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Review

Looking beyond the rim of one's teacup: a multidisciplinary literature review of Product-Service Systems in Information Systems, Business Management, and Engineering & Design

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ABSTRACT

In the past, there has been a lot of research on Product-Service Systems (PSS) – integrated bundles of products and services. However, the topic has been basically independently discussed by researchers of different disciplines. The purpose of this paper is to integrate the results of the fields of Information Systems, Business Management, and Engineering & Design and hence to investigate the state-of-the-art in PSS research by conducting a structured literature review. In total 265 articles have been intensively analyzed. A unified core definition of the PSS term is derived as well as the notion of the concept in the three disciplines is explained and summarized. A meta-analysis of previous literature reviews completes the picture. Based on our data it is shown that the understanding of PSS is very different in the three disciplines. Therefore, a research agenda for future research is developed which includes for example the need for clarifying the terminology, changing perspectives, and conducting more evaluations.

1. Introduction

About 50 years ago, back in 1962, Becker (1962) proposed his idea of shifting from products to services. In those days, the U.S. was the first nation that has been called "service economy" (Fuchs, 1965), because half of the total labor force has been employed by the service sector (Fuchs, 1968). At the end of the 1960s, Levitt (1969) stated that people do not buy products but buy the expectation of benefits. In 1976, Stahel and Reday-Mulvey (1981) presented a groundbreaking report to the European Commission. They hypothesized that by focusing not on products but on selling the utility of products new jobs could be created and energy-consumption could be decreased.

The rapid development of information and communication technologies (ICT) starting at the beginning of the 1980s is one important factor that facilitated the shift from product-orientation to service-orientation dramatically (Bhagwati, 1984; Sztipanovits, 2012). The new technology offered new opportunities in offering better products and services. More and more, companies began to use ICT to add value to their products or services (Vandermerwe and Rada, 1988). Today, there is an industrial trend toward product-service integration in a way that ICT becomes the interface between products and services (Geum et al., 2011a). In addition, globalization leads to the transferal of production to low-cost regions, competition has become fiercer, as well as customers have become more and more demanding (van Halen et al., 2005). In future, there is a trend toward a very close integration of products, services, sensors, and the Internet – already discussed as Cyber-Physical Systems (CPS) (Sha et al., 2009; Broy et al., 2012; Sztipanovits, 2012).

Today, Customers have a certain need which needs to be fulfilled until they are satisfied. Many of them do not want to buy a specific product. Instead, they demand for solutions of a problem. Therefore, companies started to offer integrated packages of "hard" tangible products as well as "soft" intangible services. These packages or bundles mostly have been called Product-Service Systems (PSS) in literature. One of the first known definitions is in a report for the Dutch government in which Goedkoop et al. (1999) states that a PSS can be understood as "a marketable set of products and services capable of jointly fulfilling a user's need". According to Mont, who also provided several often referred contributions, PSS are defined as systems of products, services, supporting networks and infrastructure that are designed to be competitive, satisfy customer needs, and have a lower environmental impact than traditional business models (Mont, 2002a). In

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the last years, there are numerous descriptions of more or less successful PS systems have been given in literature. Rolls-Royce, for example, delivers a "power-by-the-hour" instead of transferring ownership of the gas turbine engines to the airline companies (Baines et al., 2007; Huang et al., 2011). Other examples of PSS can be found for photo copiers (Geum et al., 2011b; Huang et al., 2011), car sharing (Meijkamp, 2000; Kuo, 2011), office industry (Besch, 2005), teaching (Brezet et al., 2001; Boehm et al., 2011b), or IT solutions (Herzfeldt et al., 2010).

ICT is for many of the above mentioned examples for PSS an integral foundation (cf. Ryan, 2004 for an overview on PSS using IT). ICT is seen as an enabler of new business models which can be implemented by both manufacturing and service companies (Neely, 2008). New working methods, consumption patterns and production chains are driven by IT solutions (van Halen et al., 2005). A new service economy has arisen which is driven by IT (Manzini et al., 2001). Additionally, a high level of customization of products and services becomes possible at a lower level of costs (Kellogg and Nie, 1995). That is the reason why recently the PSS concept also has been discussed in more technical oriented disciplines like for example Information Systems (Gräßle et al., 2010).

In the following a firm foundation for advancing knowledge of the PSS concept shall be created. For doing so, a rigorous and structured literature review considering the three disciplines Information Systems (IS), Business Management (BM), and Engineering & Design (ED) is conducted. These disciplines have been chosen because of their high importance for discussing aspects of PSS. Fields like marketing or consumer studies have been subsumed in the BM discipline. Researchers from the BM discipline have been one of the first ones discussing the PSS concept and ED researchers contributed the highest number of articles. Publications from the IS discipline have been included because of the important role of ICT within the development and operation of PSS.

This paper is structured as follows: First, the research framework is presented which consists of the derivation of the research question and a description of the applied methodology. Next, the results are presented. Based on this, main implications are discussed and a research agenda is motivated and discussed. Finally, conclusions are drawn and an outlook is given.

2. Research framework

2.1. Research question

Research on PSS is an interdisciplinary field. Business Management (BM) mostly investigates bundling of products and services from a marketing perspective (Shostack, 1977; Schmalensee, 1982; Eppen et al., 1991). Additionally, different terminology like "compack" (Bressand, 1986) or "servitization" (Vandermerwe and Rada, 1988) also have been presented to discuss the PSS concept. Within the Engineering & Design (ED) discipline, which focuses on designing, building, and operating physical products, a separate stream of research has evolved. Especially North-European researchers have coined the term "Product-Service System" (McAloone and Andreasen, 2004; Mont, 2004; Tukker and Tischner, 2006b). Furthermore, similar conceptualizations have been given using terms like "functional sales" (Lindahl and Ölundh, 2001), "functional products" (Kumar, 2003), "total care products" (Alonso-Rasgado et al., 2004), "extended product" (Thoben et al., 2001), "servicification" (Lodefalk, 2010), "covalent product" (Weber et al., 2002), "post mass production paradigm" (Tomiyama, 2002), or "Industrial Product-Service Systems IPS^2" (Meier et al., 2011). However, most often they mean the same thing (Lifset, 2000). Especially from German-speaking researchers in Information Systems (IS) there have been a number of contributions. Here, terms like "hybrid product" (Leimeister and Glauner, 2008), "hybrid value bundles" (Schrödl and Turowski, 2011), or "hybrid value creation" (Thomas et al., 2007) have been used. Parallel to research on PSS, the concepts of "new service development" respectively "service engineering" have been coined in America respectively in Germany and Israel (Bullinger et al., 2003). These researchers focus much more on the service-aspect of PSS. In general, on recognizes that the development aspect is very important in many contributions (cf. for example Lindahl et al., 2006a; Tukker and Tischner, 2006a; Davis et al., 2010; Müller and Stark, 2010; Berkovich et al., 2011a, 2011b).

Due to the increasing number of contributions to the PSS concept (Velamuri et al., 2011) and an exploding amount of PSS research projects, many domains discovered the PSS concept for their work (Müller and Sakao, 2010). The most critical issue about these developments is the fact that there are only quite limited connections between those researchers (Tukker and Tischner, 2006b). Different terminology has often been used for describing apparently identical phenomena (Pawar et al., 2009). Furthermore, results are published in separate journals and conferences and hence interchange is difficult. As an overview on the research landscape is still missing, researchers for example dealing with PSS development cannot rely on all relevant contributions (Sakao et al., 2009b). A further problem is the generalization of results. It is often impossible to apply them because new methods and models are tested only in a small number of examples (Mont, 2002b). Hence, there is a need for consolidation for making research results usable by more researchers and applicable in practice (Müller and Sakao, 2010).

Based on this, the research question which guides our further research is: *What is the state-of-the-art in PSS research in the Information Systems (IS), Business Management (BM), and Engineering & Design (ED) disciplines and what are future directions especially concerning PSS development?*

Contributions covering explicitly the PSS concept fall into our concern as well as papers which cover highly related issues. So far, our question has not been asked in other literature reviews on PSS (cf. for example Baines et al., 2007; Velamuri et al., 2011; Cavalieri and Pezzotta, 2012). Although the PSS concept in disciplines like Business Management and Engineering & Design has been compared (Tukker et al., 2006), our research is novel in a way that a high number of articles from three disciplines have been systematically identified, analyzed, and compared. Additionally, our goal is to support novice researchers who want to start in the PSS field in giving them a comprehensive overview on the field with respect to topics, peoples, publication medium etc. Therefore, an answer to our question will be valuable for researchers of all three disciplines.

2.2. Research methodology

For answering our research question, we conducted an exhaustive and systematic literature review. A literature review like this aims to identify critical knowledge gaps and should motivate researchers to close this breach (Webster and Watson, 2002). Reviews can be conducted on the basis of mature topics or new and emerging topics (Torraco, 2005). As PSS can be seen as a mature topic, a literature review on this should address the need for a review, critique, and the potential reconceptualization of the expanding and more diversified knowledge base of the topic as it continues to develop (Torraco, 2005). Systemic literature analyses become more and more important (Webster and Watson, 2002). Nevertheless, these reviews are a relatively recent phenomenon in social sciences (Velamuri et al., 2011). The basic requirement is methodological rigor in conducting literature reviews (vom Brocke et al., 2009). In contrast to traditional literature reviews, a systematic review follows a clear procedure and explicitly states

methods of selecting and evaluating publications (Velamuri et al., 2011). There are three phases which have to be covered (Budgen and Brereton, 2006):

- Review protocol: *What is the research question and scope?*
- Search strategy: *How to identify relevant literature?*
- Documentation and analysis: *What can we learn from a rigorous analysis of the literature?*

First, the research question and scope are defined in a review protocol. We employ a multi-disciplinary analysis by setting the scope on articles that are relevant to PSS within a wider context of the IS, BM, and ED disciplines. As depicted in Fig. 1, we focus on research outcomes and methods because these are the basic elements for a comparison. Our central goals are to integrate previous research of three different disciplines and then elaborate on central issues. We do this from a conceptual organization and take in a neutral perspective. The audiences of this review are general scholars and practitioners who are interested in recent contributions on the PSS topic. As we use a multitude of different databases and search strategies we cover an exhaustive amount of relevant literature.

We explicitly included publications in German language in our review. This has several reasons. Basically, the concept of PSS has been an important research area in the German speaking countries in the past few years (Thomas et al., 2008a). Additionally, next to numerous of research projects founded by the European Union, there has been a number of high-volume projects on hybrid value creation in Germany. Furthermore, Velamuri et al. also included German literature into their review because they wanted to make their research accessible in a systematic way, even across the boundaries of languages or publication formats (Velamuri et al., 2011). Finally, central contributions to the PSS field from researchers of the Information Systems discipline have published their results only in German language. Of course, these facts are also true for other countries, e.g. The Netherlands, Sweden, or Italy. However, Germany is the biggest industrial market in Europe with the highest number of potential end consumers. The German government explicitly supports sustainable and industrial evolution and therefore there is a lot of research on this issue. Additionally, authors have in-depth regional and local experience in German research community.

In the second phase, the definition of the search strategy, relevant data sources need to be identified. Here, we employ the recommendations by Webster and Watson (2002): First, major contributions in journal and conference databases are searched. Then, a backward and subsequently a forward search are conducted in order to identify further relevant articles. Especially, citations of the identified resources have been cross-checked for ensuring the capturing of earlier important publications. As major data source a broad selection of all relevant databases has been used: EbscoHost, Springer Link, ScienceDirect, WISO Database, AIS Electronic Library, EmeraldInsight, Wiley InterScience, IEEEXplore, INFORMS, and ProQuest. This procedure ensured the finding of a diverse range of publications, like for example journal articles, conference proceedings, theses, books, and trade journals. For a completion of the review, an internet search was conducted using the search engines Google and Google Scholar. The derivation of the set of keywords was complicated because a variety of different terms for the PSS concept exists (Knackstedt and Winkelmann, 2006). Therefore, we analyzed terms described by Velamuri et al. (2011) and Thomas et al. (2008a) in order to derive a set of the most relevant ones: Product-Service Systems, Compack, Complex Package, Value Bundle, Covalent Product, Servicification, Post Mass Production Paradigm, Hybrid Product, Hybrid value creation. The search terms have been used in all databases both in English and in German language. Retrieving publications by means of keywords is frequently used and leads to valid results (Steininger et al., 2009). The relevant time frame first has been set from 1992 to 2012 because by doing so a time span of 20 years of research can be covered. Later, the time frame has been extended in order to cover also pervious highly relevant contributions. The final research approach is depicted in Fig. 2. After retrieving the query results book reviews, editorials, and teaching cases have been excluded from the review. Additionally, duplicate references have been detected and removed. Afterward, the abstracts and conclusions have been extracted and relevant literature has been identified. In parallel, the query results of the Internet search engines have been searched for relevant contributions. The abstracts have been inspected here, too. After the integration of the two lists, the articles have been read completely. References have been analyzed and a backward and forward search has been conducted. Finally, a total number of 265 highly relevant articles have been investigated. The analysis of the papers took place between October 2011 and August 2012. Data collection took place in a form that one researcher extracted the data and another checked the extraction (Kitchenham et al., 2009).

Within the third and last phase, the main ideas and themes from the literature have to be documented and analyzed (Torraco, 2005). While the resources that form the basis for the literature review are termed primary studies, the systematic review itself is a form of secondary study (Budgen and Brereton, 2006). Criticizing of past research is only of little value (Webster and Watson, 2002). Hence, we employ a descriptive rather than normative investigation. Rather claiming previous research as inadequate and incompetent it is more valuable to explain how research builds upon previous findings (Webster and Watson, 2002). For each article the following data has been recorded: The source (journal, conference or other) and full reference, discipline of outlet, language and country of the first author, number of authors and type (researcher and/or practitioner), purpose of article and research questions, research design and research methodology (Palvia et al., 2004), main topic area and main findings, industry of investigation, perspective and discipline of the article (Velamuri et al., 2011), whether the study provides a definition of PSS, and four keywords characterizing the article. The keywords have been recorded after carefully reading the articles and have not just been taken from the authors' provided keyword

Characteristic	Categories			
Focus	Research outcomes	Research methods	Theories	Applications
Goal	Integration		Criticism	Central issues
Organization	Historical		Conceptual	Methodological
Perspective	Neutral representation		Espousal of position	
Audience	Specialized scholars	General scholars	Practitioners	General public
Coverage	Exhaustive	Exhaustive and selective	Representative	Central/pivotal

Fig. 1. Taxonomy of this literature review (based on vom Brocke et al., 2009).

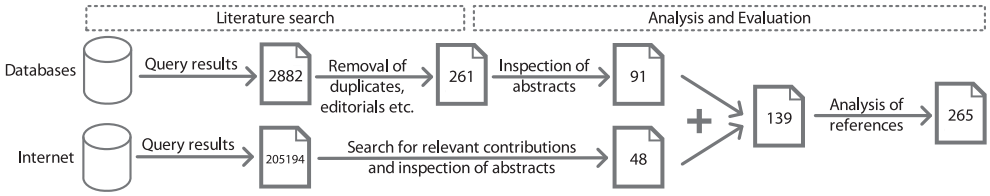

Fig. 2. Research approach.

list. This data will be used to analyze the state-of-the-art in PSS research.

In order to be able to analyze the concept of PSS more deeply, a novel approach will be employed. For every scientific field it is important to establish a common ground for central terms. Reciprocity is necessary for mutual understanding of researchers in order to communicate and exchange insights (Zarvić et al., 2012). In the PSS research field this is not a simple task because multitude of definitions exists. In order to derive crisp definitions, Hoede and Wang introduced the graph-theoretical approach of *definition graphs* (Hoede and Wang, 2006). Accordingly, E is the set of elements that occur in a given set D of definitions. If elements occur in some definitions but do not occur in all definitions, they talk about fuzzy concepts. In this case the membership function of an element x is the function $\mu(x)$. The function takes values in the interval [0,1], meaning that if elements not belonging to the set have the value 0 and elements belonging to it have the value 1. If μ only consists of the values 0 and 1, we call it a crisp set. Otherwise it is called fuzzy set. For preparing a definition graph, the number of occurrences of an element of E in some or all definitions of D is calculated. If an element e, $e \in E$, occurs n times the membership function can be calculated as follows:

$$\mu(e) = \frac{n}{N} \quad \text{where } N = |D|.$$

On this basis the definition graphs can be created, whereas concepts are nodes of the graph and pairs of concepts are the edges. Zarvić et al. (2012) used this method to derive definition graphs in the context of IT governance. We adopted their procedure. The definitions found in the PSS literature have been assigned to one of the three disciplines. For each discipline one definition graph will be created. For doing so, the occurring concepts in the definitions have been investigated. These are the nouns which have been identified on synonymy. If two nouns are closely related to each other or if a noun appears in form of an adjective, like for example "marketable product", a pair <marketability, product> is extracted. A similar procedure can be applied in case of verbs or prepositions.

3. Results

3.1. General findings

In total, we investigated 265 articles out of which 140 (without duplicates) have been retrieved through a comprehensive database search (cf. Table 1). No direct results have been found searching the WISO Database, Wiley InterScience, IEEEXplore, INFORMS, and ProQuest databases. With the help of the backward and forward search (Webster and Watson, 2002) again 125 additional highly relevant articles have been added to the list (cf. Fig. 2). In the following, general findings in terms of statics are described. This helps in getting a first overview on the field.

Out of the 265 investigated articles, 41 (15%) can be assigned to the field of IS, 77 (29%) to BM and 147 (55%) to ED. One first gets an impression that the latter field has the strongest – in terms of quantity – contribution to the PSS field. If one looks at the frequencies of publications (cf. Fig. 3) one recognizes that this high number only has been achieved recently. While the first article of ED has been published in 1997, publications of BM have started in 1973. The peak of publications in ED in 2006 can be explained by a special issue of the journal "Journal of Cleaner Production" with 7 articles. Furthermore, a lot of articles haven been published in 2009 (20 papers), 2010 (17 papers), and 2011 (19 papers). From the year 2007 on, the IS field started to cover the PSS topic. The years of 2008 and 2011 have been very productive in the result of 12 articles each year. The BM field has been covering PSS related issues for the longest time – between 1973 and 1996 there have been 24 articles in total. However, also here one recognizes a rise of papers from the year 2001 on. In 2006, the highest amount of articles in one year (6 articles) has been published. By cumulating the numbers of publications, one recognizes that in 2011 most articles (36) have been published. The years 2009 (32) and 2006 (30) have been very productive, too. Although the year 2012 has only been covered until August, there have been already 10 articles. Hence, it can be concluded that the PSS topic is still highly relevant and many researchers are working on this.

Table 1
Identified articles per search term and source.

Source	Search term							
	Product-Service systems	Value bundle	Covalent product	Servicification	Post mass production paradigm	Hybrid product	Hybrid value bundle	
EbscoHost (Business Source Complete)	24							
Springer Link	26							
ScienceDirect	10							
AIS Electronic Library	6	7				2	1	
EmeraldInsight	15							
Google	31			1		1	2	
Google Scholar	5	4	1		1	2	1	
Sum	117	11	1	1	1	5	4	140

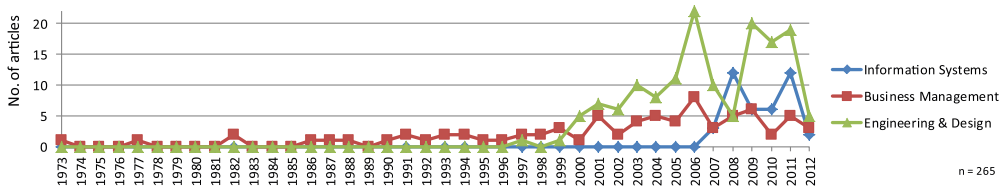

Fig. 3. Frequency of publications on PSS over time.

Within the top 10 of most productive authors 6 of them are from the IS field (cf. Table 2). In our study, the assignment of authors to a discipline depends on the discipline of the respective papers' outlets. The most productive authors have written 11 articles. By extending the list to those authors with more than 5 publications one recognizes that there is no author from the BM discipline. Andrew Davies is the highest ranked author in this field with 4 articles. In the list of the most productive authors (cf. Table 2) 62% of the authors are from the field of ED. As IS researchers are also ranked quite high one can conclude that in these fields relatively few researchers cover the PSS topic. Especially in the IS field, few publications have been written by few researchers. This can be verified by looking at the average number of authors per article. Here, on average 3.63 authors write one article in the IS field. In contrast, in BM the number is 2.26 and in ED 3.04. Hence, the BM and ED fields are more diversified. By looking at all articles it can be seen that 70.8% of the total 473 authors have one paper, 16.9% two, and 5.1% three. Only 21 authors (0.04%) wrote 5 or more articles. More than half of the 473 authors come from ED (57%); 28% of the authors come from BD and only 14% from IS. Nearly all of the 265 articles have been written solely by researchers (91.7%). For 17 articles (6.4%) researchers and practitioners collaborated. This has been done mostly in the ED field (10 articles), followed by BM (5) and IS (2). Only five articles from the BM discipline have been published by practitioners (1.9%).

The publication media is mostly a journal or conference proceedings. Only a small number of articles have been published in periodicals (like it is the case form 7 articles of the BM discipline, which have been published in Harvard Business Review, McKinsey Quarterly, or Sloan Management Review) or books (59 articles). Within the IS discipline the journals Wirtschaftsinformatik respectively Business & Information Systems Engineering mostly publish PSS articles (in total 8 papers). IS conferences also have published PSS articles in their proceedings: Wirtschaftsinformatik (9), Multikonferenz Wirtschaftsinformatik (4), Americas Conference on Information Systems (3), European Conference on Information Systems (2), Australasian Conference on Information Systems (1), Hawaii International Conference on System Sciences (1), and Pacific Asia Conference on Information Systems (1). Within the BM field there are no conference proceedings with PSS articles. However, there are much more journals: Industrial Marketing Management (6), International Journal of Operations & Production Management (4), European Management Journal (3), and Journal of Marketing (3). There are 27 further journals which published 1 or 2 articles. The Journal of Cleaner Production is the journal with the highest absolute number of articles (15 articles in total). However, also other journals like Journal of Manufacturing Technology Management (11), The International Journal of Advanced Manufacturing Technology (10), or Journal of Engineering Design (5) have published are relatively high number of papers. Furthermore, there are 26 other journals which published 2 or 1 articles. Within the ED conferences, like for example International Design Conference (6), LeNS Conference (5), or CIRP International Conference on Industrial Product Service Systems (4), in total 39 articles have been published in their proceedings. From our data we now know that there is not a single medium which publishes articles from researchers of all three disciplines. Moreover, often hardly any interchange between them can be recognized.

Of course, most publications (83%) are written in English language. However, as we wanted to explicitly include the German-speaking IS community, 45 articles (17%) are written in German language. Within the IS articles the relation is 43.1% English articles vs. 56.1% German. In the other disciplines the proportion of German articles is much lower (19.5% in BM and 4.8% in ED). Fig. 4 visualizes the country of the respective first author. It can be seen that a strong fraction comes from Europe (78.9%). Authors from Germany, United Kingdom, Sweden, Netherlands, and Denmark strongly contributed to the PSS field. There are 26 contributions (9.8%) respectively from the U.S. and Asia.

German authors have the strongest share within the IS discipline (95%). Authors from the U.S. are especially active in BM (31%). Within ED, authors from Germany (22%), United Kingdom (18%), and Sweden (18%) contributed nearly to an equal extend.

By analyzing the articles more deeply it can be noted that research designs are across all disciplines in most cases not empirical (cf. Fig. 5). The classification of research designs is based on (Palvia et al., 2004). Multiple classifications are possible in case of mixed research designs. Conceptual research is predominant: 66% of all papers use this design. Within the ED discipline, even 70% of the articles are conceptual. Qualitative empirical designs are

Table 2
Author charts.

Rank	Author	Discipline	Publications	Rank	Author	Discipline	Publications
1	Sakao, Tomohiko	ED	11	11	Mont, Oksana	ED	6
	Thomas, Oliver	IS	11		Müller, Patrick	ED	6
3	Sundin, Erik	ED	10		Ölundh, Gunilla	ED	6
4	Knackstedt, Ralf	IS	9		Shimomura, Yoshiki	ED	6
	Krcmar, Helmut	IS	9		Tukker, Arnold	ED	6
	Lindahl, Mattias	ED	9		Walter, Philipp	IS	6
7	Becker, Jörg	IS	8	17	Berkovich, Marina	IS	5
	Beverungen, Daniel	IS	8		McAloone, Timothy Charles	ED	5
	Roy, Rajkumar	ED	8		Meier, Horst	ED	5
10	Leimeister, Jan Marco	IS	7		Shehab, Essam	ED	5
					Vezzoli, Carlo	ED	5

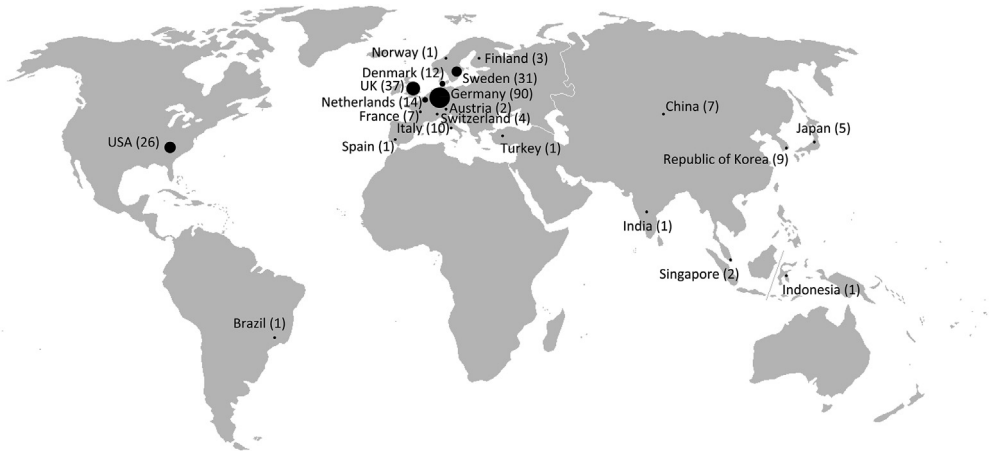

Fig. 4. World map.

used only in 19% of the cases. Quantitative designs (5%), Design Science (4%) and other methods (2%) are used rarely. A similar picture can be found in BM discipline. Here, conceptual designs are utilized in 65% of the articles, followed by qualitative empirical designs (19%) and quantitative empirical designs (9%). Design Science (3%) and other designs (4%) again do not play a key role. A different picture can be found within the IS discipline. Here, conceptual designs are still prevailing but can only be found in 54% of the cases. Design Science research is second mostly used (32%). Qualitative empirical designs (10%) and quantitative empirical designs (2%) are less often employed as well as other designs (2%). The dominance of conceptual designs itself in all disciplines is not surprising, but the extent of proportion is.

In order to better understand the used research designs, also the employed research methodologies are investigated. Here, the classification schemes by Palvia et al. (2004) and Gräning et al. (2011) have been adopted. In general, the three methods of creating models, architectures, frameworks (115 articles, 43.3%), library research (86, 32.5%), and speculation/commentary (62, 23.4%) are most often used. By comparing the three disciplines one recognizes that creating models, architectures, frameworks is only prevalent in IS (41% of the articles in this discipline) and ED (27%). In BM most articles employ a speculation/commentary method (26%). Library research is also used in all disciplines quite often. For example in ED, it is the second most often utilized method (23%). In contrast, the more sophisticated method of literature analysis or theory-based research, which covers a critical analysis of existing literature and building new groundwork, is in total only used in 14 articles (5.3% of all articles). In general, methods like laboratory experiments, qualitative research, or content analysis are only used in respectively one paper in the ED discipline. Field experiments are even conducted in none of the investigated articles. Additionally, surveys and prototyping are two further methods which are rarely utilized. Within the IS discipline, of course creating models, architectures, frameworks and library research are most often employed. However, in this discipline prototyping is the method which is used the third most times (10% of the articles in this discipline). Within ED, prototyping is employed by a higher absolute number of articles (8 in comparison to 7 in IS), but the relative proportion is smaller (4%). Here, creating models, architectures, frameworks (27%), library research (23%), and speculation/commentary (12%) are used most often. Within BM, the order is only slightly different: speculation/commentary (26%) is followed by creating models, architectures, frameworks (20%) and library research (17%). In conclusion one can say that past research has strongly focused on a limited set of research methods.

As described before, the 265 contributions have been assigned to the three disciplines. Each discipline has its specific characteristics and preferences. In order to compare the research of the three disciplines the perspectives taken in by each article have been analyzed. For doing so, Velamuri et al. have already elaborated a set of views on PSS research (Velamuri et al., 2011). We added the meta-level view as a perspective for example other literature reviews to their list:

- Strategic view (competitive advantage, concepts & barriers), organizational view (organizational design, networks, organizational capabilities, system integration),
- Marketing view (pricing, customer satisfaction), design view (strategic perspective, design process, design attributes),
- Innovation view (innovation management, transition),
- Business level view (business models, viability in specific industries, engineering & information technology),
- Sustainability view (human behavior & consumption, evaluation of sustainability),
- Macroeconomic perspective (prevalence & effect, policy making), and
- Meta-level view.

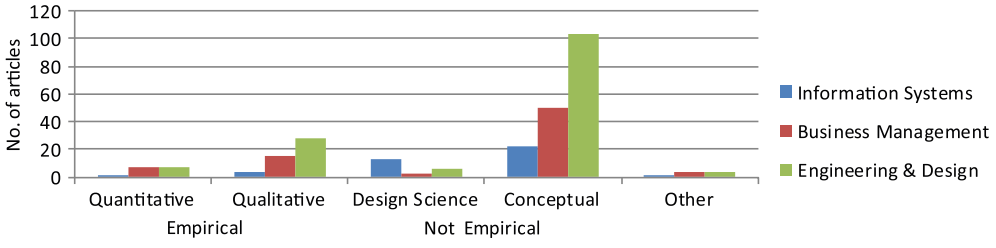

Fig. 5. Frequency of research designs.

By looking at the results (cf. Fig. 6) one recognizes that the strategic and business level view are most often taken in. IS research usually focusses on the business level view (54% of the articles in this discipline), followed by the organizational view (15%) and strategic view (7%). Sustainability view is least often taken in (3%). Within BM, the strategic view has the biggest proportion (60%). The remaining perspectives like design view (9%) or organizational view (6%) only have relatively low shares. Innovation view and meta-level view are not taken in very often (3%). Within ED, 3 views are nearly equally often represented: business level view (24%), design view (22%), and strategic view (20%). The macroeconomic perspective is here the one with the lowest proportion (3%). From this analysis one can see that BM focusses nearly solely on the strategic view, IS concentrates on the business level, and within ED a broad mixture of several views is taken in. The remaining views have been underrepresented in past research so far.

3.2. Toward a unified definition of PSS

After getting an overview on the field of PSS, now a unified definition of the term PSS is derived. Giving crisp definitions (Zarvić et al., 2012) is crucial for every discipline and the starting point for future research. For the PSS field this is insofar difficult as there is no unified and widely accepted definition. Moreover, there is a variety of different terminology and concepts which mean more or less the same (Thomas et al., 2008a). While the term Product-Service System is used by most authors (Goedkoop et al., 1999; Mont, 2000; Manzini et al., 2001; Manzini and Vezzoli, 2002; Mont, 2004; Weber et al., 2004b; Wong, 2004; Besch, 2005; Steinbach, 2005; Maxwell et al., 2006; Morelli, 2006; Tukker et al., 2006; Baines et al., 2007; Botta, 2007; Evans et al., 2007; Doultsinou et al., 2009; Maussang et al., 2009; Müller et al., 2009; Botsman and Rogers, 2010; Kuo et al., 2010; Müller and Sakao, 2010; Berkovich et al., 2011a; Creusen, 2011; Sun et al., 2011), there are several other closely related expressions. Bundling (Schmalensee, 1982; Guiltinan, 1987; Venkatesh and Mahajan, 1993) and Bundle (Eppen et al., 1991) is mostly used in Marketing literature of BM, Compack (complex package) has been presented by Bressand (1986), or Integrated Product and Service Offering (IPSO) have been coined by North European engineering researchers (Lindahl et al., 2006a,b, 2007, 2008; Sundin, 2006). Furthermore, the engineers also often use the term Industrial Product-Service Systems (IPS^2) to highlight the manufacturing-based business to business (B2B) context (Meier and Kortmann, 2007; Rese et al., 2009; Meier et al., 2010; Müller et al., 2010; Müller and Stark, 2010; Meier et al., 2011; Sadek and Köster, 2011). Within the IS discipline terms like hybrid products (Bullinger, 1997; Kersten et al., 2006; Schenk et al., 2006; Spath and Demuß, 2006; Böhmann and Krcmar, 2007; Burianek et al., 2007; Böhmann et al., 2008; Leimeister and Glauner, 2008; Schaefermeyer and Rosenkranz, 2008; Schmitz, 2008; Berkovich et al., 2009; Langer et al., 2010), hybrid value bundles (Becker et al., 2009b; Langer et al., 2009; Becker et al., 2010b; Schuh et al., 2010; Schrödl and Turowski, 2011; Soth, 2011), and hybrid value creation (Thomas et al., 2007; Zellner, 2008; Becker et al., 2009a; Knackstedt et al., 2009; Walter et al., 2009; Fellmann et al., 2011) are utilized. This list could be extended by much more terms and references.

In order to derive a unified definition of PSS we use the definition graph method. By analyzing the 265 articles, we identified 8 definitions from the IS discipline, 23 definitions from BM, and 43 definitions from ED. This is the foundation for the creation of the definition graphs. In order to do so, first the membership values for each concept (noun, verb, or preposition in the 74 definitions) are calculated (cf. Table 3). Because no concept occurred in all definitions, μ cannot become 1. As one might have expected, the concepts service and product can be found in most definitions. However, there are differences between the disciplines. In IS, only the service concept is named in nearly all definitions. The product concept can only be found in 6 definitions. Concepts like value bundle, problem solving, or hybridity are also found quite often. Within BM, service and product concept are given in nearly all definitions. However, the concepts of bundle und customer occur quite often, too. Here, the different focus of the discipline in comparison to IS becomes obvious. Within ED, the concepts of product, service, and system are named relatively often, although there is not one concept that occurs in nearly all definitions. The variation among the definitions is the highest in this discipline. Similar to BM, also in ED concepts like function fulfillment and user are named quite often.

Having determined the relevant concepts in the definitions of the 3 disciplines as well as having noted the frequency of occurrences by means of membership values, definition graphs can be created to extract all-embracing meanings or "core" definitions. In order to do so, one takes each concept from Table 3 as a node and pairs between concepts as edges. Multiple edges are drawn if a pair of concepts occurs more than once. In the final definition graph (cf. Fig. 7) only those concepts are linked that are used together in definitions. For example in Fig. 7c, "eco-efficiency" is linked to "service" and not to "product" because in our analysis we found out that the term is only used with reference to services and not to products. Only multiple edges make up core definitions of a term (Zarvić et al., 2012). The core definitions are highlighted in the respective definition graphs in Fig. 7.

Fig. 7a shows the definition graph for PSS in the IS discipline. According to this graph, a PSS in the IS discipline is a hybrid product and service, combined to a value bundle. This bundle is an integration of the components and can be seen as a transaction or an offer. It solves a problem and offers therefore as a solution customer utility.

Next, Fig. 7b represents the PSS definition graph of the BM discipline. This graph shows, as the other two ones too, a common basis structure. Products and services are combined to a bundle or system. Within the BM discipline, the focus is set to the problem solving ability and added value. By doing so, the needs of customers should be satisfied. Additionally, PSS is seen here as a paradigm and organizational frame and strategy.

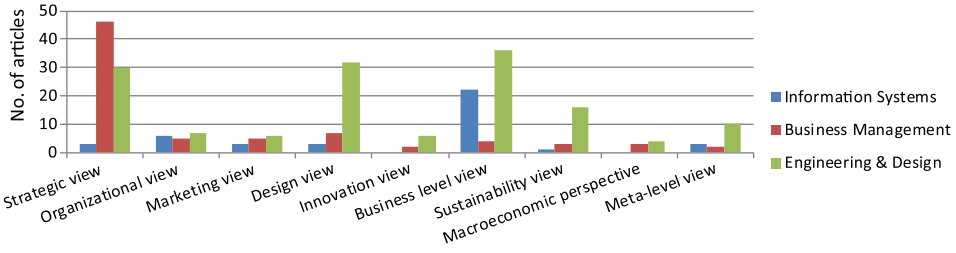

Fig. 6. Frequency of perspectives.

Table 3
Membership values.

μ	Information Systems	Business Management	Engineering & Design
0.81–0.9	Service	Service Product	–
0.61–0.8	–	Bundle/system Customer/client	Product Service System
0.41–0.6	Product	Problem solving/solution/added value	Function fulfillment/utility User/client/customer
0.21–0.4	Value bundle Problem solving/solution Hybridity Integration Customer utility/value Transaction/offer Software	Needs integration Customization	Needs integrated view
≤0.2	Price Marketability Design-based Business strategy Single-component-based hardware	Paradigm/organizational frame/strategy Satisfaction Hybridity Producer ownership …	Lower environmental impact (Value) network (User-centric) life-cycle …

Finally, in Fig. 7c the definition graph for PSS in the ED discipline is shown. As mentioned before, this discipline is the one with the highest variants in the definition. Nevertheless, again the core structure of products, service and system can be detected here. The emphasis is also on the function fulfillment and utility as well as the fulfillment of user needs. Also the lowered environmental impact and sustainability are highlighted. Furthermore, aspects like (user-centric) life cycle management, value propositions, supporting (value) networks, and the (technological) infrastructure as well as the business model character as an innovation strategy are named. The aspects of marketability and integrated view on products and services in terms of planning, development, delivery, and usage are characteristic for PSS.

From the analysis of the literature one can conclude that in each discipline there are very different definitions of the PSS concept. However, there are also a high number of definitions which mean more or less the same. This is acceptable as long as one wants to get a first insight into the PSS concept. With the help of the definition graphs a crisp definition for each discipline can be derived (Hoede and Wang, 2006). The question is now, what the core definition of PSS across all disciplines could be. This can be answered by comparing the three graphs. Accordingly, the core definition of a PSS can be formulated as follows: A Product-Service System (PSS) is an integrated bundle of products and services which aims at creating customer utility and generating value.

The aim of the derived core definition is to show the lowest common denominator of the definitions that the three disciplines provide about PSS. This definition can be therefore used as a starting point for the derivation of more specific delineations. Table 4 shows a comparison of main and often used definitions of each discipline. This helps to understand main the differences and similarities. One recognizes the universal character of the core definition because at least some parts of it can be found in every other definition. Of course, each author of the different disciplines derived their own more detailed understanding for their respective purposes.

3.3. Notion of PSS

Having derived a unified core definition of PSS the notion of PSS needs to be clarified more deeply. For doing so the main topic areas and findings of each article are analyzed.

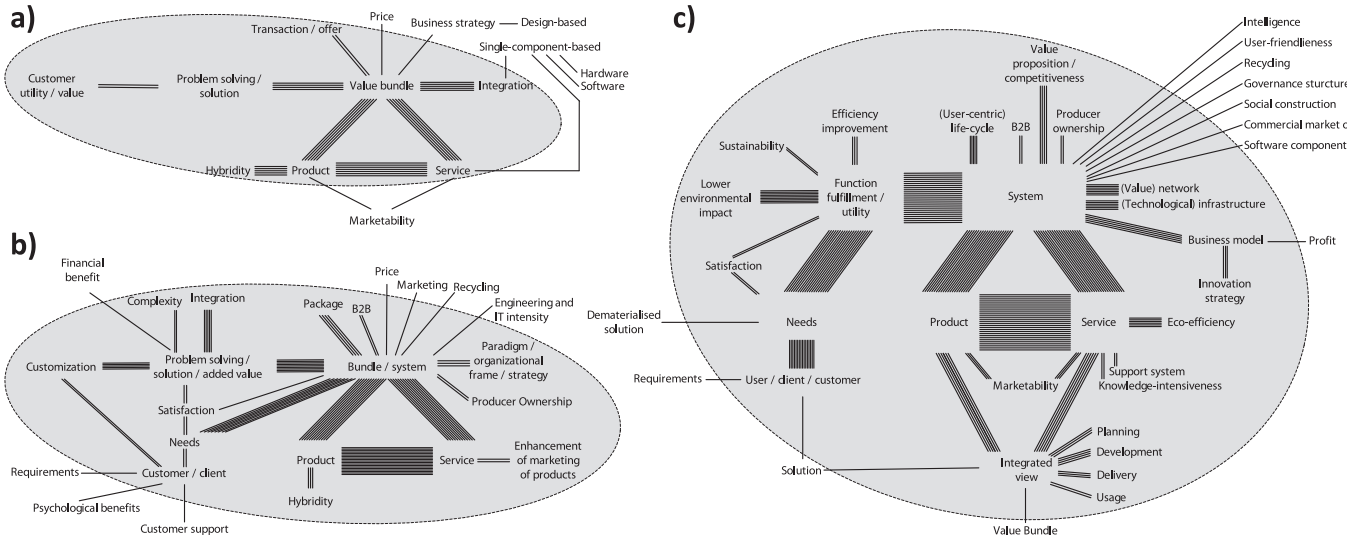

Fig. 7. Definition graphs for PSS in IS discipline (a), BM discipline (b), and ED discipline (c).

Table 4
Comparison of PSS definitions.

	Definition: PSS (and related concepts) are defined as…	Reference
	an integrated bundle of products and services which aims at creating customer utility and generating value.	*This article*
ED	"a marketable set of products and services capable of jointly fulfilling a user's need."	(Goedkoop et al., 1999)
	"a business innovation strategy offering a marketable mix of products and services jointly capable of fulfilling a client's needs and/or wants – with higher added value and a smaller environmental impact as compared to an existing system or product."	(Manzini et al., 2001)
	"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."	(Mont, 2002a)
	"a concept that integrates products and services in one scope for planning, development and delivery, thus for the whole life-cycle."	(Müller et al., 2009)
	"a functional solution that fulfills a defined customer need. The focus is, with reference to the customer value, to optimize the functional solution from a life-cycle perspective."	(Sakao et al., 2008)
	"products that comprise combinations of 'hard' and 'soft' elements. Typically, they are described as comprising hardware combined with a service support system."	(Alonso-Rasgado et al., 2004)
BM	"the set of all potential additional services a supplier can supplement his product offering with, in order to differentiate his offering relative to the competitors' as perceived by (potential) customers and distributors."	(Frambach et al., 1997)
	"comprehensive bundles of products and/or services, that fully satisfy the needs and wants of a customer related to a specific event or problem."	(Stremersch et al., 2001)
	"integrated combinations of products and/or services that are unusually tailored to create outcomes desired by specific clients or types of clients."	(Miller et al., 2002)
	"a set of customer-supplier relational processes comprising (1) customer requirements definition, (2) customization and integration of goods and/or services and (3) their deployment, and (4) post-deployment customer support, all of which are aimed at meeting customers' business needs."	(Tuli et al., 2007)
IS	an ordered set of products and services, developed and manufactured as solution of a problem and can be a subset of a superior socio-technical system.	(Botta, 2007)
	the intelligent interlocking of physical products and services that are already in the design and development phase closely linked. Their individual components can be decoupled from each other only with difficulty.	(Leimeister and Glauner, 2008)
	"offerings that provide both tangible goods as well as services and intangible assets in an integrated manner."	(Schrödl and Turowski, 2011)

3.3.1. Notion within the IS discipline

Within the IS discipline, modeling of PSS (Becker et al., 2008; Becker et al., 2009b; Langer et al., 2009; Becker et al., 2012) and requirements engineering (Berkovich et al., 2009, 2011a, 2011b, 2011c) have been widely discussed. For each topic, 4 valuable contributions can be found. For example, Becker et al. discuss the integration of reference models for PSS modeling by combining Event-Driven Process Chain (EPC) and the Service Blueprinting approach (Becker et al., 2010a). In another paper by these authors, a new modeling language for PSS is proposed which integrates requirements of different perspectives (Becker et al., 2009b). Furthermore, 4 novel PSS engineering methods are presented by Botta (2007), Böhmann et al. (2008), Thomas et al. (2008b), Gräßle et al. (2010). Topics like developing IT solutions using PSS methods (Herzfeldt et al., 2010) or discussing hybrid products (Leimeister and Glauner, 2008; Schmitz, 2008) can also be found.

A framework for hybrid value creation has been developed by 15 German researchers in the field who all work on PSS research projects (Becker et al., 2009a): Development, usage, and replacement are the core processes. These processes are supported by technology management, relationship management, and information management etc. Strategy and managerial accounting coordinate all activities.

Leimeister and Glauner provide a foundational paper which discusses the concept of hybrid products. They claim that the concept has not found its wide acceptance yet. Furthermore, it is said that more research needs to be done because in practice products and services are still developed separately and often services are added to the former value creation process as an add-on (Leimeister and Glauner, 2008).

The IS discipline often emphasizes that IT is a prerequisite for many PSS (Schuh et al., 2010) and, hence, many examples are provided: A PSS for the support of the customer service (Thomas et al., 2007; Fellmann et al., 2011) has been described as well as a PSS for sustainable IT infrastructures (Boehm et al., 2011a), a software infrastructure architecture based on semantic web services (Lee et al., 2007), or a PSS for home care applications (Breitschwerdt et al., 2011). One of the rare surveys in this discipline is the questionnaire by Sturm and Bading which covered the potential of PSS for small and medium-sized enterprises (Sturm and Bading, 2008). Unfortunately, it is limited to the investment good industry and does not follow a clear understanding of the PSS term.

3.3.2. Notion within the BM discipline

Within the BM discipline, mostly services understood as combination of products and services (Mattsson, 1973; Shostack, 1982; Quinn et al., 1990; Shostack and Kingman-Brundage, 1991; Samli et al., 1992; Fitzsimmons and Fitzsimmons, 1994; Kellogg and Nie, 1995; Zahn and Stanik, 2006) are discussed. Also the solutions concept is considered (Shepherd and Ahmed, 2000; Mathieu, 2001; Galbraith, 2002; Foote et al., 2003; Johansson et al., 2003; Davies et al., 2006; Sawhney, 2006; Tuli et al., 2007). Furthermore, 5 articles cover the transformation of business to service orientation (Vandermerwe and Rada, 1988; White et al., 1999; Oliva and Kallenberg, 2003; Davies, 2004; Windahl et al., 2004). Topics like bundling (Schmalensee, 1982; Guiltinan, 1987; Eppen et al., 1991; Venkatesh and Mahajan, 1993) and the integration of products and services (Bressand, 1986; Léo and Philippe, 2001; Spath and Demuß, 2006; Fang et al., 2008) can also be found.

Interestingly, three articles cover the field of PSS Engineering (Schenk et al., 2006; Thomas et al., 2008a; Kim and Yoon, 2012), which used to be a main research field of the ED discipline. The marketing view on the transition from products to services is prevalent in BM discipline (Quinn et al., 1990; Vargo and Lusch, 2004). Process models for the transition from product manufacturer to service provider are discussed (Oliva and Kallenberg, 2003) as well as refinements of the service engineering concept (Shostack and Kingman-Brundage, 1991) or requirements of

organizing the business process to develop hybrid products in a company (Schenk et al., 2006).

Furthermore, significant management challenges in the process of a manufacturer becoming a service-focused business are presented (Brax, 2005). There are marketing, production, delivery, product-design, communication, and relationship challenges. Additionally, business models are also widely discussed in BM literature (Lay et al., 2009; Botsman and Rogers, 2010). In BM, basically manufacturing and aerospace industry as well as capital and industrial goods sector are taken as industries of application. While Wise and Baumgartner focus on business models for the so called downstream market (Wise and Baumgartner, 1999), Tukker presents 3 main types of PSS business models (Tukker, 2004):

- Product-oriented PSS. The product is sold in traditional manner and the service is added, e.g. in form of after-sales services.
- Use-oriented PSS. The provider does not sell the product but the use or availability of it and therefore he keeps the ownership. Products are leased, rented or shared.
- Result-oriented PSS. The result or capability is sold instead of a product. This is the most sophisticated business model because not a washing machine is sold but laundered clothes, for example.

3.3.3. Notion within the ED discipline

The ED discipline clearly focuses on the discussion of the concept of PSS (Goedkoop et al., 1999; Manzini et al., 2001; Manzini and Vezzoli, 2002; Mont, 2002a; McAloone and Andreasen, 2004; Weber et al., 2004a; Matzen et al., 2005; Kanda and Nakagami, 2006; Tukker et al., 2006; Park and Lee, 2009; Catulli, 2010) and PSS engineering methods (Morelli, 2003; Weber et al., 2004b; Steinbach, 2005; Steinbach et al., 2005; Aurich et al., 2006; Maxwell et al., 2006; Rexfelt and Hiort af Ornäs, 2009; Yang et al., 2009; Geng et al., 2011; Bandinelli and Gamberi, 2012).

Questions on what a PSS is actually, why a PSS is beneficial (benefits for companies, government, society, consumers, and environment) as well as drivers for PSS, what the elements of PSS are, which characteristics PSS have, and what the barriers are answered comprehensively (Goedkoop et al., 1999; Mont, 2002a, 2004). PSS business models are also described (Meier et al., 2005, 2011). Furthermore, PSS design (Krucken and Meroni, 2006; Maussang et al., 2007, 2009; Cho et al., 2010; Davis et al., 2010; Kim et al., 2010; Kim and Won Lee, 2011; Sakao, 2011; Kim et al., 2012) and PSS Engineering (Lindahl et al., 2006b; Matzen and McAloone, 2006; Sundin et al., 2006; Tan et al., 2006; Lindahl et al., 2008; Müller and Schmidt-Kretschmer, 2008) are widely examined and highlighted as extremely important.

A method for effectively and efficiently designing PSS in manufacturing is investigated in practice, for example (Sakao et al., 2009a). Sustainability and product innovation (Stahel, 1997; Roy and Potter, 2002; Hammerl et al., 2003; Maxwell and van der Vorst, 2003; Thompson et al., 2011) is also a major issue in this discipline. Even different models of sustainable PSS are discussed (Roy, 2000), although it is acknowledged that an environmental–economical win–win is somewhat simplistic (Tukker, 2003).

Manufacturing industry is taken as the sample industry for application in more than 30 articles of this discipline. Further applications for PSS are described for the health sector (B2B and B2C) (Mittermeyer et al., 2011), car Sharing services (Meijkamp, 1998, 2000), a telecenter (Morelli, 2003), automotive industry (Williams, 2006, 2007), office copy machines (Kuo, 2011), oil and gas industries (Bandinelli and Gamberi, 2012), and even teaching (McAloone, 2006). For example, the case of office copy machines includes additional services like maintenance, recycling, reverse logistics, and final waste disposal (Kuo, 2011).

Noticeable is the fact that research in ED is in some cases closely related to the IS discipline. For example, an architecture for a software tool for realizing product-oriented PSS and use-oriented PSS is presented (Yang et al., 2009), a web-based bandwidth management system that can be used to manage bandwidth on the network to support the rural quality of digital learning services is conceptualized (Ariwibowo and Bandung, 2011), or four possible relationships between product and service design and the use of ICT in a PSS are shown (Hernández Pardo et al., 2012). Belvedere et al. claim that investing in ICTs to servitize the product offering can be a valuable opportunity (Belvedere et al., 2013). Finally, some researches in this field self-critically reflect that they need to be more rigorously: focusing solely on case studies and models is not sufficient and, for example the linkage between PSS and sustainability has to be uncovered and proven (Tukker and Tischner, 2006c). Sakao et al. propose that more research in the topics of PSS-offer modeling, PSS development, and PSS potential is necessary (Sakao et al., 2009b).

3.3.4. Summary

In order to summarize those research streams, each of the 265 contributions has been tagged with three to four keywords. One author conducted the tagging and the other cross-checked it. Conflicts have been discussed and solved.

The final keyword concept matrix according to Webster and Watson (2002) is depicted in Table 5. In this table, black cells indicate the concept which occurs most often in the respective discipline. Dark gray represents the second most often concept and light gray the third most often concept. Altogether, 19 concepts have been identified by analyzing the keywords for each article. This procedure has been done by the authors independently and results have been afterward discussed and integrated.

The concept “PSS engineering approach” includes all articles dealing with methods to develop PSS. Similarly, the concepts of “PSS concept”, “PSS design”, “PSS management”, “PSS perspective on IS” and “PSS development process” can be explained. “Related concepts” covers all papers which deal with closely associated concepts on PSS, like for example compack paradigm, bundling, or functional sales. Contributions focusing on green developments have been subsumed to the concept “Sustainability”. The concept “Meta level analysis” covers review articles that discuss the PSS topic on a meta level. Those papers dealing the modeling of PSS are associated to the concept of “Modeling”. The concepts of “Business models”, “Requirements engineering”, “Life-cycle approaches”, and “Solutions” can each be found in a high number of articles and therefore have been recorded as independent concepts. There are also papers which focus on one aspect of PSS: “Service concept”, “Service design”, “Products vs. services”, and “Product services”. Finally, there are also articles explicitly dealing with consumers. Therefore, the concept of “Consumer research” has been noted.

One first recognizes that PSS engineering approaches is the concept that is most widely discussed. However, if one looks at each discipline separately certain differences can be observed. Within ED, the engineering approaches are indeed most often discussed. However, sustainability followed by the PSS concept in general are considered also quite often. The picture is completely different in analyzing BM. Here, related concepts like bundling or servicisation are mostly discussed. Additionally, a strong focus is on the service concept and on solutions. Within IS, modeling, PSS engineering approaches, requirements engineering, and PSS design are mostly considered concepts. From this examination one can conclude that in each discipline, certain concepts are in the center of concern. However, in nearly all of them, engineering approaches and design aspects play major roles.

Table 5
Concept matrix.

Discipline	Concept																		
	PSS engineering approach	Related concepts	Sustainability	PSS concept	PSS design	Meta level analysis	Modeling	Service concept	Products vs. services	Consumer research	Requirements engineering	Service design	Solutions	PSS management	PSS perspective on IS	Business models	Product services	PSS development process	Life-cycle approaches
IS	5	2	3	1	4	3	8			1	5		1	2	4			1	1
BM	6	20	2	2		2	1	12	5	2		3	7	3		3	4	1	1
ED	33	14	18	16	13	11	3		4	5	3	5		2	3	3	2	4	3
SUM	**44**	**36**	**23**	**19**	**17**	**16**	**12**	**12**	**9**	**8**	**8**	**8**	**8**	**7**	**7**	**6**	**6**	**6**	**5**

3.4. Meta-analysis of previous literature reviews

In analyzing the 265 articles of course also previous literature reviews have been investigated. In total 12 reviews on the state-of-the-art of PSS concept or PSS engineering have been identified. To show the differences between those reviews and this one we want to compare the applied methodology and gained results. Table 6 gives an overview on this.

Although there are the most reviews within the ED discipline, these are also the least systematic ones. In 4 out of 6 reviews, a description of the used methodology is missing. However, also one review from IS respectively ED lacks a comprehensive description of the way of conducting the review. Furthermore, one could criticize that assignment of labels to articles is sometimes not reproducible (cf. for example Park and Lee, 2009; Velamuri et al., 2011; Cavalieri and Pezzotta, 2012) or multi-disciplinary review are said to be conducted but IS research is often neglected in these cases (cf. for example Pawar et al., 2009; Müller and Sakao, 2010). In comparing the previous reviews with this review one first recognizes that it has the longest time frame and, hence, the highest number of considered articles. The applied method is comparable to other contributions. Finally, one can say that although there are several other literature reviews on PSS, the analysis which has been conducted here has never been done before in this breadth and deepness.

4. Research agenda

After presenting the results of the comprehensive literature review, in the following it is demonstrated how these results extend past research and give new directions for future research. Ways are shown how theory can be empirically examined and how implications for practice and future theorizing can be drawn.

The research agenda is based on the presented findings and additional notes recorded while analyzing the articles. The authors independently analyzed this data and searched for gaps and possible future research opportunities. Afterward, the results have been discussed and condensed into one list. Then, argumentation for each issue has been developed and references in literature have been searched in order to ensure even a better motivation for the issues.

The research agenda covers 11 issues which are relevant for the future based on our data:

- Integrating other disciplines' results. The major issue for future contributions in the PSS field is to look across borders and integrate results from other disciplines. In the literature review we found out that for example engineering approaches which have been developed within the IS field are often not considered at all in publications of ED. Since IS and ED are closely related – as we identified in our examination – the respective results need to be integrated in each other's work. A recommendation from us is here to avoid citation syndicates: In many articles we found that some authors always cite in their articles the same set of contributions. Here, a citation analysis might help in future to uncover this issue more rigorously.
- Clarifying the terminology. We recognized that often the results of different contributions are not comparable because of the usage of different terms. In future, a common foundation

Table 6
Comparison of previous literature reviews to this contribution.

	Source	Method	Time frame	Articles
IS (3 + 1)	Berkovich et al. (2009)	–	–	–
	Berkovich et al. (2011b)	Database search (only Google Scholar)	–	15
	Bensch and Schrödl (2011)	Selection of highly ranked IS journals and conferences	1998–2010	11
	This article	*Database search and Internet search; systematic review*	*1973–2012*	265
BM (3)	Pawar et al. (2009)	Key papers analysis and further extension with relevant articles	–	–
	Velamuri et al. (2011)	Database search; systematic review	1995–2010	169
	Cavalieri and Pezzotta (2012)	–	2001–2011	79
ED (6)	Baines et al. (2007)	Database search; systematic review	1995–2006	40
	Baines et al. (2009)	Database search; systematic review	1988–2008	58
	Sakao et al. (2009b)	–	–	100
	Park and Lee (2009)	–	–	–
	Meier et al. (2010)	–	–	–
	Müller and Sakao (2010)	–	–	50

has to be achieved in which all the different concepts are clearly distinguished. Otherwise, the transferability of research is impeded. Additionally, closely related concepts to PSS, like for example hybrid products or Post Mass Production Paradigm could be either integrated into the PSS conception or have to be more clearly separated. A first step into this direction has been achieved by the derivation of the core definition for PSS. More work is necessary here for a further clarification.

- Changing perspectives. A broader set of views should be taken in Velamuri et al., (2011): Innovation view, organizational view, or sustainability view have been mostly neglected so far. Authors should look beyond the rim of their teacups. This could enhance research in PSS by getting a more comprehensive and holistic picture of the concept.
- Explicating the methodology. Even today there are a number of articles which do not clearly postulate their applied methodology (cf. for example Manzini and Vezzoli, 2002; Alonso-Rasgado et al., 2004; Gebauer et al., 2005; Sundin and Bras, 2005; Tan et al., 2006; Sakao and Shimomura, 2007; Berkovich et al., 2009; Rese et al., 2009; Sakao et al., 2009b; Catulli, 2010; Ceschin, 2010; Cortesi et al., 2010; Davis et al., 2010; Schuh et al., 2010). Especially while creating new PSS approaches for example this is problematic because the procedure is not traceable and, hence, not applicable in practice (cf. for example Cho et al., 2010; Kim et al., 2012).
- Concretizing results. So far, several high-level articles have been published (cf. for example Luiten et al., 2001; Abdalla, 2006; Meier and Kortmann, 2007; Park and Lee, 2009). Others offer for example only a vague understanding of the PSS concept or PSS engineering approaches. In general, more in depth analysis are required.
- Conducting an evaluation. We recognized that in many cases developed PSS engineering approaches are applied solely in one case. This hampers the validity of the proposed procedure considerably. Of course, a comprehensive evaluation is time-consuming and costly. But it is necessary for achieving more practically relevant results.
- Extending international collaboration. Often studies within the PSS field are conducted explicitly for one industry in one country. Although there are projects and studies like the EU projects SusProNet (Tukker and Tischner, 2006b) and MEPSS (van Halen et al., 2005), which involved companies from more countries and adopted a multidisciplinary approach, in general the collaboration between international researchers on papers is limited. There are only a very few contributions which compare two or more cases of different countries (cf. for example Lindahl et al., 2009; Bayraktaroglu and Bayazit, 2010). However, this is necessary in order to avoid the creation of results which are applicable only in culture. Furthermore, this helps overcoming barriers such as language problems or cultural uncertainties.
- Overcoming research-practice gap. Current research in the PSS field is in most cases conducted without the participation of practitioners. More collaboration between researchers and practitioners is necessary in order to ensure more practical relevance (Gill and Bhattacherjee, 2009).
- Changing research design. We identified a lack of quantitative empirical research designs. So far, a strong focus has been on conceptual designs. This is true for all disciplines. Of course, the adoption of a research method depends very much on the research questions. In some cases qualitative methods are more appropriate than quantitative ones. Nevertheless, it seems that researches have been concentrating on non-empirical methods because they are easier to conduct in the field of PSS. Research questions have to be adapted in order to conduct a more balanced mix of quantitative and qualitative research. In future, more empirical and especially quantitative work needs to be done in order to validate the achieved results or test theories or models.
- Enhancing set of research methods. Similar to a lack of empirical research designs, also an unbalanced usage of research methods can be identified. While concentrating on models, architectures, frameworks or speculation/commentary methods like field studies or experiments nearly have been completely neglected. Though, these methods could be extremely helpful in future to better understand the PSS concept.
- Discovering of future PSS. Research on PSS has to move forward. In future, technology will offer new opportunities for companies to offer new products and services (Sztipanovits, 2012). One direction is the advent of cyber-physical systems (CPS). CPS are understood as the integration of embedded systems with global networks such as the Internet (Broy et al., 2012). Complex interactions and dynamics of how cyber and physical subsystem interact with each other are one possible future direction of research (Sha et al., 2009). Additionally, within fields like mobility further research is necessary. One keyword is here eMobility (Stamp et al., 2012). As everything becomes a PSS there are also other fields for future research.

The above mentioned issues should be applied by researchers of all three disciplines. However, each discipline should focus on their individual strengths and collaborate with others.

Every research has its limitations. Although we tried to capture as much articles as possible, not all contributions to the PSS field could be identified and analyzed. For a detailed overview on the engineering discipline we refer to Meier et al. (2010) and for a business view see Velamuri et al. (2011). By comparing these reviews with this article, it can be stated that a good proportion of contributions in each field have been covered. Furthermore, publications in other languages than German speaking articles should be included in future. In order to do so, international collaborations between researchers are necessary.

Several implications for theory and practice can be derived from this analysis. The results help researchers, and especially but not exclusively novice researchers, to understand the concept of PSS. The suggested upcoming research directions with the presented research agenda is a solid foundation for future research. Additionally, the overview on previous literature reviews and comparison with this contribution is useful especially for other researchers who want to get a quick overview on relevant articles of the PSS field.

Also practitioners can profit from our results. The derived definition and elaborated notion of PSS is a useful basis for practitioners in order to develop PSS. Core definition, overview of the research field, and meta-analysis are also a good starting point in discussing the PSS area in practice.

5. Conclusion

Technological advancements, globalization, and a changed user demand lead to a new paradigm which is often called PSS. Research in this field has been conducted for more than 50 years but is still one of the highly relevant topics. This contribution aimed at investigating this long history and giving recommendations for future research by conducting a rigorous literature review. Because PSS is a multi-disciplinary topic we separately analyzed the three disciplines IS, BM, and ED. A comprehensive literature search has been conducted and resulted in a list of 265 relevant articles.

The presentation of the most productive authors, often used journals and conference proceedings is especially valuable for novice researchers who want to start in this field. Our derivation of

a core definition of PSS is one of the main contributions of our research. Furthermore, the notion of PSS in the three disciplines has been described and analyzed. By comparing these notions one recognizes tremendous differences which have to be consolidated in future. Of course, each discipline should stay independent, but a viable exchange could be beneficial for all participants. After putting this research in context and comparing it to previous reviews a research agenda has been developed and presented. This list is a solid basis for future research.

In conclusion, one can say that our research offers new insights on the PSS concept and especially on the role of the three disciplines. By following a systematic procedure the logic and thoroughness of the review can be ensured. In future, the authors themselves will cover some issues which have been raised in our research agenda.

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