodology to Generate Design for Product Service Supportability (DfPSS) Guidelines and Rules: An application case. *Procedia CIRP*, 64, 265–270. <https://doi.org/10.1016/j.procir.2017.03.121>
- Schenkl, S. A., Rösch, C., & Mörtl, M. (2014a). Literature study on factors influencing the market acceptance of PSS. *Procedia CIRP*, 16, 98–103. <https://doi.org/10.1016/j.procir.2014.01.013>
- Schenkl, S. A., Sauer, R. M., & Mörtl, M. (2014b). A Technology-centered Framework for Product-service Systems. *Procedia CIRP*, 16, 295–300. doi:10.1016/j.procir.2014.01.029
- Settanni, E., Newnes, L. B., Thenent, N. E., Parry, G., & Goh, Y. M. (2014). A through-life costing methodology for use in product-service-systems. *International Journal of Production Economics*, 153, 161–177. doi:10.1016/j.ijpe.2014.02.016153
- Shimomura, Y., Hara, T., & Arai, T. J. C. a. (2009). A unified representation scheme for effective PSS development. *CIRP Annals*, 58(1), 379–382.
- Song, W., Ming, X., Han, Y., & Wu, Z. (2013). A rough set approach for evaluating vague customer requirement of industrial product-service system. *International Journal of Production Research*, 51(22), 6681–6701. doi:10.1080/00207543.2013.832435
- Song, W., & Sakao, T. (2017). A customization-oriented framework for design of sustainable product/service system. *Journal of Cleaner Production*, 140, 1672–1685. <https://doi.org/10.1016/j.jclepro.2016.09.111>
- Storbacka, K., Windahl, C., Nenonen, S., & Salonen, A. (2013). Solution business models: Transformation along four continua. *Industrial Marketing Management*, 42(5), 705–716. doi:10.1016/j.indmarman.2013.05.008
- Story, V. M., Raddats, C., Burton, J., Zolkiewski, J., & Baines, T. (2017). Capabilities for advanced services: A multi-actor perspective. *Industrial Marketing Management*, 60, 54–68. <https://doi.org/10.1016/j.indmarman.2016.04.015>
- Sundin, E., & Bras, B. (2005). Making functional sales environmentally and economically beneficial through product remanufacturing. *Journal of cleaner production*, 13(9), 913–925. doi:10.1016/j.jclepro.2004.04.006
- Sundin, E., Lindahl, M., Comstock, M., Sakao, T., & Shimomura, Y. (2009a). Achieving mass customisation through servicification. *International Journal of Internet Manufacturing and Services*, 2(1), 56–75. doi:10.1504/IJIMS.2009.031340
- Sundin, E., Lindahl, M., Ijomah, W., & Roy, R. (2009b). Product design for product/service systems: Design experiences from Swedish industry. *Journal of Manufacturing Technology Management*, 20(5), 723–753. doi:10.1108/17410380910961073
- Sundin, E., Rönnerbäck, A. Ö., & Sakao, T. (2010). From component to system solution supplier: Strategic warranty management as a key to efficient integrated product/service engineering. *CIRP Journal of Manufacturing Science and Technology*, 2(3), 183–191. doi:10.1016/j.cirpj.2010.04.007
- Sundin, E., Sandström, G. Ö., Rönnerbäck, A. Ö., Sakao, T., & Larsson, T. (2009c). Challenges for Industrial Product/

- Service Systems: Experiences from a learning network of large companies. CIRP IPS2 Conference, Cranfield University Press.
- Teixeira, E. L. S., Tjahjono, B., Alfaro, S. C. A., & Julião, J. M. S. (2013). Harnessing prognostics health management and product-service systems interaction to support operational decisions. *Journal of Manufacturing Technology Management*, 24(1), 78–94. <https://doi.org/10.1108/17410381311287490>
- Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *British journal of management*, 14(3), 207–222. doi:10.1111/1467-8551.00375
- Trevisan, L., & Brissaud, D. (2016). Engineering models to support product-service system integrated design. *CIRP Journal of Manufacturing Science and Technology*, 15, 3–18. <https://doi.org/10.1016/j.cirpj.2016.02.004>
- Tukker, A. (2004). Eight types of product-service system: Eight ways to sustainability? Experiences from SusProNet. *Business strategy and the environment*, 13(4), 246–260. doi:10.1002/bse.414
- Tukker, A. (2015). Product services for a resource-efficient and circular economy - A review. *Journal of Cleaner Production*, 97, 76–91. <https://doi.org/10.1016/j.jclepro.2013.11.049>
- Ullaga, W., & Reinartz, W. J. (2011). Hybrid offerings: How manufacturing firms combine goods and services successfully. *Journal of marketing*, 75(6), 5–23. doi:10.1509/jm.09.0395
- Vandermerwe, S., & Rada, J. (1988). Servitization of business: Adding value by adding services. *European Management Journal*, 6(4), 314–324. [https://doi.org/10.1016/0263-2373\(88\)90033-3](https://doi.org/10.1016/0263-2373(88)90033-3)
- Vargo, S. L., Lusch, R. F., Akaka, M. A., & He, Y. (2010). Service-dominant logic. [https://doi.org/10.1108/s1548-6435\(2009\)0000006010](https://doi.org/10.1108/s1548-6435(2009)0000006010)
- Vasantha, G. V. A., Roy, R., Lelah, A., & Brissaud, D. (2012). A review of product-service systems design methodologies. *Journal of Engineering Design*, 23(9), 635–659. <https://doi.org/10.1080/09544828.2011.639712>
- Visintin, F. (2012). Providing integrated solutions in the professional printing industry: The case of Océ. *Computers in Industry*, 63(4), 379–388. <https://doi.org/10.1016/j.compind.2012.02.010>
- Visnjic, I., Jovanovic, M., Neely, A., & Engwall, M. (2017). What brings the value to outcome-based contract providers? Value drivers in outcome business models. *International Journal of Production Economics*, 192, 169–181. <https://doi.org/10.1016/j.ijpe.2016.12.008>
- Wallin, J., Parida, V., & Isaksson, O. (2015). Understanding product-service system innovation capabilities development for manufacturing companies. *Journal of Manufacturing Technology Management*, 26(5), 763–787. doi:10.1108/JMTM-05-2013-0055
- Weigel, S., & Hadwich, K. (2018). Success factors of service networks in the context of servitization—Development and verification of an impact model. *Industrial Marketing Management*, 74, 254–275. <https://doi.org/10.1016/j.indmarman.2018.06.002>
- Williams, A. (2006). Product-service systems in the automotive industry: The case of micro-factory retailing. *Journal of Cleaner Production*, 14(2), 172–184. <https://doi.org/10.1016/j.jclepro.2004.09.003>
- Windahl, C., & Lakemond, N. (2006). Developing integrated solutions: The importance of relationships within the network. *Industrial Marketing Management*, 35(7), 806–818. doi:10.1016/j.indmarman.2006.05.010
- Zhang, W., & Banerji, S. (2017). Challenges of servitization: A systematic literature review. *Industrial Marketing Management*, 65, 217–227. <https://doi.org/10.1016/j.indmarman.2017.06.003>
- Ziaee Bigdeli, A., Bustanza, O. F., Vendrell-Herrero, F., & Baines, T. (2018). Network positioning and risk perception in servitization: Evidence from the UK road transport industry. *International Journal of Production Research*, 56(6), 2169–2183. doi:10.1080/00207543.2017.1341063



© 2020 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:

Share — copy and redistribute the material in any medium or format.

Adapt — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.

You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.



***Cogent Business & Management* (ISSN:) is published by Cogent OA, part of Taylor & Francis Group.**

Publishing with Cogent OA ensures:

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com

