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Analysis of publications on product-service systems (PSS): towards a taxonomy and literature mapping

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Abstract

Companies from different industrial sectors have started offering solutions that add services to the products aimed at enhancing their market position. In this context this study aims at conducting a systematic literature review on product-system services (PSS) using the bibliometric analysis. PSS is being considered a competitive opportunity for the companies, which seeks to reduce the consumption of products through their use and through the provision of services. Deliverables from this literature study are main publications and journals, an author citation analysis, and taxonomy by constructing a theoretical map. Through this systematic literature review a number of publications on PSS were identified from 2006 to 2011. The quantity of articles and related terminology has evolved over the years with publications in diversified academic journals. Business models such as PSS have faced problems related to the terminology and there is certain lack of consensus among academics and practitioners. This would facilitate the knowledge exchange among stakeholders as well as the reader's understanding. Although there are business models on PSS, they usually emphasize the economic aspect so environmental and social aspects should be considered in future studies.

Keywords: product-service system; PSS; service offering.

1 Introduction

With the growth in the production of large scale, there is an increase in consumption and consequently intensification of environmental problems. The increase in consumption of products has no longer been considered as a competitive strategy. Thus, companies start offering solutions aiming at increasing their market position as well as customer's satisfaction (Sundin, 2009; Sakao et al., 2009b). One of the solutions being discussed is the design and offer of product-service systems (PSS). PSS aims to increase the competitiveness and profitability of companies and is mainly aimed at reducing the consumption of products through alternatives of product use.

In this context, this study aims to realize a review of literature on the PSS in the recent years (2006 to 2011). Through a systematic search of the literature in relevant international databases, an author citation analysis was carried out on PSS publications in recent years. This step is a further work by Hänsch Beuren et al. (2011), where the authors performed a content analysis and identified some relevant findings on PSS.

For its development the present study is structured as follows. Firstly, the adopted research methods are outlined. This is followed by definitions and categories of PSS, starting by how the literature has been addressing this subject. After that, the evolution of the concept of PSS is highlighted by mapping the literature considering main journals, keywords, authors, and articles. Finally, issues for future research as well as the conclusions are presented.

2 Research Methods

The present study is categorized as a theoretical article based on a systematic literature review. It covers an analysis of articles on PSS from 2006 to 2011. For literature search the following databases were used: ISI/Web of Science, Scopus, Compendex and Springer Link, which present the main journals related to the subject. Only journal articles were used in the analysis by identifying PSS subject in their titles, abstracts and keywords. All articles were read completely to verify their relation with the subject. Keywords were related to the term "product-service system" (PSS); most of them the same as used by Baines et al. (2007): servitization, sustainability, service economy, remanufacturing, service design, productization, product substituting service, dematerialization, system solution, and functional economy, as well as their combinations. Two hundred and three articles were identified from the databases above. Endnote software and SCI2 were used for retrieving, organizing and analyzing the articles.

3 Product Service System

This section presents some PSS definitions stated by various authors concerning PSS and its categories. Those definitions are used by the authors to illustrate the transition from a "pure product" to a "pure service".

3.1 PSS Definition

The main definition of PSS and the most cited in the literature is the one given by Goedkoop et al. (1999). The authors consider PSS as a combination of products and services in a system, which provide functionalities for the consumers and reduce the environmental impact. Mont (2002) highlights the offer of a product and system of integrated products and services which are planned aiming to reduce the environmental impact through alternative scenarios of product use. The key elements of the PSS are (Goedkoop et al., 1999): the product; the service, in which an activity is performed without the need of a tangible good and of the system, the combination of products, services and their relations. Most authors consider PSS a competitive proposal to satisfy the consumer's needs. Other authors stress that the PSS goes beyond this, considering the concern on sustainability through the balance between the environmental, economic and social aspects (Baines et al., 2007).

In general, the products are developed to satisfy the needs of the consumers and can be customized to include the services. Thus, the PSS is a competitive opportunity which becomes important for changes in the consumption standards. However, this process is considered to be long since people acquire products, and, in order to get acceptance by consumers, sustainable solutions in the initial design phase are needed. Designing a product and/or a service considering its life cycle is a start to achieve better results (Tukker and Tishner, 2006).

The planning for the durability and the dematerialization of products with the inclusion of services are the main aspects for making the products more sustainable (Vogtländer et al., 2008). The dematerialization aims at reducing the quantity of materials used in the whole product life cycle, not only in its conception, but also during its use, reutilization and recycling (Li et al., 2010). Thus, there is a trend for a more efficient development of products and services through reduction of natural resources (Kestemont and Kerkhove, 2010). What is called dematerialization has been discussed in the literature and has also been used as a goal for the PSS (Baines et al., 2007). The main objective of dematerialization is human well-being through a more efficient and more sustainable development (Kestemont and Kerkhove, 2010). Waste prevention and reutilization of products are examples of this (Cleary, 2010).

The needs of sustainable production and consumption are more and more discussed in the literature. Thus, some companies seek to add value to their products through adding services which is a strategic resource for obtaining new relationships with the consumers (Vandermerwe and Rada, 1988; Sakao et al., 2009b). The term used for this strategy is the "servitization", which is a process of creation of value through adding services to the products (Baines et al., 2009; Martinez et al., 2010). Actually, the academic

community has been extensively discussing the PSS, but there is no comprehensive definition on the topic yet (Aurich et al., 2010). In this sense, Table 1 presents the main definitions of PSS and the most cited ones by the authors between 2006 and 2011.

Table 1: Definitions on Product-Service Systems.

Authors	PSS Definition
Mont (2002)	"A system of products, services, supporting networks and infrastructure that is designed to be: competitive, satisfy customer needs and have a lower environmental impact than traditional business models".
Manzini and Vezzoli (2003)	"An innovation strategy, shifting the business focus from designing (and selling) physical products only, to designing (and selling) a system of products and services which are jointly capable of fulfilling specific client demands".
Brandstötter et al. (2003)	"A PSS consists of tangible products and intangible services, designed and combined so that they are jointly capable of fulfilling specific customer needs. Additionally PSS tries to reach the goals of sustainable development".
Wong (2004)	"Product Service-Systems (PSS) may be defined as a solution offered for sale that involves both a product and a service element, to deliver the required functionality".
Baines et al. (2007)	"A PSS is an integrated product and service offering that delivers value in use. A PSS offers the opportunity to decouple economic success from material consumption and hence reduce the environmental impact of economic activity".
Goedkoop et al. (1999)	"A product service-system is a system of products, services, networks of players and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have lower environmental impact than traditional business models".

3.2 PSS Categories

Organizations started changing strategically from the sale of products to provision of services (Oliva and Kallenberg, 2003; Sundin, 2009). This change from tangible products to products based on services is a trend which aims to add value to the business (Ping and Jia, 2010). Consequently, more companies are opting for solutions which involve services. This change occurs due to the sale of products with value added by services and products servitization (Sundin, 2009). There is, however, a radical change for using the function of a product without necessarily having it as a property. The products provide technical functions for the consumer (Aurich et al., 2010), while the services ensure the availability of these functions (Maussang et al., 2009). Thus, given the displacement of the economy based on purchasing products to the economy based on their use, there is a change (Figure 1) from the pure product to the pure service and, when having both product and services in a unique offer, this is known as PSS (Tukker, 2004). Figure 1 is one of the most used graphical representations of this concept.

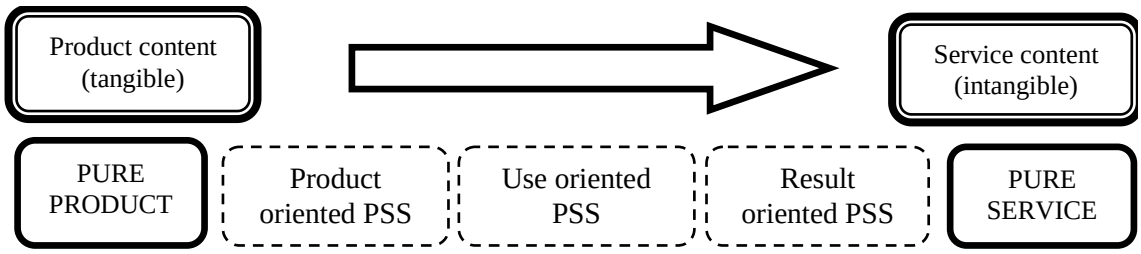

Figure 1: Main categories of the PSS (Tukker, 2004).

It is observed that the divisions of PSS are not strictly defined and may include more emphasis in the product or in services. Thus, the change from pure product to pure service aims at dematerializing the use of materials offering solutions in products and services which satisfy the needs of stakeholders. Moreover, it aims to reduce the environmental impact caused by the intensive consumption of tangible products. As illustrated in Figure 1, PSS may then be classified in the following perspectives (Tukker, 2004):

- Product-oriented: supply of products with extra services where the consumer acquires a product becoming the owner of the same and also uses services which the company offers and which add value to the product.
- Use-oriented: the use of the product is sold together with the services which add value to it. In this case, the product is the property of the company which offers its use.
- Result-oriented: the objective of this category is to offer a result or a competency for the consumer, like selling washed clothes instead of washing machines (Fan and Zhang, 2010). In this case the product is the property of the organization where the client pays only the delivered results (Baines et al., 2007).

A number of authors (Aurich et al., 2010; Geum and Park, 2010; Sakao et al., 2009b) considered the Tukker's (2004) classification. They consider it as the most appropriate to represent the perspectives of the PSS. Nevertheless, it seems that there is no consensus yet on the categorization of PSS and this can be explored. Some researchers consider that the property of the products should not be on the customers and others consider that different types of services correspond to a PSS (Sakao et al., 2009a). Therefore, it becomes necessary to explore these categories in order to facilitate the positioning of companies in the most appropriate category.

4 Evolution of the PSS concept

This section presents the evolution of PSS by doing a mapping the main journals that published the subject, considering most common keywords, main authors, and most cited articles. The evolution of the PSS publications can be seen in Figure 2, which shows the growth in number of publications from the past years.

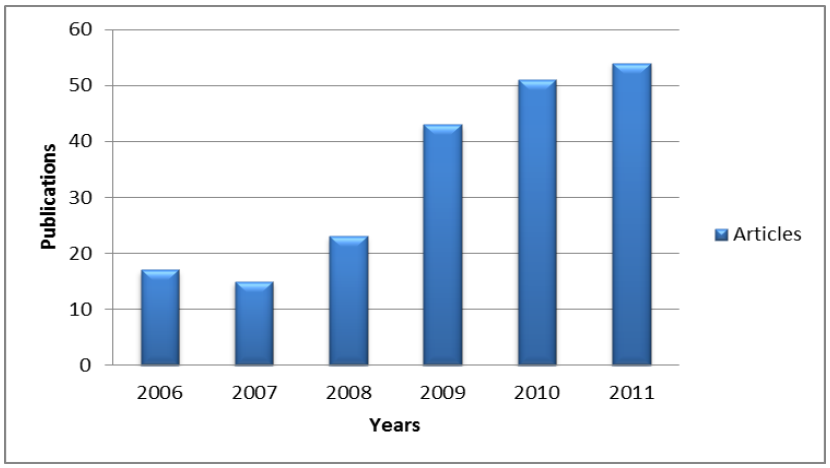

Figure 2: Evolution of publications in journals.

4.1 Main journals

A diversity of journals used for the publications on PSS was identified (105 journal titles). Since the list is extensive, Table 2 shows only the top fourteen.

The Journal of Cleaner Production has most publications on PSS (18 articles). In 2006, the JCP published a special edition, contributing for this result, but the journal has not published many articles on PSS in recent years with no article in 2009 and 2010 and only two in 2011. The following journals with most publications are the Journal of Manufacturing Technology Management and the Computer Integrated Manufacturing Systems, both with the same number of publications (14 articles). All publications in the JMTM and in the CIMS were issued in the past three years. IJAMT, CIRP JMST and IJIMS have published in the subject from past four years (2008-2011). Thus, it is evident that the JCP has the largest number of publications but not as current as the other journals in Table 2.

Table 2: Main journals with publications on PSS (n = 203 articles).

Academic Journals	Percentage (%)
Journal of Cleaner Production (JCP)	17.1
Journal of Manufacturing Technology Management (JMTM)	13.3
Computer Integrated Manufacturing Systems (CIMS)	13.3
International Journal of Advanced Manufacturing Technology (IJAMT)	12.4
CIRP Journal of Manufacturing Science and Technology (CIRP JMST)	11.5
International Journal of Internet Manufacturing and Services (IJIMS)	6.7
Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture	4.8
CIRP Annals - Manufacturing Technology	3.8
International Journal of Operations and Production Management	3.8
Computers and Industrial Engineering	2.8
International Journal of Computer Integrated Manufacturing	2.8
International Journal of Services Operations and Informatics	2.8
Journal of Engineering Design	2.8
ZWF Zeitschrift fuer Wirtschaftlichen Fabrikbetrieb	2.8

Note: the remaining journals have less than 2.8% of the total number of articles.

4.2 Main keywords

A number of studies on PSS have been published and other terms besides PSS have been used as synonym such as (Goedkoop et al., 1999): servitization, dematerialization, sustainability, service design and others. An attempt to identify those terms used in the literature was made in order to verify the evolution of the concept. Figure 3 presents the most common terms used in the publications, mostly according to the keywords suggested by Baines et al. (2007). It shows the main keywords cited in the 203 articles. As expected, the term used most often was "product-service system", which appeared in half of the articles.

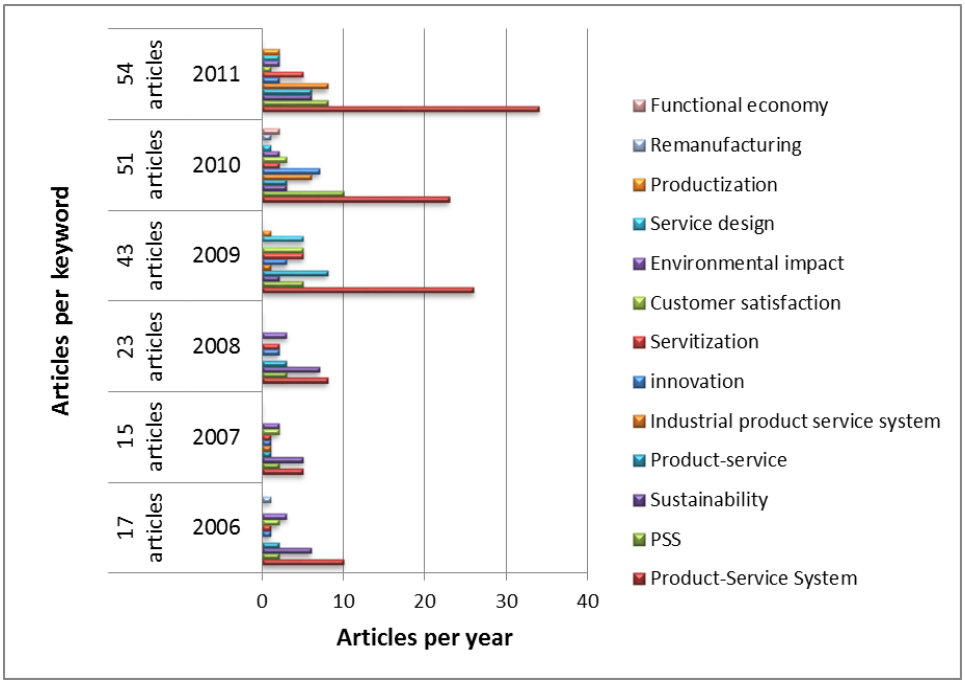

Figure 3: Main keywords related to PSS.

Actually, a large quantity of keywords was identified, but is presented here only the most frequently ones. It is still noted that some of the keywords stated in section 2 (Research Methods) were not found in the present bibliographical search, such as "service economy" and "system solution".

4.3 Main authors

The analysis performed in the EndNote X5 software (EndNote, 2011) and Sci2 Tool (SCI2 TEAM, 2009), identified the authors that have the highest number of citations alone (i.e. as a unique author) and the number of citations in joint publications among co-authors. Given a large number of articles identified in this work (203), Figure 4 highlights the main authors cited alone and those with joint publications found in the references of each article found in the references of each article.

The size of the node in the Figure 4 corresponds on how many times the author in question has been cited in the set of articles, i.e. the larger the size of the node, the more often the author has been cited. Noteworthy are the authors: Roy, R. (34 citations) and Evans, S. (32 citations) as the most cited authors in 203 articles identified in this work. It should be noted that Roy, R., has a greater number of joint publications. For example Roy, R. with Shehab, E., present 27 joint publications, with Tiwari, A. with 26 joint publications and Alcock, JR with 25 joint publications. In the case Evans, S., joint publications are performed with several authors. These values can be observed in Figure 4 by the thickness of the line; the thicker the line, the greater the number of joint publications.

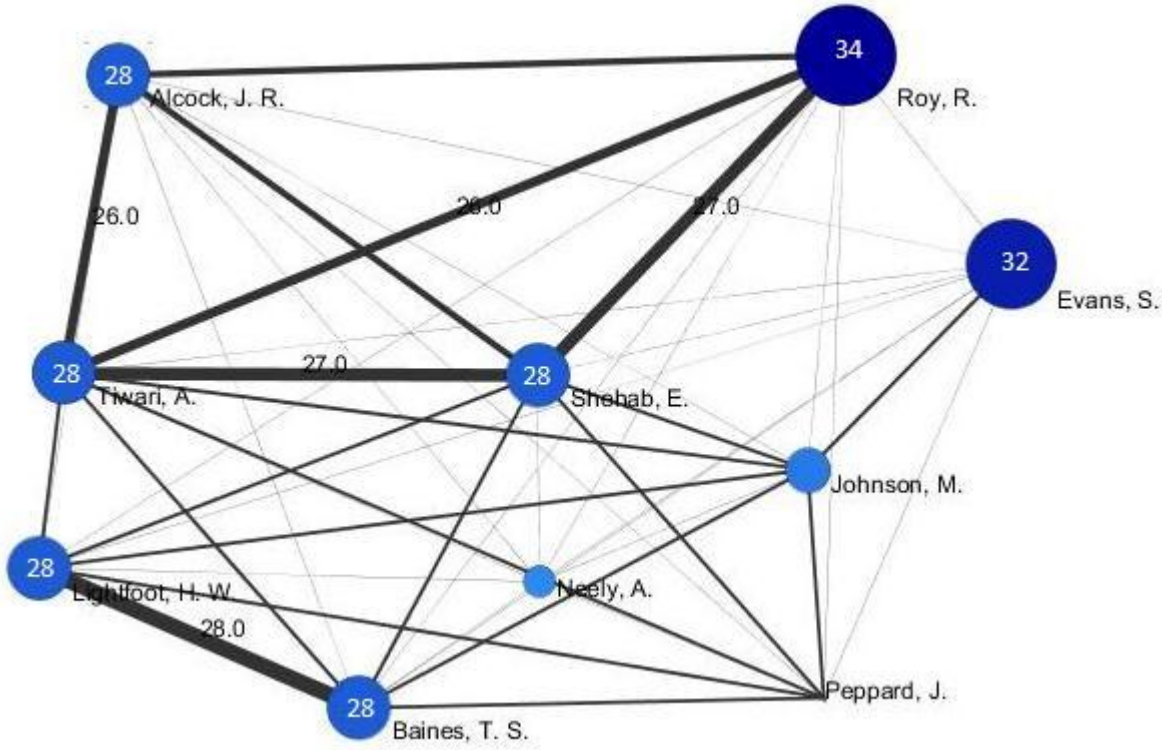

Figure 4: Net of author citations.

As can be seen, the main objective of Figure 4 was to demonstrate which authors are cited more often and especially if the authors usually develop joint publications. The results from Figure 4 are helpful to undertake studies on PSS since it may serve as a basis for future research.

Another basis for any research in this area is to identify which authors have published more papers in the subject. The more work the author has, the greater chances of finding work are. Table 3 presents the authors who have the highest number of papers published between 2006 and 2011. The authors Chu, X.N. and Tiwari, A. have 9 publications in the studied period from the total of 203 articles identified in this work.

Table 3: Publications per author.

Authors	Frequency
Chu, X. N.	9
Tiwari, A.	9
Alcock, J. R	8
Jiang, P. Y.	8
Baines, T. S.	7
Lightfoot, H. W.	7
Roy, R.	7

Note: the remaining authors have 6 or less published articles

It can be seen in Table 3 that the Roy, R. has 7 published articles in the third place. However, it is observed in Figure 4 that that author is the most cited among all others. Thus, while not having the greatest number of articles published, Roy, R. has a high recognition in terms of citations.

4.4 Main articles

The most cited article during the period of the study were "state-of-the-art in product-service systems" by Baines et al. (2007), with 50 citations from the total of 203 articles. Baines et al. (2007) offer a great contribution by making an introduction on the subject by presenting concepts, practical examples, benefits and barriers in starting a business as the PSS.

The second article was "life cycle oriented design of technical product-service systems" by Aurich et al. (2006) with 37 citations. Aurich et al. (2006) encompasses the life cycle of a PSS, which covers the entire system, involving products, services, infrastructure, and customer satisfaction. Thus, there are major changes in both economic performance and the environmental performance.

The third article was "developing new product service systems (PSS): methodologies and operational tools" By Morelli (2006) with 24 citations. Morelli (2006) seeks to present methodologies and tools that contribute to the development of PSS. Other articles have been developed exploiting these methodologies and tools, but more research is needed.

Table 4: Main citations within six-year period.

Citations	2006	2007	2008	2009	2010	2011	Total
Baines et al. (2007)				11	12	27	50
Aurich et al. (2006)		1		14	3	19	37
Morelli (2006)			1	7	3	13	24
Willians (2007)				7	2	7	16
Cook et al. (2006)				8	1	6	15

Note: the remaining articles have 10 or less citations.

It is worthy observing from Table 4 that the majority of citations of Baines et al. (2007), Aurich et al. (2006) and Morelli (2006) were done more recently in 2009, 2010 and especially in 2011.

5 Summary, Conclusions and Future Research

From a literature review of PSS between 2006 and 2011, 203 articles in relevant databases were identified. The articles were analyzed by mapping the main journals which has been publishing on the topic, the

main keywords used, the main authors, and principal articles. The evolution of PSS presented in the previous sections of this paper shows that there is a growing interest in researching the subject. Several journals have published articles on PSS, with a growing number of publications year after year.

The study highlighted the diversity of keywords used in the articles; "product service system" is certainly the most used by the authors. The word "PSS" that shortens the main keyword is also present. Some terms such as "sustainability", "product-service", "industrial product served system", among others highlighted in Figure 2, should be considered when performing a bibliographical search in the subject.

It is worth pointing out some authors who have more publications over the period from 2006 to 2011. They have published a number of articles over the years and this should be taken into consideration when conducting research in the subject. It is also important the citations and joint publications among authors, when the work of an author is used for the development of other works. This study sought to identify key articles in the field, which will be used mainly to develop new proposals.

From the literature perspective, it can be concluded that, when performing a search on PSS, one should take into account those results. Thus, the main objective to verify the evolution of the PSS is fulfilled. Nevertheless, there are still questions about the definition, categories, benefits, barriers of PSS and this should be investigated theoretically and empirically. With the evolution of PSS, future research should be conducted in different contexts of PSS. The subject needs to be further explored, seeking applications in other countries, cultures, and types of businesses to contribute to the development of empirical research on the subject. Those are possibilities for further work that is intended to be carried out. Firstly, some of existing PSS empirical experiences in a developing country is going to be investigated. Then, a construction of a conceptual model based on the current literature mapping, empirical analysis, as well as a taxonomy development is also planned for future research.

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