Mapping of PSS Research: A Bibliometric Analysis

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Abstract

The importance of services in manufacturing is getting increasingly evident as the benefits of PSS becoming more and more documented. The prospective for these benefits is motivating manufacturers and scholars to explore servitization, and PSS strategies. Consequently, the number of publications focused on PSS, as well as scholarly interest, has continued to grow exponentially. Numerous studies have been carried out on the various aspects of PSS, such as design, management, business model, ICT, remanufacturing, etc. Meanwhile, these studies were published in a diverse set of journals in many subject categories, such as operations, service, marketing, environment, innovation, engineering design etc. In this context, it is necessary to map PSS literatures in order to better understand the current research progress and future research directions in terms of knowledge creation, diffusion and utilization. For this purpose, this study performs bibliometric analysis to map the available literature of the PSS research field. This is crucial to help scholars in identifying and conducting new and innovative research within their discipline. The following analyses were performed in this study: i) number of articles and proceeding papers per year, ii) number of articles by author, iii) number of papers by source, iv) most cited papers, v) most used keywords, and vii) keywords network. The main differentiator of this study to previous ones is the inclusion of conference proceedings to reflect the novelty of the topic.

Keywords
PSS; product-service system; servitization; bibliometric analysis; network analysis; smart manufacturing; industry 4.0

1. Introduction

In 1999, Goedkoop et al. (1999) introduced the term Product-Service Systems (PSS) and defined it as “system of products, services, networks of players and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models”. However, PSS can be understood as a special case of servitization - a concept introduced by Vandermerwe and Rada in 1988, long before PSS were introduced. Servitization describes the phenomenon of manufacturing firms developing value proposition by incorporating additional services (Baines et al., 2007) in order to attain a competitive edge in the market (Porter and Heppelmann, 2014). Servitization and PSS, both describe the same concept (i.e., ‘a marketable set of products and services’) but PSS usually involves the sustainability context in addition to the somewhat ‘economic only’ context of servitization.

With benefits of PSS are getting documented (Baines et al., 2007), the importance of services in manufacturing is becoming increasingly evident (Bustinza et al., 2015). A business strategy built around the PSS concept establishes a value proposition in which manufactures retain the product ownership and are responsible for its functionality, maintenance, upgrade, and end of life strategies. This transfer of the responsibility to manufacturer creates an incentive for them to design best possible products in terms of superior functionality, reduced operational (i.e., less consumables inputs) and maintenance cost, and better recyclability (Vaittinen, 2013). As a result, PSS may prove to be a more resource-efficient and effective solution with less environmental impact compared to conventional product-oriented solutions. On the other hand, a solution composed of physical products and related services may be harder to replicate for a competitor, compared to solely product and process-based manufacturing (Martinez et al., 2010). Additionally, integrated services mean more satisfactory experience for customers and generally increased revenue for the
manufacturers (Annarelli et al., 2016). The prospective for these benefits is motivating manufacturers and scholars to explore servitization, and PSS strategies.

Consequently, the number of publications on PSS, as well as scholarly interest, has continued to grow exponentially. Numerous studies have been carried out on the various aspects of PSS, such as design, management, business model, ICT, remanufacturing, etc. Meanwhile, these studies were published in diverse journals of many subject categories, such as operations, service, marketing, environment, innovation, engineering design etc. (Baines et al., 2007). In this context, it is necessary to map PSS literatures in order to better understand the current research progress and future research directions in terms of knowledge creation, diffusion and utilization. For this purpose, bibliometric analysis has proven (De Battisti et al., 2013) to be a useful tool to map the literature around PSS research field in order to help scholars in identifying and conducting new streamlines of research within the discipline.

There are few studies that have used bibliometric techniques to analyze certain aspects of servitization and the PSS disciplines. Beuren and Miguel (2012) used bibliometric analysis to carry out a systematic literature review on PSS. Oliveira et al. (2015) developed quantitative matrices for PSS research field with the aim of supplementing qualitative literature reviews. Homrich and Carvalho (2016) used bibliometric and content analysis to analyze relationship between servitization and sustainability. Martin-Pena et al. (2017) identified the literatures that have had the greatest impact on research on servitization using bibliometric analysis. All these studies were performed using a small sample of selected journal articles that were published before July 2015. Furthermore, none of the previous studies included conference proceedings, which are a source for current, cutting edge research, particularly in relatively new and dynamic disciplines such as PSS that are not fully matured yet. Table 1 summarizes the samples used in above-mentioned studies that involved bibliometric analysis to some extent.

Table 1. Summary of samples used for bibliometric analysis in previous studies.

<table>
<thead>
<tr>
<th>Literature</th>
<th>Period</th>
<th>No. of Articles</th>
<th>No. of Proceedings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beuren (2012)</td>
<td>2006 - 2011</td>
<td>105</td>
<td>N/A</td>
</tr>
<tr>
<td>Oliveira (2015)</td>
<td>2002 - 2013</td>
<td>118</td>
<td>N/A</td>
</tr>
<tr>
<td>Homrich (2016)</td>
<td>2007 - July 2015</td>
<td>57</td>
<td>N/A</td>
</tr>
<tr>
<td>Martin-Pena (2017)</td>
<td>1992 - March 2015</td>
<td>343</td>
<td>N/A</td>
</tr>
<tr>
<td>This study (2018)</td>
<td>2000 - 2017</td>
<td>359</td>
<td>387</td>
</tr>
</tbody>
</table>

The purpose of this study is to map the PSS literatures in order to better understand the scientific progress, publication trend, and collaboration networks. In contrast to previous studies, this study contributes to the body of knowledge through a more systematic and updated analysis of scientific contributions on PSS and servitization. After the introduction, the paper is structured as follows: section 2 describes the research methodology in detail; section 3 visualizes and explains the results obtained from bibliometric analysis and section 4 is conclusion.

2. Methodology

This study analyses the research on PSS until December 2017 by means of bibliometric analysis, which is a systematic approach that can quantitatively analyze scientific publications in order to identify particular research phenomena (Jacobs, 2010). The research methodology followed in this study consists of three main steps (Figure 1): (i) database selection and literature identification; (ii) screening identified literatures for relevancy to PSS/servitization; (iii) apply bibliometric analysis and generate outputs.
In the first step, we have selected Web of Science (WoS) as our database. This database has been chosen for including the core academic literature related to the subject of interest, and for providing essential metadata (i.e., respective abstracts, references, number of citations, list of authors, institutions and countries) for bibliometric analysis (Carvalho et al., 2013). Following, we conducted a keyword search in the database (2000 to 2017) using the search string: "product service system" or "product-service systems" or "servitization" or "servitisation" or "servicizing", resulting in 654 journal articles and 859 proceeding papers. As journal articles are more acceptable and considered to be ‘certified knowledge’, we decided to emphasize more on articles and perform bibliometric analysis separately from proceeding papers.

In the second step, after reading the titles and in selected cases the abstracts of all 654 articles and 859 proceeding papers, 92 articles and 164 proceeding papers were excluded as these papers are not directly related to PSS/servitization based on our understanding. This exclusion resulted in final sample of 562 relevant articles and 695 proceeding papers. A similar methodology has also been applied previously by Oliveira et al. (2015) for analyzing the PSS research field. However, in our study, we developed and used an improved search string that resulted in a greater number of papers during the same period of time. Furthermore, our study includes five times more journal articles compared to their study. This is mainly due to the fact that the number of PSS articles has increased exponentially since (Oliveira et al., 2015) conducted their study. We have also included proceeding papers in our study. Therefore, we believe our analysis provides additional value and an original contribution to the body of knowledge in the field of PSS research.

In the third and final step of the study, we applied the bibliometric analysis to the identified literature. Based on the publications selected in the previous steps, we developed a number of tables and graphs using VOSviewer software (Van Eck and Waltman, 2010; 2011). The following analyses were performed in this study: i) number of articles and proceeding papers per year, ii) number of articles by author, iii) number of papers by source, iv) most cited papers, v) most used keywords, and vii) keywords network.

3. Results and Discussion

Figure 2 shows the distribution of the publications over the years. An exponential trend in the number of both journal articles and proceeding chapters can be observed during the last few years, indicating a fast-growing interest in PSS research. It is also interesting to note that only 11% of the 562 journal articles were published up until 2010, which means that the last seven years were particularly productive.
Over the entire period under review, and according to our selection criteria, the Journal of Cleaner Production (72 articles) has published the majority of papers in the field of PSS, followed by the Int. Journal of Production Research (22 articles) and Int. Journal of Operations Production Management (17 articles) (Table 2). Table 2. Number of PSS papers per journal.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Journals</th>
<th>Articles</th>
<th>Citations</th>
<th>Impact Factor (2016)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Journal of Cleaner Production</td>
<td>72</td>
<td>3,156</td>
<td>5.715</td>
</tr>
<tr>
<td>2</td>
<td>Int. Journal of Production Research</td>
<td>22</td>
<td>284</td>
<td>2.325</td>
</tr>
<tr>
<td>4</td>
<td>Industrial Marketing Management</td>
<td>16</td>
<td>143</td>
<td>3.166</td>
</tr>
<tr>
<td>5</td>
<td>Part B: Journal of Engineering Manufacture</td>
<td>12</td>
<td>526</td>
<td>1.366</td>
</tr>
<tr>
<td>6</td>
<td>Production Planning &amp; Control</td>
<td>12</td>
<td>40</td>
<td>2.369</td>
</tr>
<tr>
<td>7</td>
<td>Int. Journal of Adv. Manufacturing Technologies</td>
<td>11</td>
<td>162</td>
<td>2.209</td>
</tr>
<tr>
<td>8</td>
<td>Computers in Industry</td>
<td>10</td>
<td>200</td>
<td>2.691</td>
</tr>
<tr>
<td>9</td>
<td>Research-Technology Management</td>
<td>9</td>
<td>43</td>
<td>2.429</td>
</tr>
<tr>
<td>10</td>
<td>Int. Journal of Computed Integrated Manufacturing</td>
<td>9</td>
<td>42</td>
<td>1.949</td>
</tr>
</tbody>
</table>

Table 3 shows the top conferences ranked based on number of papers. IPS2 is by far the largest source of relevant conference papers (35%) that are indexed in WoS. APMS and ICED are the other two major conferences that publish PSS papers.

The 562 journal articles were written by 1,138 authors and co-authors. Together, they used 19168 cited references and 1,376 keywords. These documents were produced by 436 research institutions from 41 countries and published in 132 journals. As for the 695 conference papers, they were published by 1261 authors and co-authors, who used 9,865 cited references and 1589 keywords.

Table 3. Number of PSS papers per conference.
The most prominent authors are Baines (18 articles), Roy (15 articles) and Lightfoot (10 articles). Other highly productive authors in the field are Park, Sakao, Raddats, Durugbo, Parida, Pezzotta and Zhang (Figure 3).

Table 4 shows the 10 most cited journal articles on PSS published between 2000 and 2017. The longer an article has been published, the higher the likelihood to be cited and, generally, the higher the number of overall citations. For this reason, the number of citations since 2013 (the most current paper in this list is from 2013) was also calculated to provide a different index for comparison. Citation-wise, these articles were found to be in the similar ranking position in Google Scholar. The top-ranking paper, with 633 citations, was published in Journal of Cleaner Production. The second-ranking paper was a review article published in Journal of Engineering Manufacture in 2007 with 584 citations.
Table 5 lists the frequently used keywords by the authors. It is no surprise that PSS and Servitization are the most used keywords. The authors’ keywords found in journal articles and proceedings are more or less similar.

Bibliometric tool VOSviewer is used to construct Figure 4, which shows the co-occurrence network of keywords that occurred in the title or abstract of at least 15 papers. The size of a circle reflects the frequency of that keyword while the distance and width of the connecting line between two keywords respectively indicates the frequency of their co-occurrence and the strength of the relatedness between them. In figure 4, there are four clusters of keywords. Servitization is the central keyword of green cluster and the other keywords of this clusters are business model, service innovation, integrated solution, etc. This outcome matches with the observation of Annarelli et al. (2016) that the term servitisation is most of the time used in a purely economic context. On the other hand, PSS is the central keyword of red cluster and the other keywords of this clusters are sustainability, circular economy, remanufacturing, etc. This outcome also conforms to the observation of Beuren et al. (2013) that the term PSS is referenced when there is an interest of lower environmental impact of the offerings.
Figure 4. Keyword network

4. Conclusion

This study provided a quantitative overview of productivity and visibility of research work in PSS research field. For this purpose, we identified 562 journal articles and 695 conference papers in the web of science database and performed bibliometric analysis to discover progress of the PSS research field, main sources of the contributions (journals and conferences), main authors, principle articles and most frequently used keywords.

Figure 2 confirms that in the last decade the interest in PSS research grew significantly and has not shown any notable decline yet. The major source of PSS articles is the Journal of Cleaner Production, which focuses on cleaner production, environmental, and sustainability research and practice. This is relatable considering the fact that the authors often consider the PSS business model to be more sustainable and environment friendly. Figure 4 depicts the difference in definition between PSS and servitization that PSS usually involves the sustainability context in addition to the somewhat ‘economic only’ context of servitization. In order to better identify research trend and prioritize research efforts in PSS, future research may include thematic analysis with the aim to discover key issues related to PSS and servitization.

There are a few limitations of this study that need to be considered. The screening criteria used in this study may be vulnerable to both unintentional and intentional bias in the selection of relevant contributions. Although we have taken a transparent and comprehensive search method, the search was carried out only in the WoS database, which may not include all relevant PSS publications. Also, the citation data presented in this study is different from Google Scholar, this is because WoS counts the citation only if the citing paper is indexed in WoS.

References


Biographies

Muztoba Ahmad Khan is an Industrial Engineering Ph.D. student in the Industrial and Management Systems Engineering department at West Virginia University, WV, USA. He holds a master’s degree in engineering management from the Bangladesh University of Engineering and Technology (BUET). His main research interests are Product-Service Systems, Servitization, Upgradability, Smart Manufacturing and Industry 4.0.

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