

THE INTELLECTUAL DEVELOPMENT OF THE PRODUCT-SERVICE SYSTEM CONCEPT: A CITATION / CO-CITATION ANALYSIS

EL DESARROLLO INTELECTUAL DEL CONCEPTO DE SISTEMA PRODUCTO-SERVICIO: UN ANÁLISIS DE CITACIÓN / CO-CITACIÓN

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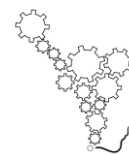
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ABSTRACT. The concept of product-service system (PSS) can be described as a market proposition that increases the value of a product by adding additional services. The present paper aims to contribute to the current understanding of PSS research field by identifying and visualizing its theoretical evolution. A citation and co-citation bibliometric analysis was conducted and it was possible to identify that PSS theory was supported by an integrated approach of the servitization (VANDERMERWE; RADA, 1988) and the service-dominant logic concepts. A co-citation map enables the visual representation of the intellectual structure of PSS research field contributing to better identify gaps and opportunities for future research

Keywords: Product-Service System, Co-citation, Bibliometric study

RESUMEN El concepto de sistema producto-servicio (PSS) es una propuesta para incrementar el valor de un producto agregando servicios adicionales, aumentando así la competitividad de la industria y, al mismo tiempo, resolviendo desafíos de sustentabilidad. Este estudio tiene como objetivo identificar y retratar la evolución teórica de la literatura sobre PSS. A través de un análisis bibliométrico de citación y co-citación, demostramos que la teoría de PSS fue apoyada por los conceptos de servitización (VANDERMERWE; RADA, 1988) y lógica dominante de servicio. Una representación gráfica del mapa de co-citación permite visualizar la estructura intelectual del campo de investigación de PSS, contribuyendo a una mejor identificación de futuras oportunidades de investigación.

Palabras-clave: Product-Service System, Co-Citación, Bibliometría



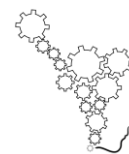
1 INTRODUCTION

Since the 1990's manufacturing industries worldwide undergo colossal change. Wise & Baumgartner (1999) called attention to the need of looking for new sources of revenue “going downstream, beyond factory gates”, that is to say, adding service-based advantages to manufacturers' offers to increase competitiveness. This move from mass production to mass customization put services in the central role of providing value for the manufacturing industries, configuring the service economy, in which the boundaries of manufacturing and services have been increasingly blurring (O.K. MONT, 2002; VANDERMERWE; RADA, 1988).

Another important driver of change for the industries is the environmental problems caused by the rising level of consumption requiring dramatic increases in resources. In order to guarantee long term economic growth and environment sustainability, the current production and consumption systems need to be redefined. (GOEDKOOP et al., 1999).

The concept of product-service system (PSS) has been proposed by several authors as a possible strategy to increase industries' competitiveness while addressing sustainability challenges. PSS can be described as a market proposition that increases the value of a product by adding additional services. The first definition of the term PSS was provided by Goedkoop et al (1999, p. 3): “A PS (product-service) system is described as a marketable set of products and services capable of jointly fulfilling a user's need. The product/service ratio can vary, either in terms of function fulfilment or economic value. Since PSS is focused on satisfying consumer needs rather than delivering material goods, alternative scenarios of product use emerge, as for example, car sharing systems as opposed to acquiring a car. As those alternatives end up by changing ownership structures and reducing consumption, PSS systems can also contribute to a more sustainable society. (BEUREN; GOMES FERREIRA; CAUCHICK MIGUEL, 2013; O.K. MONT, 2002)

PSS concept has been discussed in the literature for over two decades. (VEZZOLI et al., 2015). It has been evolving around diverse approaches such as: efforts of conceptualization (BAINES et al., 2007; BEUREN; GOMES FERREIRA; CAUCHICK MIGUEL, 2013; O.K. MONT, 2002), development of methodologies (AURICH; FUCHS; WAGENKNECHT, 2006; BARQUET et al., 2013; BARTOLOMEO et al., 2003; MEIER;



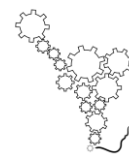
ROY; SELIGER, 2010; MORELLI, 2006; TUKKER, 2004; VASANTHA et al., 2012), analysis of PSS implementation and results (CESCHIN, 2013; CHANEY; BEN SLIMANE; HUMPHREYS, 2016; COOK; BHAMRA; LEMON, 2006; KOHTAMÄKI et al., 2013; LINDAHL; SUNDIN; SAKAO, 2014; NEELY, 2009; REXFELT; HIORT AF ORNÄS, 2009; WILLIAMS, 2007).

The rapid growth of this research field also presents challenges to organize and systematize its main findings. Contributions came from different disciplines – engineering, product design, environmental studies, sociology, psychology.(MONT; TUKKER, 2006). Also, many other different approaches and concepts have been developed to address environmental problems, such as cleaner production, cleaner technologies, eco-design, etc., making it even more important to clarify PSS's theoretical framework, features, benefits, and methodologies.

Several literature review studies were conducted within PSS research field, with specific approaches and objectives, such as: the characterization of PSS concept (BEUREN; GOMES FERREIRA; CAUCHICK MIGUEL, 2013); integration of Information Systems, Business Management, and Engineering & Design fields (BOEHM; THOMAS, 2013; CAVALIERI; PEZZOTTA, 2012); implementation of PSS business models (REIM; PARIDA; ÖRTQVIST, 2015) and PSS research field's challenges (BAINES et al., 2007; TUKKER, 2015).

The present research paper aims to contribute to the current understanding of the PSS field by identifying and visualizing the intellectual structure of the literature on PSS, thus providing a perspective about how the field has theoretically evolved. A co-citation analysis was performed to identify cross-disciplinary fertilization. Through this unique way of organizing and presenting the field, we hope to create a base to help identify new research challenges.

The rest of the paper is structured as follows. The following section discusses the data collection and the methodology employed. Then, the results of the bibliometric analyses and a graphic representation of the intellectual structure of the literature are presented and discussed. The last section presents the study's conclusions and limitations.



2 METHOD

The present study employs a bibliometric technique, analyzing articles available at the Web of Science database main collection from all the available period (1945-2019). The data was collected on June 26, 2019, and only journal papers were considered. The keyword used in the search was “product-service system*” and the search was limited to the following Web of Science categories: Social Sciences Interdisciplinary, Environmental Sciences, Management, Business, Business Finance, Environmental Studies, Humanities Multidisciplinary and Economics. A total of 300 articles matched the search criteria.

The documents obtained were downloaded in plain text form (.txt) and converted using Vosviewer, a public domain software available free on the Internet. Then, an initial validation of the 300 articles was conducted through the examination of its titles and abstracts to confirm that PSS was a key theme in all of them.

2.1 SAMPLE

Although there was no period restriction on the data collection, we may observe (see Figure 1) that the first article appears in the year of 2000, right after the PSS concept first formulation, by Goedkoop et al (1999). In 2006, a special issue from the Journal of Cleaner Production– “Product-Service Systems: reviewing achievements and refining the research agenda”- caused an abrupt growth in the number of articles albeit not sustained in the following years.

It wasn't until 2014 that the publishing of PSS articles saw a sustainable growth year over year. In 2019 there are already 39 publications, more than half of the total articles published in 2018, which may indicate that the growth will continue. The frequency distribution of these publications per year is presented in Figure 1.

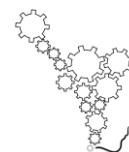
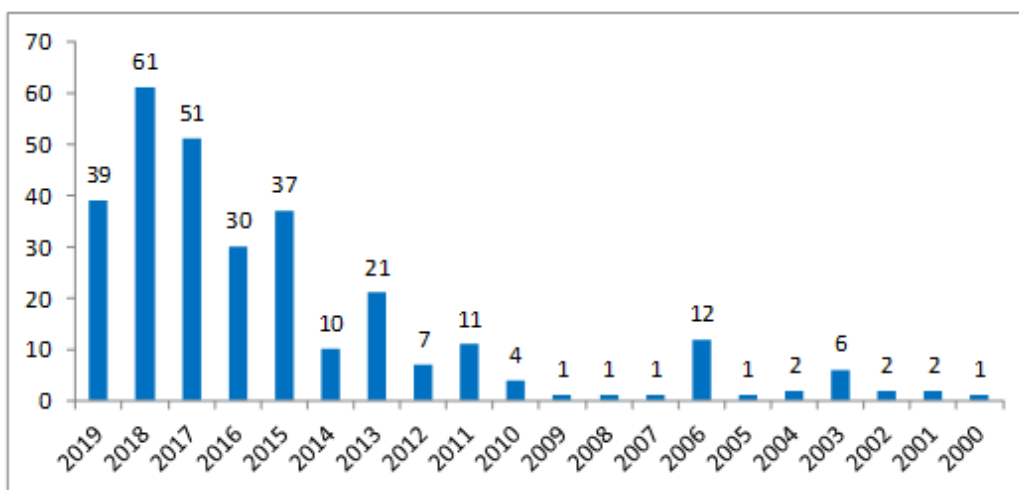


FIGURE 1 – NUMBER OF PUBLICATIONS PER YEAR



SOURCE: The author (2021)

2.2 DATA ANALYSIS

This bibliometric study consisted in a citation and co-citation analysis. First, it was conducted the citation analysis with the objective of identifying the key authors, the studies conducted around the researched theme and the main approaches that were used. This analysis is based on the extraction of the reference and counting of the number of times that this reference is cited by all the other papers from the sample. For this analysis, only documents with a minimum of 15 citations were considered.

The second analysis was the co-citation one. Its objective is to identify the intellectual structure of the field and the links between authors and theories. For this analysis, it was considered the minimum of 15 citations of a cited reference and the fractional counting method. Both analyses were conducted with the Vosviewer software.

3 RESULTS

3.1 CITATION ANALYSIS

From the 300 articles of the sample, there were 115 that met the criteria of having a minimum of 15 citations. Table 2 shows the list of the 20 most cited documents that represent 51,8% of all citations.

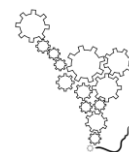


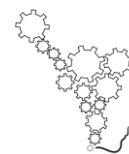
TABLE 1 – MOST OFTEN CITED DOCUMENTS

RANK	MOST CITED DOCUMENTS	SOURCE	NUMBER OF CITATIONS	%
1	Mont (2002)	Journal of Cleaner Production	769	10,6%
2	Tukker & Tischner (2006)	Journal of Cleaner Production	352	4,8%
3	Aurich , Fuchs & Wagenknecht (2006)	Journal of Cleaner Production	289	4,0%
4	Manzini & Vezzoli (2003)	Journal of Cleaner Production	273	3,7%
5	Maxwell & Van der Vorst (2003)	Journal of Cleaner Production	249	3,4%
6	Boons et al (2013)	Journal of Cleaner Production	246	3,4%
7	Morelli (2006)	Journal of Cleaner Production	186	2,6%
8	Roy (2000)	Futures	147	2,0%
9	Firnkorn & Mueller (2011)	Ecological Economics	142	2,0%
10	Cook , Bhamra & Lemon (2006)	Journal of Cleaner Production	119	1,6%
11	Lightfoot, Baines & Smart (2013)	International Journal of Operations and Production Management	112	1,5%
12	Mont (2004)	Ecological Economics	109	1,5%
13	Mont, Dalhamar, Jacobsson (2006a)	Journal of Cleaner Production	109	1,5%
14	Baines & Lightfoot (2014)	International Journal of Operations and Production Management	108	1,5%
15	Williams (2007)	Journal of Cleaner Production	108	1,5%
16	Maxwell, Sheate, Van der Vorst (2006)	Journal of Cleaner Production	104	1,4%
17	Ceschin (2013)	Journal of Cleaner Production	98	1,3%
18	Lindahl, Sundin & Sakao (2014)	Journal of Cleaner Production	92	1,3%
19	Bezerra Barquet et al (2013)	Industrial Marketing Management	82	1,1%
20	Vezzoli et al (2015)	Journal of Cleaner Production	81	1,1%

SOURCE: The author (2021)

From the results above, it can be noted that the paper from Mont (2002) leads the ranking with 769 citations, which is more than double of the second one, Tukker & Tischner (2006), with 352 citations. In her paper, Mont (2002) attempts to build a theoretical framework for PSS by clarifying its elements, characteristics, benefits, and barriers. Also, Mont is by far the most cited author, totalizing 1070 citations with 6 papers. The second most cited paper, Tukker & Tischner (2006) is part of a special edition of the Journal of Cleaner Production - “Product-Service Systems: reviewing achievements and refining the research agenda”, and discusses the potential of PSS to enhance competitiveness, the progress of the research field so far and the challenges ahead.

The majority of the remaining papers that complete the top-ten - Aurich et al (2006), Maxwell & Van der Vost (2003), Boons et al (2013) , Morelli (2006), Roy (2000), are theoretical and present methodologies and tools. Only three of the top-ten papers- Manzini & Vezzoli (2003), Firnkorn & Muller (2011) and Cook et al (2006) present empirical cases.



From all the 115 most cited documents, 59 of them were published in The Journal of Cleaner Production (51,3%). The International Journal of Operations and Management Journal and the Industrial Marketing Management published 8 documents or 7% of the total each. The remaining documents were published in 26 other journals.

3.1 CITATION ANALYSIS

The co-citation analysis shows the frequency in which the references are cited together in the same articles. The co-citation is a measure of the relationship degree between papers. The highly cited documents represent the key concepts, methods, or ideas shared by the citing documents in a field, so with this analysis is possible to identify groups of authors or themes in common, which are grouped in clusters.

The software Vosviewer was used to perform this analysis. With the Vos technique, when a co-citation network is constructed at the level of cited references, the raw reference strings are used as the unit of analysis (VAN ECK; WALTMAN, 2019).

A total of 12.159 references were cited in all the sample - 300 documents. However, for this analysis it was considered only references with at least 15 citations, which reduced the results to 78 documents that met the threshold. The fractional counting method was chosen, as opposed to the full counting, since it reduces the influence of documents with many authors. (VAN ECK; WALTMAN, 2019). With the Vosviewer it is also possible to visualize a map, with the elements positioned so that the distance between any pair reflects their degree of similarity as accurately as possible. Each element in the map is represented by a label and a circle and the more important an element is, the larger its label and its circle. To avoid superpositions and make the visualization clearer, the map was built with the 50 cited references with the greatest link strength (see Figure 2). The co-citation analysis resulted in 3 clusters. The clusters were named after a review of its documents to identify their unifying elements, as presented in Table 2.

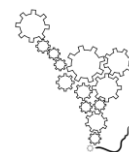
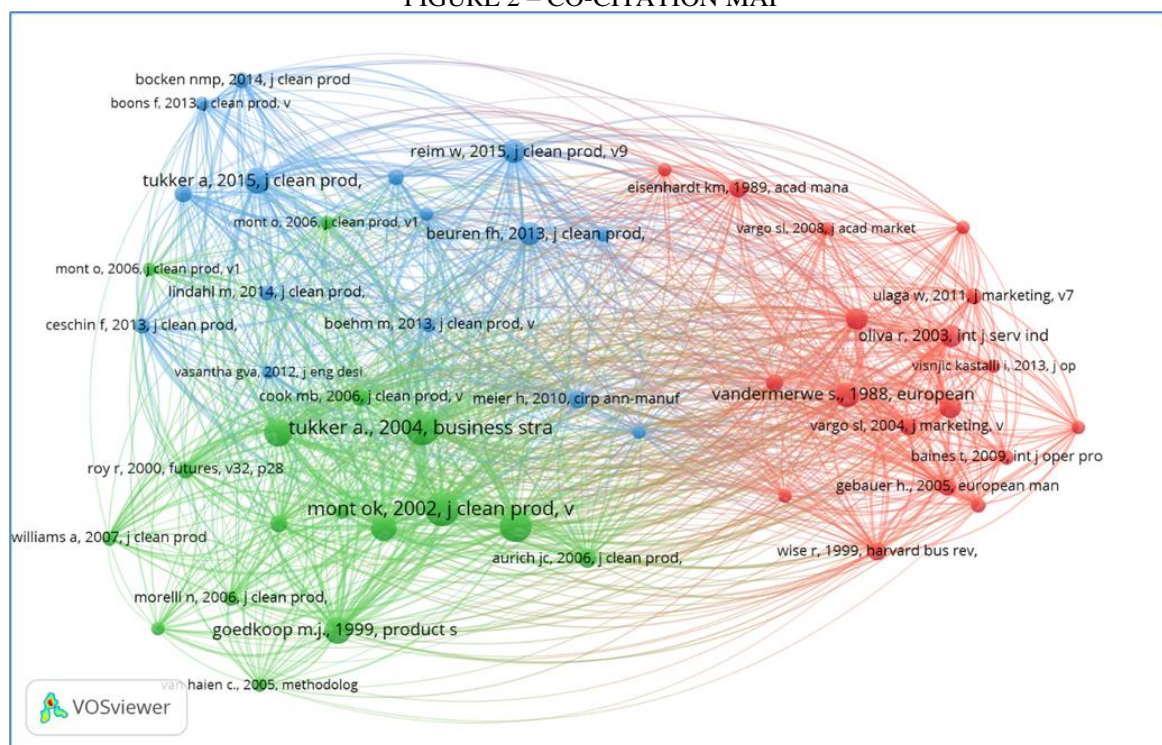


FIGURE 2 – CO-CITATION MAP



SOURCE: The author (2021)

TABLE 2 – CO-CITATION CLUSTERS

COLOR	CLUSTER NAME	KEY AUTHORS	CHARACTERISTICS
1- Red	Servitization	Vandermerwe, Vargo, Wise, Baines, Neely, Fang, Gebauer, Baines, Brax, Martinez, Kohtamaki, Visnija, Oliva, Pawar, Ulga, Yin, Eisenhardt	- Related to servitization concept that came before the PSS one – explains its concept, typology, motivations, challenges, and impact on business - Service Dominant Logic theory
2 - Green	PSS Operationalization	Mont, Manzini, Goedkoop, Aurich, Cook, Tukker, Roy, Morelli, Sakao, Williams, Baines, Bartolomeo, Van Hein	- Theoretical models and tools to implement and evaluate PSS initiatives - PSS conceptualization and typology - Sustainable aspects of PSS; S.PSS
3- Blue	Business Model, Multidisciplinary contributions	Beuren, Boehm, Cavalieri, Bochen, Boons, Reim, Tukker, Vasantha, Vezzoli, Ceschin, Lindhal, Rexfelt, Osterwalder, Barquet, Meier	- Discuss Business Model concepts, tactics, and archetypes - Literature reviews including Engineering and Design disciplines - Multidisciplinary discussions: Industrial PSS (IPS), Design challenges for PSS - Reflection on PSS research field

SOURCE: The author (2021)

From the map in Figure 2 , it is possible to observe that the most important references , represented by the bigger circles are: Mont (2002), also the most cited document , Tukker (2004) and Baines et al (2007) , all from the same cluster (green). The three different clusters identified are represented in the Figure 2 by the colors red, green, and blue, also identified in Table 2 by the numbers 1, 2 and 3 respectively.

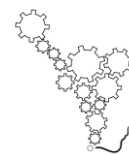


The red cluster (cluster 1) mostly analyses servitization, “the process of creating value by adding services to products” (VANDERMERWE; RADA, 1988, p. 312). According to Baines et al (BAINES et al., 2009b), servitization and PSS belong to different research communities or clusters. While servitization has emerged from managerial literature, with major contributions coming from the USA, the PSS concept was originated in Northern Europe, mainly Scandinavian countries, and among environmental and social sciences researchers.

An important reference in this cluster is Vandermerwe & Rada (1988), the first paper that defined servitization (BAINES et al., 2009b; MARTINEZ et al., 2010). The service dominant logic (VARGO; LUSCH, 2004, 2008) also appears in this cluster, as this service-centered view support firms transition to service-based initiatives. Other references in this cluster present empirical studies that aim to identify the challenges (MARTINEZ et al., 2010), motivations (NEELY, 2009) and business impact (KOHTAMÄKI et al., 2013) of servitization initiatives

The green cluster (cluster 2), PSS operationalization, is the one with the greatest link strength and essentially deals with the theme of PSS development, implementation and evaluation through several theoretical models and tools. Mont (2002), as previously mentioned, is the most cited and most important document and presents a theoretical framework for PSS. Tukker (2004) present eight archetypal PSS business models and a conceptual model of the relation between PSS and sustainability. Goedkoop et al (1999) provided the first definition of PSS concept. Cook et al (2006) present a methodology to transfer the PSS concept to the industry. Williams (2007) proposes five criteria to evaluate PSS initiatives and Aurich et al (2006) presents a process for a systematic design of product related technical services based on life cycle perspective.

Some references focus on the sustainability aspect of PSS, such as Manzini & Vezzoli (2003) that bring a strategic design approach to analyze examples of eco-efficient PSS solutions and then propose a framework to describe the sustainable potential of a PSS. Roy (2000) outlines four types of sustainable PSS, that differentiate themselves from other initiatives like eco-design and cleaner production as they require environmental impacts by a factor of 4 to 20 times. Bartolomeo et al (2003) present a typology of eco-efficient producer services (EEPS) based on an analysis of 40 of such services. This study also concluded that most of EEPS were not driven by environmental factors and the several different types of EEPS require more targeted policy initiatives.



Both Tukker & Tischner (2006) and Baines et al (2007) propose reflections about the PSS research field. The former evaluates the first decade of the field and proposes that a broader community of researchers (consumer scientists, designers, business developers) should be involved to address issues such as consumer acceptance that currently hinders the win-win potential of PSS - competitiveness enhancement with less environmental impact. The latter states that PSS cannot be considered universally approved and need more long term and integrated research to help develop methodologies and theories.

The blue cluster, (cluster 3), is the one that is more related to other disciplines such as Engineering and Design. With respect to the Business Model theme, Barquet et al (2013) use the Business Model concept to develop a framework to evaluate PSS implementation. Bocken et al (2014) present Sustainable Business Model archetypes with the aim to develop a common language for researches and Vasantha et al (2012) reviewed eight PSS methodologies and developed a PSS maturity model concluding that from its 20 dimensions only 3 were strongly treated.

More than one third of cluster 3 references are literature reviews. Two of them – Boehm & Thomas (2013) and Cavalieri & Pezzotta (2012) – are multidisciplinary ,expanding the research scope to service engineering, information system and design. The literature reviews of Boons & Ludeke-Freund (2013) and Reim et al (2015) focus on Business Model. Tukker (2015), in the most important reference of the cluster, reviews PSS research field in comparison with its 2006 paper, previously mentioned in cluster 2.

Multidisciplinary contributions also came through the documents of Meier et al (2010) who analyzed Industrial Product Systems, Vezzoli et al (2015) who analyzed design challenges to implement PSS, Ceschin (2013) who brought insights from innovation studies to identify critical factor for PSS implementation and Lindhal et al (2014) who analyzed PSS implementation cases using Life Cycle Assessment and Life Cycle costing. It is also worth mentioning the document from Rexfelt & Ornas (2009), the only one found that addresses the issue of consumer acceptance of PSS.

4 DISCUSSION

The results show that the PSS research field is underpinned by the servitization concept, as the seminal paper from Vandermerwe and Rada (1988) in Cluster 1 is the one with more links with Cluster 2, which represents the theoretical development of PSS. However, the



distance of these two clusters may be an indicator that there has not been much of cross-fertilization between the two research fields, and that these two research communities – Servitization and PSS – may have been developing separately. The document from Martinez et al (2010) from Cluster 1, a single case approach to understand the challenges in transforming manufactures in PSS providers is the one positioned closer to Cluster 2.

The Cluster 2 (PSS operationalization) and 3 (Business Model) are more closely related, as one can observe a short distance between them. Cook et al (2006), that investigates UK manufacturing firms to propose a framework for PSS implementation is the Cluster 2 element positioned more closer to Cluster 3, and Vasantha et al (2012), from Cluster 3, that present a review on product systems design methodologies is the one closer to Cluster 2.

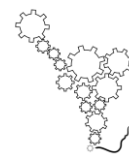
Tukker (2015), Beuren et al (2013) and Reim et al (2015), all literature review documents as previously described, are the Cluster 3 elements with the strongest links with Cluster 2. This proximity from Clusters 2 and 3 make sense since both discuss the PSS concept, with the difference that Cluster 3 has a specific focus on Business Model and expands research to other disciplines.

Finally, on Cluster 3, two elements - Cavalieri & Pezzotta (2012) and Meier et al (2010) stand out in the map, positioned more closer to Cluster 1. They both base their theoretical background on Engineering Sciences.

5 CONCLUSION

The bibliometric analysis conducted in this study allowed the representation of the theoretical structure of the PSS research field, and to our knowledge this is the first study of this theme to present such analysis.

Through its results it was possible to identify that the PSS theory was supported by an integrated approach of the servitization concept (VANDERMERWE; RADA, 1988) and the service-dominant logic (VARGO; LUSCH, 2004, 2008). It is also possible to observe that as the PSS research field developed its theorization, methodologies and tools, disciplines such as Engineering and Design played an important role (LINDAHL; SUNDIN; SAKAO, 2014; MEIER; ROY; SELIGER, 2010; REIM; PARIDA; ÖRTQVIST, 2015; SAKAO; SHIMOMURA, 2007; VEZZOLI et al., 2015).



Sustainability, surprisingly, is a central theme of a minority of the references (BARTOLOMEO et al., 2003; BOCKEN et al., 2014; BOONS; LÜDEKE-FREUND, 2013; ROY, 2000), since it is one of the key differentiators of the PSS concept (BAINES et al., 2009a; ROY, 2000). Another important remark is the lack of quantitative analysis of the impact of PSS solutions as all the empirical research were case studies (CESCHIN, 2013; GOEDKOOP et al., 1999; LINDAHL; SUNDIN; SAKAO, 2014; MANZINI; VEZZOLI, 2003; WILLIAMS, 2007).

In a theoretic perspective, to further advance the PSS research field, futures studies could focus on exploring more the key differentiators of PSS and servitization, since only few references attempted to do it so far (BAINES et al., 2009a; ROY, 2000). In an empirical perspective, future studies could give more attention to aspects such as consumer's perspective on PSS solutions, sustainability impacts of PSS initiatives and quantitative methods to better substantiate PSS projects results.

In terms of limitations, this study is subject to some limitations because of the use of bibliometric techniques. The first limitation is associated with the selection of documents, since thesis and conference papers, that were excluded from the sample, could be covering the most recent advancements of the field. Another specific limitation is the fact that the bibliometric analysis only counts the references and does not take into the account the context in which they were applied.

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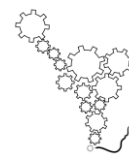
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AUTHORS' CONTRIBUTIONS

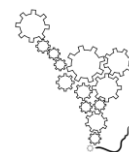
- A. Zehoul conceptualized, designed the study, was responsible for the data extraction and treatment as well as writing the manuscript.

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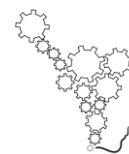
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