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The 9th CIRP IPSS Conference: Circular Perspectives on Product/Service-Systems

Product/Service-System Origins and Trajectories: A Systematic Literature Review of PSS Definitions and their Characteristics

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Abstract

Literature provides multiple definitions on Product/Service-Systems (PSS), and as the field develops, certain trajectories emerge. The purpose of this article is to provide an overview of the stabilization of PSS definitions within PSS research, by presenting the most prominent PSS definitions and their interrelationships. As the result of a strict protocol, the paper identifies 52 prominent definitions related to PSS, where the citation relations between the prominent definitions are studied and graphically illustrated. The definitions are furthermore analyzed to identify common PSS definition characteristics and eleven different characteristics identified. Descriptive analysis is carried out on the identified PSS definition characteristics, to determine commonalities and differences in the field. Even though the literature provides many different variations of PSS definitions, there is certain convergence regarding key characteristics of PSS, including *Product and Services* as well as *Customer Needs*.

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Keywords: Product/Service-Systems (PSS); Definitions; Systematic Literature Review

1. Introduction

Product/Service-Systems (PSS) is a growing field of research and industry practice, with the intentional and designed combination of products and services at its core. Since the first literature on PSS, that dates back to the late 1990ies [1]–[3], the research field has been very active – notably during the past 15 years, where the number of published articles has quadrupled [4]. PSS application in industry is often linked to multiple benefits such as reduction of environmental impact, increase in competitiveness and user value [1], [5].

Given the relatively short, yet active history of the field, PSS can be seen to be a promising concept for companies to explore. But as the field emerges and the contributions from various research backgrounds mature, what exactly defines a PSS?

Currently, a wide range of definitions and characterizing dimensions are suggested in the PSS literature, with only limited consensus on a common definition.

This article seeks to support answering the question of what characterizes PSS, by examining divergence and commonalities between prominent definitions* in the literature. This is not the first literature review on PSS definitions; earlier studies have been performed with different types and degrees of systematic approaches [6]–[8]. Although servitization is often linked with PSS, this paper focuses exclusively on PSS definitions.

Among the identified articles on PSS definitions, the article by Boehm and Thomas (2013) [8], presents the most quantitative approach towards analyzing PSS definitions. In their article, they map the state-of-the-art of PSS definitions and future developments. Through a systematic literature

* Prominent definitions are defined as definitions occurring in the most cited

papers in the field.

review they identify 74 different definitions of PSS and associated definitions from the three disciplines: *Information Systems, Business Management and Engineering Design*. Boehm and Thomas do not distinguish between PSS and associated concepts in their analysis. They develop a graph of the PSS definition elements for each of the three disciplines. The graphs show how identified PSS definition elements are linked together and how often the linkages occur in the investigated definitions. Boehm and Thomas also present a keyword concept matrix, where they count how often a total of 19 different identified concepts appear.

Compared to earlier literature reviews on PSS definitions, the research in this paper contributes with a systematic and quantitative approach, which identifies characterizing dimensions for PSS by mapping how the different PSS definitions relate to each other. Furthermore a descriptive analysis of each of the PSS Characteristics is provided.

2. Methodology of the Systematic Literature Review

This study was conducted as a systematic literature review, which is defined as a type of literature review that follows a strict methodology to enable replicability. This study has adapted the three proposed phases of the systematic literature review presented by Biolchini et al. (2005) [9], namely: *Planning, Execution and Analysis*.

2.1. Planning Phase

In the *Planning phase*, a protocol inspired by the standard protocol suggested by Biolchini et al. (2005) [9] was developed. The review included terms associated with PSS such as *servitization* and *functional economy*, as these terms are commonly used interchangeably with PSS [8], [10]. The list of associated concepts for PSS were generated by studying papers on PSS [11], [12]

The relevance of associated concepts was tested through iterations in the databases. The search string started with 20 terms, associated with PSS and after several iterations, it ended up with five. The 5 terms, as well as the excluded synonyms, are listed in Table 1.

Table 1. Search Terms included and excluded from Search String

	Search Terms
Search string after iteration	"Product Service System" OR "Product Service Systems" OR "Product Service Solutions" OR "Function-oriented business model" OR "Functional Sales"
Synonyms not contributing with articles	"Integrated Product Service Offering" OR "Integrated Product Service Engineering" OR "Product Substituting Service" OR "Eco-efficient service" OR "Function-oriented business model"
Synonyms providing irrelevant articles	"Dematerialization" OR "PSS" OR "System Solution" OR "Service design" OR "Service Product" OR "ecosystem services" OR "Functional Economy" OR "Servicizing" OR "Servitization" OR "Productization"

This study used *Web of Science (WoS)* and *Scopus* as databases, due to their relevance to the studied research field.

2.2. Execution Phase

In the *Execution phase*, the refined search string from the planning phase was used in the selected databases to search on paper titles. The document types were restricted to proceeding papers and reviewed articles in English.

In the study, it was only intended to map the most prominent definitions of PSS. Citation restrictions were therefore applied to the papers found in the databases. The 10% most quoted articles from WoS and Scopus among papers published in 2013 or earlier were selected for further examination. To account for the time dimension of getting a high citation rate, papers from the last three years were handled with special citation criteria. Among the papers published in 2014, papers were selected for further examination if they had three or more citations. Papers published in 2015 or 2016 were selected for further examination, if they had two or more citations.

The database search was performed in March 2016. The search string resulted in a total of 335 articles from WoS and 500 articles from Scopus. After applying the exclusion criteria, 37 articles from Web of Science and 47 from Scopus were selected for further investigation (Fig. 1).

Some of the papers appeared in both databases. To remove duplications, a *common list* with the titles of the selected papers from the two databases was generated. The abstracts of the articles from the *common list* were read through, to ensure that the papers were on the topic of PSS or an associated term. A total of 25 of the articles appeared in both Scopus and WoS and a resulting 59 papers emerged on the common list.

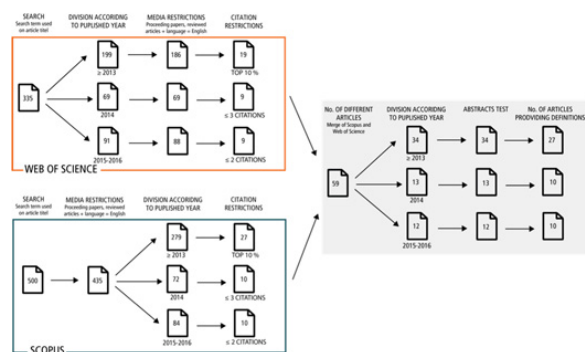


Fig. 1. Literature research results at different stages

All 59 articles passed the abstract test. From the 59 papers, 47 different articles provided definitions on PSS or an associated term.

2.3. Analysis Phase

The papers that passed the abstract test were carefully studied and definitions of PSS or associated concepts were extracted. The definitions found in the articles were classified according to two categories (*from either primary or secondary*

literature) and further divided into four subcategories (*new*, *reformulation*, *quotation* or *listed*) as seen in Table 2.

Table 2. Categories for classification of the PSS definitions

From Primary Literature. Definitions defined by authors from articles found in the literature search.
New. The definition is presented for the first time in the studied article (there are no references after the definition).
Reformulation. The definition builds upon another article’s definition (reference is provided just after the definition).
From Secondary Literature. Definitions are from articles the primary literature refers to.
Quotation. The definition is another article’s definition. The studied article quotes and agrees upon it.
Listed. The definition is another article’s definition. The studied article quotes it but does not use it (the read article mentions the other paper’s definition because it criticizes the PSS definition or mentions a spectrum of PSS definitions without deciding which it agrees with).

All identified definitions, plus the authors that were referred to in the primary literature in connection with the definitions, were placed on a chart, according to year of publication (Fig. 2).

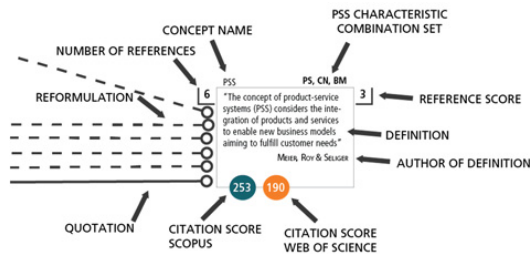


Fig. 2. Explanation of chart symbols and notations

The definitions were placed in boxes with white or blue background colors according to whether they were from primary or secondary literature, respectively. On the left side of the boxes from the primary literature a number was added, to indicate the *number of references* that the given definition had. It was noted above each box, which concept the definition in the given box was on. A relation between two papers was illustrated with a solid line if a paper quoted the definition of another paper (*quotation*). The relation was illustrated with a dotted line if a paper referred to another paper’s PSS definition (*reformulation*). On the right side of each box, a number was placed to indicate the total *reference score*, i.e. the number of other papers on the chart that were citing that particular paper. If a relation between two papers had been classified as *listed*, no line between the two papers was added. The *listed* reference was included in the numbers indicating the *reference scores* as well as *number of references*. An example of the listing of a PSS definition on the chart and explanation of its notations is seen in Fig. 1. The full chart can be found on <http://www.ecodesign.dtu.dk/PSS-Chart>.

In the *Analysis phase*, the PSS definitions on the chart were analyzed to identify common *PSS Characteristics*. Afterwards, the elements of definitions on PSS and the definitions on associated concepts were classified, according to the PSS Characteristics. Each definition’s set of PSS Characteristics was noted above the definition on the chart.

Descriptive analyses were made on numbers of occurrence of each Definition Characteristic, in order to identify common aspects of the definitions. Analyses were also made on definitions of PSS and definitions of associated concepts, separately, to see if different patterns of PSS Characteristics occurred. All analyses were made with unweighted and weighted data. The reference scores to the right side of the boxes on the chart were used to make the weighting. To credit that a definition appeared in the primary literature, the weighting indexes of definitions from the primary literature were given a bonus value of 1. Analyses were also made with the purpose of getting an overview on how the PSS Characteristics had developed over time. The publications on PSS definitions were divided into two time periods: 1999-2009, and 2010-2015. A statistic on the average numbers of citation scores for each of the PSS Characteristics was also made. The ability of the protocol to catch the most prominent PSS definitions in the field was evaluated on the basis of presence of the six definitions presented by Beuren et al. 2013 [7].

3. Results & Discussion

3.1. Distribution of Definitions on PSS and Definition on Associated Terms

The 47 different articles provided 55 different definitions of PSS or associated concepts. Definitions provided by the same authors (e.g. [13], [14]) were clustered, resulting in 52 definitions. Out of the 52 definitions, 40 of them were on PSS and 14 were on associated concepts, as seen in fig. 3.

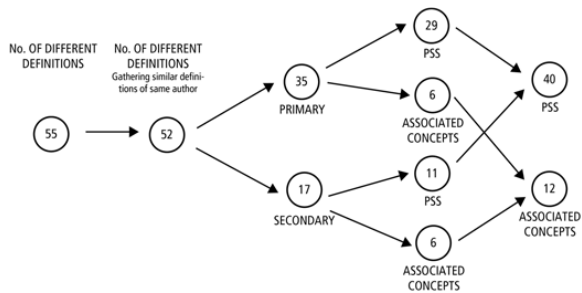


Fig. 3. The distribution of the origin of the different definitions according to primary/secondary study and definition type.

All 6 definitions from the literature review by Beuren et al. [7] were present on the chart. Three of the definitions appeared in the primary literature [1], [6], [15], whilst the other three appeared in the secondary literature [3], [16], [17].

3.1.1. Prominent definitions

The most referenced PSS definition in the literature review was the definition by Mont from 2002, which was referred to 18 times in the primary literature: “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” [1].

The second most referenced definition on PSS was the one given by Goedkoop et al. from 1999 [3], which was quoted 13

times: “A marketable set of products and services capable of jointly fulfilling a user’s need” [3].

3.1.2. PSS and Associated Concepts

Definitions of the following eight associated PSS concepts were found in the literature research: *Servitization*; *Functional economy*; *Functional Sales*; *Service-dominant logic*; *Product bundling*; *Industrial product-service systems (IPSS)*; *Sustainable product service systems (SPSS)* and *Eco-efficient service*.

After 2009, only definitions on IPS² and PSS occur. According to the findings of the literature study, the term *Product-Service System* was used for the first time in the literature in 1999 by Goedkoop et al. The earliest article appearing in this literature review presenting a PSS related definition was an article from 1988 on *Servitization* by Vandermerwe & Rada [18].

3.1.3. Defining PSS Characteristics

From the 40 definitions on PSS 11, PSS Characteristics were identified as listed in table 3.

Table 3. Explanation on PSS Characteristics

Abbreviations	PSS Characteristics	Explanation
PH	Physical products	Products in the PSS are defined as “physical” objects.
PS	Product and service	A PSS consists of product and service elements.
AN	Actor network and infrastructure	A PSS creates an infrastructure that includes other actors than only the company and end user. The PSS does not (necessarily) only create value for the company and the user, but also for other part of the actor network.
CN	Satisfy customer needs and create value	A PSS (can) lead to an increase in customer satisfaction and customer value.
EI	Reduce environmental impact	A PSS (can) reduce the environmental impact in connection with delivery of customer need, compared to traditional solutions.
CP	Competitive	A PSS develops solutions that are competitive on the market.
BM	Business model	PSS offers a new business model, which includes shift in product ownership.
IS	Innovation strategy/ design process	PSS is a design process/innovation strategy.
CL	Customer life cycle	There is a focus on other customer activities related to the PSS than only the use phase.
PL	Product life cycle	Consideration of the whole product life cycle is included in the PSS.
SF	Self learning system	Through the implementation and use of PSS, goals of the system are continual improvement.

Judging the number of different definitions on the chart from the combination of the 11 Characteristics gave a total of 34 different definitions. Only four combination sets were repeated more than twice:

- 3 definitions had the combination PS, CN, EI, CP
- 4 definitions had the combination, PS, CN, CP

- 4 definitions had the combination and PS, PH, CN
- 4 definitions had the combination PS, CN

3.1.4. Descriptive analyses on PSS Characteristics

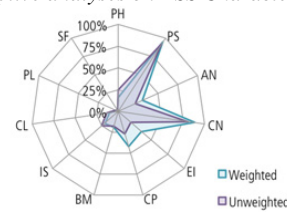


Fig. 4. PSS-Definition Characteristics distribution for definitions on PSS and definitions on associated concepts combined according to weighted and unweighted data

The most common appearing PSS Characteristics among all the definitions were *product & services* (PS) with 92% of occurrence and *satisfy customer needs* (CN) with 81% of occurrence (fig. 4). For the weighted data PS and CN were present in 95% and 89% of the cases. The least occurring PSS Characteristics were SF and PL. They occur in less than 4 % of the definitions (taking both weighted and unweighted data into account).

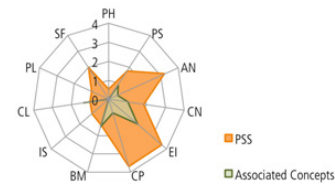


Fig. 5. Average citation score for each PSS Characteristic for definitions on PSS and definitions on associated concepts separated.

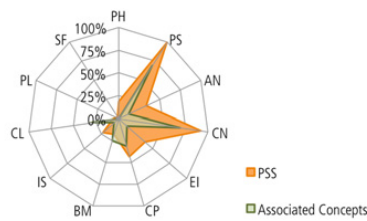
Definitions on PSS containing an EI or CP Characteristic were in average cited almost 4 times (fig. 5). Definitions on PSS containing the AN Definition Characteristic were the third most popular definitions to cite, with an average citation score of three times. Definitions on PSS containing the PH Definition Characteristic were cited the least. They were in average cited ½ of the time they occurred. For definitions on associated concepts the most cited PSS Characteristics were EI, BM and CL. Definitions on associated concepts containing one of these Definition Characteristics were cited around 1½ times.



Fig. 6. Percentage of occurrence among unweighted definition on PSS and definitions on associated concepts divided

In total, 98% and 88% of definitions on PSS include PS and CN Characteristics, respectively (fig. 6). Less than 5 % of the definitions on PSS include the aspects of PL and SF. PS and CN were also the most common Characteristics for definitions on associated concepts. They were present in 75 % and 58 %

of the cases. PH, PL and SF were not present at all among the



definitions on associated concepts.

Fig. 7. Percentage of occurrence among weighted data according to definitions on PSS and definitions on associated concepts.

In fig. 7 the Characteristics were weighted according to their citation score on the chart. PS and CN were still the most prominent Characteristics. PS and CN occurred among 99% and 92% of the definitions on PSS and they both occurred among 69 % of the definitions on associated concepts. CP and EI were the third and fourth most occurring PSS Characteristics for definitions on PSS with 44% and 39% of occurrence, respectively. For definitions on associated concepts the third and fourth most occurring Characteristics were CP and BM. Both Characteristics occurred in 31 % of the weighted definitions on associated concepts.

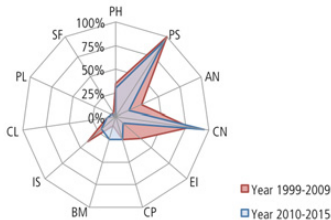


Fig. 8. Division into two time periods for definitions on PSS according to published year. Unweighted data is used.

Fig. 8 shows the development in PSS Characteristics among definitions on PSS from the period of 1999-2009 and 2010-2015. The EI Definition Characteristic decreased by 71% between the two time periods. AN and IS both decreased by 50%. BM increased by 150%.

4. Discussion

Judging from combination of identified PSS Characteristics, no universal PSS definition has yet been agreed upon within the field. Though, there seem to exist a consensus that a PSS includes the PSS Characteristics PS and CN. In the weighted data, nearly 100% of the definitions on PSS contained PS and CN. It seems natural that the definitions on PSS contain PS, since *products* and *systems* are embedded in the name of the concept itself. CN is, on the other hand, not ‘as given’. The definition by Goedkoop et al. [3] has the PSS Characteristics combination PS, CN, CP. Even though many researchers do not make a direct reference to Goedkoop et al., it appears from their choice of wordings that they were inspired by this definition. The repeatedly occurring traces from Goedkoop et al. could be an explanation as to why researchers throughout the years seem to have included the PSS Characteristic CN in their definitions.

The PSS Characteristics EI and CP increase by 72% and 74%, respectively, from the unweighted to weighted statistics on definitions on PSS. Since the definitions of Goedkoop et al. [3] and Mont [1] were by far the most cited definitions in this study, their PSS Characteristics dominates the weighted data. The PSS Characteristics combination of Mont were PS, AN, CN, EI, CP. This could explain why the PSS Characteristics CP and EI have such a high citation rate. It was not clear if the high citation rates of CP and EI were causes or effects of the popularity of the PSS definitions provided by Mont and Goedkoop et al.

The definitions on associated PSS concepts provide a similar overall pattern as the definitions on PSS, but in a smaller scale. Among both definitions on PSS and definitions on associated concepts the PSS Characteristics PS and CN were the most popular ones, though the occurrence of the two PSS Characteristics for definitions on associated concepts were around 25% lower than for definitions on PSS (in the unweighted data). There is a decrease in percentage of occurrence in all unweighted definitions on associated concepts’ PSS Characteristics, compared to definitions on PSS, except for CP and IS. The highest decrease in occurrence in PSS Characteristic among definitions on associated concepts compared to definitions on PSS was IS, with a 72% (disregarding the three Characteristics that do not occur among definitions on associated concepts). The total picture of definitions on associated concepts’ PSS Characteristics seems to be more scattered and inconsistent than the one of the definitions on PSS. This is not surprising, since the definitions on associated concepts originate from 8 different terms, whereas the definitions on PSS only were related to one concept name. It can be concluded that the definitions on associated concepts resembled the definitions on PSS to a certain degree, but it did not seem suitable to use definitions on associated concepts interchangeably with definitions on PSS.

The analyses on *average citation score* in Fig. 6 did not seem to provide a full picture of the popularity of the Characteristics. SF was the least used aspect (only one definition uses it), but it still has a relative high average citation score. A conclusion from fig. 5 was that EI was among the most cited PSS Characteristics. From the analyses on PSS Characteristics in the two different time periods (fig. 9), it was clear that EI was a popular PSS Characteristic among the early PSS definitions, but not in the later. The papers from before 2010 were by far the most cited papers, which seems natural since they have had a longer period to build up a high citation score. It can therefore be concluded that the statistics on *average citation score* in fig. 5 have difficulties in identifying a new trend evolving away from EI.

Some of the PSS definitions focus on sustainability, whereas others focus on describing what services and products are and what you get, when you combine them. The inclusion of sustainability in PSS definition is quite different across the literature. According to some definitions, sustainability is a core part of PSS [1], hence a PSS can not be argued to be so unless it is more sustainable than a conventional alternative solution. For others, sustainability is a possible benefit of a PSS but not a necessary element for the system to be a PSS [19]. In the literature the terms Sustainable PSS (SPSS) or Eco-

Efficient Service were used to emphasize the sustainable aspects of PSS [15].

5. Final remarks and next steps

The term PSS originates from a field of service-product related concepts, where different similar terms have competed to become the dominant concept in the field. During the last decade, the field of PSS and associated terms seems to have narrowed down to two main tracks, consisting of the two concepts PSS and IPS². In this study, 52 different definitions of PSS and associated concepts were identified from 47 of the most prominent papers in the PSS field.

Goedkoop et al. and Mont are the most cited PSS definitions. Goedkoop et al. provide the first definition on PSS, and many researchers seem to build upon that definition. In total, 11 different PSS Characteristics were identified from the PSS definitions. Considering the PSS Characteristic combination sets, the 52 definitions on PSS and associated concepts provide 34 different definitions. The maximum number of definitions having the same PSS Characteristic combination set was 4, so no clear tendency of a homogenous Characteristic set crystalized from the PSS Characteristic analysis. Statistical analysis of PSS Characteristics showed a consensus concerning inclusion of the Definition Characteristics *satisfaction of customer needs* (CN) and elements of *products and services* (PS) in a PSS definition.

According to the analyses, a PSS definition is most likely to be cited if it contains the PSS Characteristics *Reduce Environmental Impact* (EI) or *Competitive* (CP), though looking at the statistics of the development in PSS Characteristics before and after 2010, a decrease in the PSS Characteristic EI and increase in *business model* (BM) are seen. This suggests a shift of focus from environmental benefits of PSS to economical benefits.

The analyses suggest that PSS associated concepts cannot be used interchangeably with PSS, but a further study of the associated PSS terms on an individual basis is needed to enable a more detailed conclusion. The main limitations of this research are related to: subjectivity in the extraction of definitions and characteristics; limited robustness of the weighting system; lack of evaluation of the relative importance of the PSS Characteristics; limited selection of the search strings and databases; and limited data sample.

Next steps for this work are to carry out an investigation of the *precision* of the different PSS definitions. A PSS definition with a high precision enables replicable distinguishability between whether or not a system is a PSS. Further investigation should be done to identify whether or not the existing PSS definitions provide a satisfying level of precision.

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