J. Eng. Technol. Manage. 43 (2017) 83–97

Contents lists available at ScienceDirect

Journal of Engineering and Technology Management

journal homepage: www.elsevier.com/locate/jengtecman

# The intellectual basis of servitization: A bibliometric analysis

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ARTICLE INFO

*Article history:*
Received 10 March 2016
Received in revised form 13 October 2016
Accepted 25 January 2017

*JEL classification:*
M11
D2

*Keywords:*
Servitization
Service innovation
Bibliometric analysis
Co-citation analysis

ABSTRACT

This research pretends to identify the studies and disciplines that have had the greatest impact on servitization among manufacturing firms, with a view to illustrating the intellectual structure of this discipline.

The methodology is based on bibliometric techniques of citations and co-citations that appear in documents, in journals included in the Web of Science. Network theory was used to identify the documents that constitute the core of the co-cited documents. A multivariate analysis has allowed establishing the underlying intellectual structure of servitization, comprising three factors: (a) service strategy in industrial firms, (b) service innovation, and (c) service dominant logic.



## 1. Introduction

Servitization can be defined as the process of increasing value by adding services to products; it is driven by customer demand, and is perceived by corporations as sharpening their competitive edge. Firms are increasingly offering "bundles" of customer-focussed combinations of goods, services, support, self-service, and knowledge" (Vandermerwe and Rada, 1988). It is a means of creating added value capabilities that are distinctive and sustainable versus competitors (Baines et al., 2009a). Authors such as Neely (2008) believe that the servitization process can be seen as the development of an organisation's innovation capabilities, in the sense that it not only provides products but product-service systems (Visnjic Kastalli et al., 2013). Servitization can provide a competitive advantage from a strategic perspective (Bustinza et al., 2015).

The manufacturing industry is undergoing a deep transformation, with services contributing to its income (more than 50% in some industries) and a large proportion of employees (65–75%) performing service functions (Doultsinou et al., 2009). Furthermore, the value of chain of asset manufacturers is becoming less attractive as the demand for products remains stagnant. In this scenario, firms are aware that value can be found in the provision of the services required to enhance the functionality and sustainability of the products that they manufacture (Wise and Baumgartner, 1999). Davies et al. (2007) say that services provide continuous income, plus high profit margins, and require less assets than manufacture. In sum, servitization has become an objective for many firms.

Firms can operate in a "product-service continuum" during the servitization process (Oliva and Kallenberg, 2003; Neu and Brown, 2005; Gebauer, 2008; Baines et al., 2009b). On one end is the traditional manufacturer, who only supplies

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http://dx.doi.org/10.1016/j.jengtecman.2017.01.005
0923-4748/

products, and services are added to these products; income and profits are largely generated through the products sold, and the contribution of services to the creation of value is quite low. On the other end are service providers, in which services represent the foundation of the value creation process, with tangible assets added to satisfy clients' needs; these assets represent but a small part of the total value (Gebauer and Friedli, 2005). Firms have to define their positions on said continuum, providing product-service combinations.

In this context, interest in servitization has grown in the literature. In other disciplines there have been bibliometric analyses (Casillas and Acedo, 2007; McKerlich et al., 2013; Pilkington and Meredith, 2009; Pinto et al., 2014; Pinillos, 2011; Ramos-Rodríguez and Ruíz-Navarro, 2004; Ronda-Pupo and Guerras-Martín, 2010; Sánchez-Riofrío et al., 2015), that help to review the literature with a view to tracing the study's origins, locating the more significant papers and the scientific community's more recent contributions. Studies based on bibliometric analysis are classified in two categories, according to the indicators used: (1) activity indicators and (2) relation indicators. The former provide information about the volume and impact of research activities, while the latter track the relationships and interactions between investigators and fields, hence describing the content of research activities and their evolution (Callon et al., 1993; Ramos Rodríguez and Ruiz Navarro, 2006).

In the study of servitization, there are only 8 papers with literature reviews. Five are largely qualitative (Pawar et al., 2009; Berkovich et al., 2011; Cavalieri and Pezzotta, 2012; Park et al., 2012; Beuren et al., 2013) and three are quantitative (Lightfoot et al., 2013; Boehm and Thomas, 2013; Park and Yoon, 2015). There is no general consensus on the theoretical and empirical development of the research. Furthermore, bibliometric techniques have not been used to include the greatest amount of available information in the literature review. Thus, there appears to be both a clear need and an opportune time to conduct this review of the literature on servitization.

The purpose of this study is to identify the papers that have had the greatest impact on research on servitization in the manufacturing industry in order to illustrate the intellectual structure of this discipline.

The methodology used is based on bibliometric techniques for the analysis of document citations and co-citations, applied in all the papers published from January 1980 to March 2015 in journals in the Science Citation Index Expanded (SCI-EXPANDED) database and the Social Sciences Citation Index (SSCI) of the Web of Science (WoS). Network theory is used to identify the documents that represent the core of the network of co-cited documents. Network theory is the study of graphs as representations of either symmetric relations or asymmetric relations between discrete objects. Network theory is one part of graph theory: a network is a set of items, which we will call vertices or nodes, and the connections between these vertices or nodes are called edges (Newmann, 2003). Systems that take the form of networks abound in the world. Examples include the Internet, the World Wide Web, social networks of acquaintances or other networks connecting individuals, organisational networks and networks of business relations between companies, and networks of citations between papers, as well as many other networks (Newmann, 2003). The ubiquity of networks, and networking at industry, firm, group, individual, or indeed any other level, indicates why the development of network theory is of paramount importance (Parkhe et al., 2006).

This study is the first time that bibliometric techniques have been applied to this discipline, identifying the most studied topics in servitization literature in the last thirty-five years. This supplements and enhances the results of other studies that have approached the topic from a qualitative perspective, obtaining the intellectual structure of the discipline and enabling is to define its theoretical foundations.

The paper is organised as follows: the next section outlines the bibliometric methods used to analyse both the bibliographic references and citing documents in servitization. The next section discusses the findings and how they are related to the current literature on servitization. Finally, the conclusions focus on the paper's more salient contributions.

## 2. Methodology

### *2.1. Unit of analysis*

The selected unit of analysis is all the documents about servitization published in the Science Citation Index Expanded (SCIE) database and Social Sciences Citation Index (SSCI) of the Web of Science (WoS), considered "certified knowledge" (Ramos-Rodríguez and Ruíz-Navarro, 2004).

As the first step, in order to recover the documents published on the WoS about servitization, other key words related to the term were identified; the search was performed in the main collection of the WoS for the entire period covered by the database. The following citation indices were selected from the main collection:

- Science Citation Index Expanded (SCIE)
- Social Sciences Citation Index (SSCI)
- Conference Proceeding Citation index (CPCI-S)
- Conference Proceedings Citation Index (CPI-SSH)

To ensure the broadest possible search, we recovered all the documents containing the word servitization in the title, key words or abstract. This led to a total of 114 documents distributed in the following areas: Management (49 documents), Business (28), Engineering Electrical Electronic (17) and Computer Science information System (17).

**Table 1**
Publications about servitization on the WoS from January 1992 to March 2015.

| Year of publication | Number of documents published annually on WoS about servitization | Year of publication | Number of documents published annually on WoS about servitization | Year of publication | Number of documents published Annually on WoS about servitization | Year of publication | Number of documents published annually on WoS about servitization |
|---|---|---|---|---|---|---|---|
| 1992 | 1 | 1998 | 2 | 2004 | 3 | 2010 | 24 |
| 1993 | 0 | 1999 | 3 | 2005 | 2 | 2011 | 77 |
| 1994 | 4 | 2000 | 2 | 2006 | 6 | 2012 | 48 |
| 1995 | 2 | 2001 | 3 | 2007 | 9 | 2013 | 45 |
| 1996 | 0 | 2002 | 7 | 2008 | 15 | 2014 | 47 |
| 1997 | 4 | 2003 | 2 | 2009 | 27 | 2015 | 10[a] |

[a] The articles published in 2015 correspond only to the months of January, February and March.

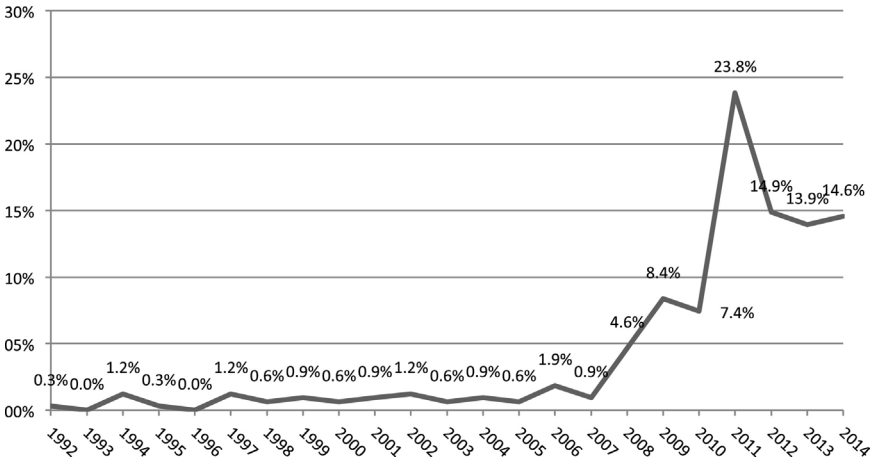


**Fig. 1.** Evolution of publications on WoS about servitization.

These 114 documents were subject to manual debugging and a subsequent count, using Bibexcel[1] (Persson et al., 2009) of the other key words associated to the term servitization, resulting in a total of twenty-one words that were used to configure the terms for the search of significant literature. The search terms were specifically as follows: Industrial Product-Service Systems (IPSS), Integrated Product-Service (IPS), Manufacturing Servitization, New Product-Service Development (NPSD), Product-Service, Product-Service System (PSS), PSS Design and Planning Strategies, PSS Development Process, PSS Strategies, Service business orientation, service integration, Service orientation, service-centred, Service-Dominant Logic, Service-Embedded Manufacturing, Service-Oriented, Servitization, Servitization of Manufacturing, Servitization Strategy, Servitize and Servitizing.

After determining the search terms, we then identified in the WoS (not including proceedings[2] which are not indexed) all the documents published up to March 2015 that contained at least one of the above twenty-one terms in the title, key words or abstract.

The search resulted in a total of 343 documents related to servitization published on the WoS from 1992 to March 2015 (see Table 1 and Fig. 1).

The 343 articles that form the cited sample were published in 118 different journals. The 36 journals with the highest impact, from the period analysed, are shown in Table 2. 73% of the 343 documents that form the citing sample were published in one of these 36 journals.

The *Journal of Cleaner Production* is the dominant source for those articles that form the cited sample, accounting for 26 of the 343 articles. This also demonstrates that research related to environmental engineering is closely connected to servitization.

[1] Bibexcel is a versatile bibliometric software, which was designed by Professor Olle Persson of the Institute of Information Sciences at the University of Umea (Sweden). Bibexcel is designed to assist a user in analysing bibliographic data, or any data of a textual nature which is formatted in a similar manner. The objective is to generate data files that can be imported to Excel, or any program that takes tabbed data records, for further processing. The program offers the user a high degree of flexibility in terms of both data management and analysis, and this flexibility is one of the program's real strengths. However, flexibility may initially cause new users to perceive it as difficult to use. Bibexcel is a free software that can be downloaded at https://bibliometrie.univie.ac.at/bibexcel/.

[2] As such publications are not considered to be "certified knowledge".

**Table 2**
Top journals with at least three publications.

| Journal | Number of articles | WoS category | | |
|---|---|---|---|---|
| *Journal of Cleaner Production* | 26 | Engineering, environmental | Environmental sciences | Green & Sustainable Science & Technology |
| *Industrial Marketing Management* | 18 | Business | Management | - |
| *International Journal of Production Research* | 16 | Engineering, industrial | Engineering, manufacturing | Operations research & Management science |
| *International Journal of Operations & Production Management* | 15 | Management | | |
| *International Journal OF Advanced Manufacturing Technology* | 14 | Automation & Control systems | Engineering, manufacturing | |
| *Journal of Service Management* | 12 | Management | | |
| *Service Industries Journal* | 12 | Management | | |
| *Proceedings of the Institution of Mechanical Engineers Part B: Journal of Engineering Manufacture* | 9 | Engineering, manufacturing | Engineering, mechanical | |
| *Marketing Theory* | 7 | Business | | |
| *Computers in Industry* | 7 | Computer science, interdisciplinary applications | | |
| *Journal of Engineering Design* | 7 | Engineering, multidisciplinary | | |
| *Journal of the Academy of Marketing Science* | 6 | Business | | |
| *European Journal of Marketing* | 6 | Business | | |
| *Journal of Business & Industrial Marketing* | 6 | Business | | |
| *Service Business* | 6 | Business | | |
| *International Journal of Computer Integrated Manufacturing* | 6 | Computer science, interdisciplinary applications | Engineering, manufacturing | Operations research & Management science |
| *Journal of Service Research* | 5 | Business | | |
| *Wirtschaftsinformatik* | 5 | Computer science, Information systems | | |
| *Business & Information Systems Engineering* | 5 | Computer science, Information systems | | |
| *International Journal of Production Economics* | 5 | Engineering, industrial | Engineering, manufacturing | Operations research & Management science |
| *Managing Service Quality* | 5 | Management | | |
| *International Journal of Physical Distribution & Logistics Management* | 5 | Management | | |
| *Journal of Business Research* | 4 | Business | | |
| *Expert Systems with Applications* | 4 | Computer science, Artificial intelligence | Engineering, Electrical & Electronic | Operations research & Management science |
| *Computers & Industrial Engineering* | 4 | Computer science, interdisciplinary applications | Engineering, industrial | |
| *Cirp Annals-Manufacturing Technology* | 4 | Engineering, industrial | Engineering, manufacturing | |
| *Journal of Engineering and Technology Management* | 3 | Business | Engineering, industrial | Management |
| *Supply Chain Management-an International Journal* | 3 | Business | Management | |
| *Research Technology Management* | 3 | Business | Engineering, industrial | Management G46 |
| *Information Systems and e-Business Management* | 3 | Business | Management | |
| *IEEE Transactions on Engineering Management* | 3 | Business | Engineering, industrial | Management |
| *Journal of Services Marketing* | 3 | Business | | |
| *Journal of Business-to-Business Marketing* | 3 | Business | | |
| *Journal of Macromarketing* | 3 | Business | | |
| *Decision Support Systems* | 3 | Computer science, Artificial intelligence | Computer science, Information systems | Operations research & Management science |
| *International Journal of Technology Management* | 3 | Engineering, multidisciplinary | Management | Operations research & Management science |

In addition, the journal of Industrial Marketing Management accounts for 18 articles, the International Journal of Production Research accounts for 16, and the International Journal of Operations and Production Management for 15.

Combined, the articles in the present review demonstrate clearly that the topic applies to many different research areas; however, these areas are mainly related to business, engineering (environmental, industrial and manufacturing), management and computer science, according to the WoS categories. The authors of these 343 articles come mainly from England (20% citing sample), USA (15% citing sample), Germany (8% citing sample) and Sweden (8% citing sample).

### 2.2. Process

The bibliometric study comprises citation, co-citation and factorial analyses. The citation study involves collecting all the bibliographic references from the 343 papers published on the WoS, hereinafter the citation sample, to examine co-citations. The 343 study papers cited 12,123 different documents, 1001 of which were cited more than once (henceforth referred to as the cited sample).

The analysis of co-citations of documents, on which this study is founded, is based on the premise that authors cite documents that they believe are important for the conduct of their research. The co-citation analysis is based on the strength of the relationship between two cited documents, which is determined by the number of papers in the citation sample that simultaneously cite these two documents. Co-citation is therefore the frequency with which two prior documents are cited together in the subsequent literature.

When two documents are frequently cited together it is obvious that this also applies to them individually. We can say, therefore, that the most cited documents represent key concepts, methods or experiments in a study field; indeed, co-citation patterns can be used to objectively represent the intellectual structure of that field (Small, 1973). The most cited documents will thus have a greater impact on the discipline, and their links to other cited documents configure a network of relations that comprise the intellectual structure of a research area.

Network theory was used to identify the most cited documents that form the core of the network of cited documents. Typical network studies address issues of centrality (which nodes are best connected to others or have most influence), connectivity (whether and how nodes are connected to one another through the network) and closeness (distance between nodes). In his renowned study on the structure and function of complex networks, Newmann (2003) points out that a typical network category are the so-called information networks or "knowledge networks", and according to him the classic example of an information network is the network of citations between academic papers. Most learned articles cite previous works by others on related topics. The structure of the citation network thus reflects the structure of the information stored in its vertices – hence the term information network.

Network analysis techniques have been used in this study, as they enable the determination of the closeness indices for nodes (bibliographic references) and the identification of those at the core of the network. Finally, the factorial analysis for the bibliographic references that configure the core of the network identified the intellectual structure of science in a discipline or field (Small, 1973).

The process for identifying the intellectual structure about servitization was therefore as follows:

(a) Preparation of the co-citation matrix. A co-citation matrix was constructed with the 1000 references cited more than once,[3] using Bibexcel to count the number of times that each possible pair of bibliographic references had been cited together.

(b) Determination of the degree of closeness of each cited bibliographic reference. The use of network theory indicators calculated the closeness of each of the 1001 cited bibliographic references. This is a measure or the proximity or closeness of a node (cited document) to all the other nodes in a network. The value can range from 0 to 100, according to the number of co-citations received. The references with the largest number of co-citations will therefore present the highest degree of closeness. On the other hand, each value represents a node's contribution to the network, so the greater its degree of closeness, the greater the document's importance in the network.

The Ucinet software package and NetDraw (Borgatti, 2002; Borgatti et al., 2002), were used to determine and chart the closeness of the nodes in the co-citation network.

(c) Identification of the bibliographic references with the highest degree of closeness. In order to identify the key or more influential bibliographic references, the co-citation network, consisting in this case of 1001 references, was stratified according to closeness range into three segments or thresholds, following the methodology proposed by Ronda-Pupo and Guerras-Martín (2010). On the first threshold were the references located peripherally in the network, the second comprises the references in a semi-peripheral position and the third includes the bibliographic references belonging to the core, the subject of the analysis.

[3] The co-citation matrix is a square (containing the name number of rows as of columns), identical (the number and names of the columns and rows are identical) and symmetrical matrix (relations are two-directional). The cells of the co-citation matrix contain the number of times that each pair of references has been cited together. In this study, the co-citation matrix is a square matrix with 1001 × 1001 elements (references cited more than once).

Note that the nodes' closeness values can range from 0 to 100, and in this case the first threshold is configured by documents with closeness values of 0 to 33, the second by documents with values of 34 to 67, and the third by documents with values from 68 to 100 (Ronda-Pupo and Guerras-Martín, 2010).

In this study, considering that the closeness values of the nodes (bibliographic references) are within a range from 37.4 to 93.7, this range was stratified as follows. The first threshold includes peripheral references, with closeness values ranging from 37.4 to 56.1. The second includes semi-peripheral references, with values from 56.2 to 74.9. Finally, the third contains the core references, with closeness values from 75 to 93.7. Seventy-nine (79) of the 1001 references that were cited more than once, and therefore integrated the co-citation network, we at its core.

(d) Application of a two-level multivariate analysis using SPSS statistical software, in order to determine the existence of groups in the co-citation network structure. These two levels are the following:

d.1 Factorial analysis in order to obtain a set of factors that explain an appropriate percentage of the variance found. Based on the co-citation matrix, a factorial analysis was performed for the references (cited sample) located at the core of the co-citation network. The factorial analysis determines which references are grouped together.[4]

A factorial analysis was performed with varimax rotation for variables with a factorial load of more than |±0.4|, as usual in this type of analysis (Hair et al., 1998).[5]

d.2 Identification of the literature bases from the factorial scores obtained for the bibliographic references. In the factorial analysis, the bibliographic references that are conceptually close or refer to the same topic tend to load in the same factor. The factorial load shows the extent to which the reference explains the factor. Therefore, we can interpret the factor and infer the subject of the factor through examining the articles that make it up (Portugal Ferreira et al., 2014).

## 3. Results and discussion

This section presents the results obtained by the aforementioned methodology.

Table 3 shows the 79 bibliographic references located at the core of the co-citation network, by order of closeness or, in other words, their importance or impact on the research topic of servitization. It can be seen that the paper by Vargo and Lusch (2004a) is in the most central position, followed by Vandermerwe and Rada (1988), Wise and Baumgartner (1999), Oliva and Kallenberg (2003) and Baines et al. (2007).

Fig. 2 shows the central threshold of the analysed co-citation network of 79 documents. It shows the degree of closeness of each bibliographic reference, simply from its location in the network; however, each reference is preceded by its closeness value in brackets.

Closeness measures a node's contribution according to its position in the network (Borgatti, 2005), meaning that the closest nodes have made greater contributions to the development of the discipline.

Also note that only 6 of the 79 publications are books. As in some other fields (Sánchez-Riofrío et al., 2015), one of the possible explanations of why books represent such a small percentage could be because it is quite a specific and, in a way, new field, so there are not many specialist books on the topic. This opinion is supported by the fact that the books include Yin (2003), about research with case studies, a particularly appropriate methodology when investigators are interested in learning *how* or *why* something occurs, in exploratory research and in other studies aimed at establishing, extending and generalising theories.

Fig. 2 shows that the analysed papers are grouped around three different sets of research studies as far as the objective is concerned. The variation in the colour of the nodes is associated to the node (bibliographic reference) pertaining to one of the three main theme areas or schools that represent the intellectual structure of research on servitization, called: service strategy in industrial firms, service innovation and service dominant logic, which are explained and analysed below by factorial analysis and its results.

### 3.1. Factorial analysis

The factorial analysis performed with the cited documents located in the central perimeter of the co-citation network obtains three factors that explain 73.62% of the total variance. Following McCain (1990), documents with a load of more than |±0.4| are considered. Table 4 shows the main components obtained and Fig. 3 shows the intellectual structure of the research from 1992 to March 2015, presenting the documents that integrate each factor together, and with node size representing the factorial load of the document or the extent to which the documents helps to explain the factor.

[4] Factorial analysis enables the identification of underlying variables or factors that explain the configuration of relations in an observed set of variables. Factorial analysis is usually used in data reduction to identify a small number of factors that explain most of the variance found in a larger number of manifest variables.

[5] In specific studies of the analysis of joint citations, White and McCain (1998) recommend the use of a factorial load of more than 0.7 if the goal is to clearly identify the topics of the factors to be analysed.

**Table 3**
Bibliographic references with highest degree of closeness.

| Closeness | Reference (paper, book, etc.) | Closeness | Reference (paper, book, etc.) |
|---|---|---|---|
| 93.7 | (Vargo and Lusch, 2004a) | 77.3 | (Ostrom et al., 2010) |
| 88.2 | (Vandermerwe and Rada, 1988) | 77.1 | (Yin, 2003) |
| 87.9 | (Wise and Baumgartner, 1999) | 77.0 | (Alonso-Rasgado et al., 2004) |
| 87.4 | (Oliva and Kallenberg, 2003) | 76.9 | (Shostack, 1977) |
| 86.9 | (Baines et al., 2007) | 76.7 | (Neu and Brown, 2005) |
| 86.3 | (Vargo and Lusch, 2008a) | 76.7 | (Tukker and Tischner, 2006a) |
| 83.9 | (Mont, 2002) | 76.7 | (Windahl and Lakemond, 2006) |
| 83.2 | (Goedkoop et al., 1999) | 76.6 | (Jacob and Ulaga, 2008) |
| 82.7 | (Gebauer et al., 2005) | 76.6 | (Sawhney et al., 2004) |
| 82.1 | (Mathieu, 2001a) | 76.5 | (Grönroos, 2008) |
| 81.9 | (Mathieu, 2001b) | 76.4 | (Frambach et al., 1997) |
| 81.9 | (Tuli et al., 2007) | 76.4 | (Morgan and Hunt, 1994) |
| 81.7 | (Davies, 2004) | 76.4 | (Parasuraman et al., 1985) |
| 81.7 | (Galbraith, 2002) | 76.3 | (Meier et al., 2010) |
| 80.7 | (Tukker, 2004) | 76.2 | (Cook et al., 2006) |
| 80.5 | (Vargo and Lusch, 2004b) | 76.2 | (Gebauer, 2008) |
| 80.4 | (Manzini and Vezzoli, 2003) | 76.2 | (Maglio and Spohrer, 2008) |
| 80.2 | (Cohen et al., 2006) | 76.1 | (Lusch and Vargo, 2006) |
| 79.9 | (Davies et al., 2006) | 75.9 | (Vargo and Lusch, 2008b) |
| 79.9 | (Eisenhardt, 1989) | 75.8 | (Sawhney, 2006) |
| 79.7 | (Lusch et al., 2007) | 75.6 | (Foote et al., 2001) |
| 79.5 | (Lovelock and Gummesson, 2004) | 75.6 | (Miller et al., 2002) |
| 79.5 | (Neely, 2008) | 75.6 | (Roy, 2000) |
| 79.3 | (Aurich et al., 2006) | 75.5 | (Johnstone et al., 2009) |
| 79.2 | (Brax, 2005) | 75.4 | (Woodruff, 1997) |
| 79.2 | (Fang et al., 2008) | 75.3 | (Matthyssens and Vandenbempt, 1998) |
| 78.9 | (Gebauer and Friedli, 2005) | 75.3 | (Morelli, 2003) |
| 78.4 | (Baines et al., 2009a) | 75.2 | (Gebauer and Fleisch, 2007) |
| 78.2 | (Lusch et al., 2010) | 75.2 | (Michel et al., 2008) |
| 78.2 | (Windahl et al., 2004) | 75.2 | (Quinn et al., 1990) |
| 78.1 | (Davies et al., 2007) | 75.2 | (Ulaga and Reinartz, 2011) |
| 78.0 | (Spring and Araujo, 2009) | 75.1 | (Chesbrough and Rosenbloom, 2002) |
| 78.0 | (Tukker and Tischner, 2006b) | 75.1 | (Maxwell and van der Vorst, 2003) |
| 77.9 | (Baines et al., 2009b) | 75.0 | (Boyt and Harvey, 1997) |
| 77.9 | (Payne et al., 2008) | 75.0 | (Bullinger et al., 2003) |
| 77.9 | (Vargo and Lusch, 2008c) | 75.0 | (Neu and Brown, 2008) |
| 77.8 | (Edvardsson et al., 2005) | 75.0 | (Sakao and Shimomura, 2007) |
| 77.7 | (Normann and Ramirez, 1993) | 75.0 | (Shepherd and Ahmed, 2000) |
| 77.5 | (Normann, 2001) | 75.0 | (Shostack, 1982) |
| 77.3 | (Grönroos, 2000) | | |

Fig. 3 only shows bibliographic references with a factorial load of more than |±0.7|. Below is an analysis of each of the factors obtained from the factorial analysis, which form each of the lines of research found in this study.

The results in Table 4 show that the line of research focusing on service strategy in industrial firms is related to the largest number of studies, followed by service dominant logic and, finally, service innovation.

Each factor represents one of the central research topics in the literature about servitization, and the factorial scores or loads can be interpreted as the extent to which each paper contributes to the topic, with the studies with the greatest loads explaining the factor to the greatest extent.

Table 5 shows the documents that comprise each factor in detail, together with their respective factorial loads.

The first factor, called "*Service strategy in industrial firms*", is represented by documents that comprise the theoretical and conceptual foundations of what is known as servitization, which is the addition of services to manufacturing, with industrial firms producing different product and service combinations in which the product comes before the service. The provision of services satisfies specific client needs, so that more value is created for clients and represents a source of differentiation.

The base of the literature is built around this term, first used by Vandermerwe and Rada (1988). The different studies are related to strategic management and represent research that tries to explain servitization as a business strategy (Neu and Brown, 2005; Gebauer, 2008). The output supply is seen as a continuum that goes from the production of goods to the production of services, resulting in an evolution in which firms provide the most appropriate combination of goods/services (Oliva and Kallenberg, 2003; Neu and Brown, 2005, 2008; Johnstone et al., 2009) It is considered that the addition of services to manufacturing processes responds to a change in strategy, ranging from vertical integration (Wise and Baumgartner, 1999; Davies et al., 2007) to the constitution of services in a new business model (Shepherd and Ahmed, 2000; Galbraith, 2002; Tuli et al., 2007).

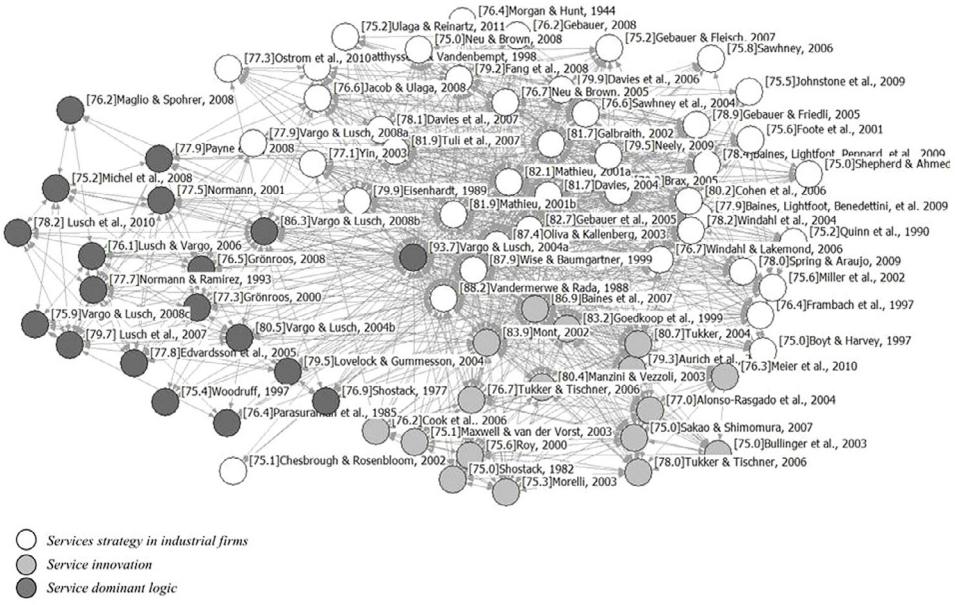


**Fig. 2.** Intellectual structure of research on servitization from the period January 1992 to March 1995.

**Table 4**
Explained variance.

| Factor | Number of documents | Initial value | % variance | Total variance |
|---|---|---|---|---|
| Service strategy in industrial firms | 43 | 32.448 | 41.07 | 41.07 |
| Service innovation | 17 | 14.969 | 18.95 | 60.02 |
| Service dominant logic | 19 | 10.737 | 13.60 | 73.62 |

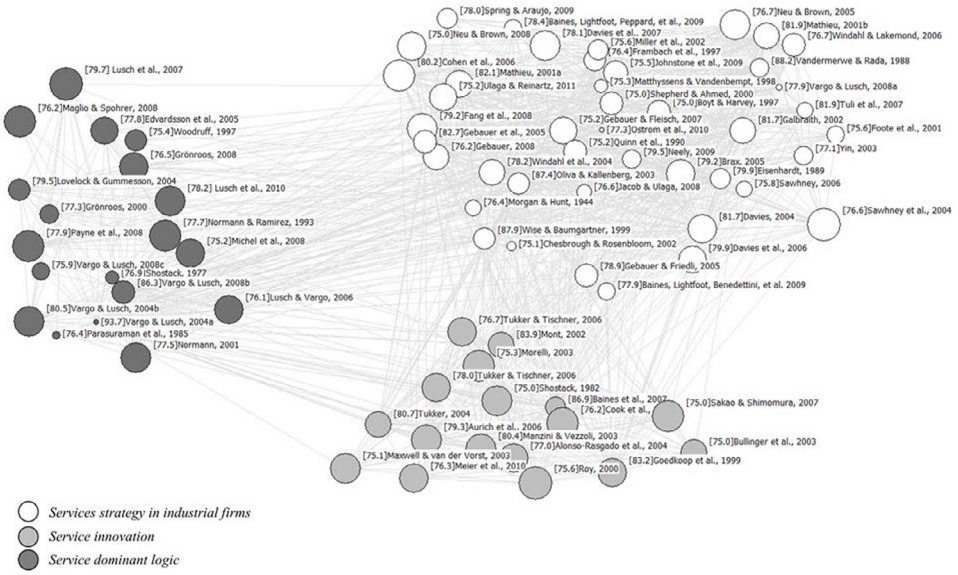


**Fig. 3.** The intellectual structure of servitization research from the period January 1992 to March 1995 by research area.

**Table 5**
Factorial analysis results (Method of extraction: Principal component analysis).

| Factor 1: Services strategy in industrial companies | Factorial load | Factor 1: Services strategy in industrial companies (continued) | Factorial load | Factor 2: Service innovation (continued) | Factorial load |
|---|---|---|---|---|---|
| Sawhney et al., 2004 | 0.935 | Eisenhardt, 1989 | 0.753 | Alonso-Rasgado et al., 2004 | 0.878 |
| Cohen et al., 2006 | 0.907 | Miller et al., 2002 | 0.749 | Tukker and Tischner, 2006a | 0.875 |
| Davies et al., 2007 | 0.904 | Vandermerwe and Rada, 1988 | 0.746 | Goedkoop et al., 1999 | 0.872 |
| Neu and Brown, 2005 | 0.899 | Neely, 2008 | 0.730 | Mont, 2002 | 0.841 |
| Fang et al., 2008 | 0.897 | Yin, 2003 | 0.730 | Bullinger et al., 2003 | 0.841 |
| Brax, 2005 | 0.874 | Foote et al., 2001 | 0.723 | Tukker, 2004 | 0.837 |
| Davies, 2004 | 0.868 | Baines et al., 2009a | 0.721 | Baines et al., 2007 | 0.765 |
| Neu and Brown, 2008 | 0.867 | Baines et al., 2009b | 0.717 | **Factor 3: Service dominant logic** | **F. load** |
| Gebauer and Fleisch, 2007 | 0.866 | Tuli et al., 2007 | 0.704 | Lusch et al., 2007 | 0.927 |
| Davies et al., 2006 | 0.853 | Morgan and Hunt, 1994 | 0.703 | Normann and Ramirez, 1993 | 0.922 |
| Mathieu, 2001a | 0.853 | Sawhney, 2006 | 0.697 | Payne et al., 2008 | 0.914 |
| Ulaga and Reinartz, 2011 | 0.850 | Jacob and Ulaga, 2008 | 0.673 | Maglio and Spohrer, 2008 | 0.914 |
| Gebauer, 2008 | 0.836 | Matthyssens and Vandenbempt, 1998 | 0.657 | Vargo and Lusch, 2004b | 0.904 |
| Windahl et al., 2004 | 0.831 | Chesbrough and Rosenbloom, 2002 | 0.594 | Lusch et al., 2010 | 0.898 |
| Mathieu, 2001b | 0.828 | Vargo and Lusch, 2008a | 0.561 | Normann, 2001 | 0.896 |
| Galbraith, 2002 | 0.828 | Ostrom et al., 2010 | 0.543 | Michel et al., 2008 | 0.879 |
| Johnstone et al., 2009 | 0.809 | **Factor 2: Service innovation** | **F. load** | Lusch and Vargo, 2006 | 0.873 |
| Shepherd and Ahmed, 2000 | 0.805 | Roy, 2000 | 0.932 | Grönroos, 2008 | 0.866 |
| Windahl and Lakemond, 2006 | 0.801 | Sakao and Shimomura, 2007 | 0.923 | Edvardsson et al., 2005 | 0.853 |
| Gebauer et al., 2005 | 0.799 | Morelli, 2003 | 0.914 | Vargo and Lusch, 2008b | 0.794 |
| Gebauer and Friedli, 2005 | 0.791 | Cook et al., 2006 | 0.908 | Lovelock and Gummesson, 2004 | 0.783 |
| Boyt and Harvey, 1997 | 0.790 | Manzini and Vezzoli, 2003 | 0.904 | Woodruff, 1997 | 0.776 |
| Quinn et al., 1990 | 0.790 | Aurich et al., 2006 | 0.901 | Grönroos, 2000 | 0.739 |
| Frambach et al., 1997 | 0.771 | Maxwell and van der Vorst, 2003 | 0.901 | Vargo and Lusch, 2008c | 0.720 |
| Wise and Baumgartner, 1999 | 0.769 | Shostack, 1982 | 0.898 | Shostack, 1977 | 0.652 |
| Oliva and Kallenberg, 2003 | 0.769 | Meier et al., 2010 | 0.881 | Parasuraman et al., 1985 | 0.576 |
| Spring and Araujo, 2009 | 0.762 | Tukker and Tischner, 2006b | 0.881 | Vargo and Lusch, 2004a | 0.549 |

A business model is a conceptual tool which helps us to understand how the firm does business – that is, how it competes – and which can be used for analysis, comparison, management and innovation (Osterwalder et al., 2005). Business models reflect the firms' competitive strategy by defining the product and service design, the costs incurred, the way the firm distinguishes itself from other firms through its value proposition, and how this is integrated into its value chain (Rasmussen, 2007). Innovation can be understood as the transformation of the value proposition of a firm which links products with sales and product-service systems (Vandermerwe and Rada, 1988). As long as innovation follows technological change and involves the supply of new services, servitization gives the manufacturing firm an edge. These new services are linked to stable core technology (Baines et al., 2009a). The integration of products and services or of product-service systems are also regarded as a business model (Reim et al., 2015).

Servitization implies designing new business models based on a search for solutions that enable the correct integration of goods and services (Visnjic et al., 2016). The analysis of the papers included in this first factor enables the identification of new approaches to the search for solutions:

1. System of solutions aimed at satisfying consumer demands by combinations of goods and services (Vandermerwe and Rada, 1988; Foote et al., 2001) developed as new business models in which portfolio complexity is the distinctive feature (Shepherd and Ahmed, 2000).
2. Solution orientation from a cultural, regulatory and organisational perspective (Wise and Baumgartner, 1999).
3. Integrated solutions in relation to: (a) the characteristics of the competition (Windahl et al., 2004), (b) the importance of business relations and value chain (Davies, 2004; Windahl and Lakemond, 2006), (c) comprehensive solutions for clients in which goods and services are integrated to provide custom products adapted to each client's specification, based on the "dominant service" approach (Sawhney, 2006).
4. Effective solutions based on the study and analysis of provider and client variables (Frambach et al., 1997; Foote et al., 2001; Davies et al., 2007; Tuli et al., 2007; Bustinza et al., 2013).
5. "Hybrid supply" based on Resource and Capability Theory, focusing on the development of distinctive service-related capabilities (Davies et al., 2006; Ulaga and Reinartz, 2011).

As this is a new topic that arose less than twenty years ago, most of the papers are not based on a specific theory, which is characteristics of new fields of research, where conceptual aspects are the priority, so there are different conceptual approaches.

This factor has a clear strategic orientation, which includes the consideration of Resource and Capability Theory and the achievement of a competitive advantage (Davies et al., 2006; Fang et al., 2008; Brax, 2005; Ulaga and Reinartz, 2011). Other theories used include contingent theory, in Neu and Brown (2005, 2008) and Gebauer (2008), which explains the adjustment process between internal and external factors for choosing the most appropriate servitization strategy. On the other hand, "resource-advantage theory of competition" enables the analysis of whether servitization strategy enables the firm to obtain comparative advantages in resources with which to provide greater value to clients (Neu and Brown, 2005). Organisation theory and organisational conduct and motivation are also used to explain managers' reasons for initiating the servitization process and the internal factors that affect this strategy's development (Gebauer et al., 2005; Gebauer and Friedli, 2005; Gebauer and Fleisch, 2007). And finally, in the papers that comprise the first factor, we have also found the operations strategy approach (Baines et al., 2009a; Spring and Araujo, 2009).

Different lines of research can be identified from the strategic perspective used in these studies. On the one hand, the goal is to conceptualise and identify different types of service strategies (Mathieu, 2001a,b; Sawhney et al., 2004; Gebauer, 2008) according to the firm's product or service approach, enabling an analysis of the integration/transition process from a pure product to a pure service (Mathieu, 2001a; Oliva and Kallenberg, 2003; Sawhney et al., 2004; Fang et al., 2008; Johnstone et al., 2009).

On the other, a second line shows the importance of contextual factors in firms' servitization processes and the manner in which they enable the appropriate integration of the servitization strategy in the strategic development of industrial firms. From this perspective, the aim is to: (1) identify the internal (organisational structure, strategy design and implantation, managerial behaviour, human resource policies) and external (characteristics such as complexity) factors that favour the development of a servitization strategy (Miller et al., 2002; Gebauer et al., 2005; Neu and Brown, 2005, 2008; Windahl and Lakemond, 2006; Tuli et al., 2007; Johnstone et al., 2009; Turunen and Toivonen, 2011); (2) identify the factors that determine the most appropriate combination of products and services and the type of servitization to be applied (Windahl et al., 2004; Gebauer, 2008).

Another field of research focuses on the analysis of the effects and consequences of servitization for firms. It analyses the costs and benefits (Mathieu, 2001b), the risks (Sawhney et al., 2004) and the impact on financial performance (Neely, 2008).

The conceptual bases include a literature review (Baines et al., 2009b) and the bases of the science of services (Ostrom et al., 2010).

The studies that comprise this factor are largely theoretical, specifically 43% of the total; this is because research in this factor focuses on the conceptual foundations of the topic. On the other hand, 38% of the publications use the case study method, applying theoretical bases. As most of them highlight, the objective of this methodology is not to obtain generalisable results but find results that enable the development of a broader servitization strategy theory (Eisenhardt, 1989; Yin, 2003). The few empirical studies use primary sources to obtain information. In-depth interviews have been used, applying statistical techniques such as cluster, exploratory, descriptive or regression analysis.

The second factor, "*Service innovation*", is configured by papers that focus on service design in the context of product-service systems. The following research topics or fields can be identified in the documents in question: (I) *technological innovation* or technology and (II) *sustainability* and/or *eco-efficiency*.

The first of the identified topics is in all the analysed papers, so it can be said that the factor includes research on product-service systems, focusing on: (a) the impact of innovation or technology on the servitization process, or (b) case studies of the development of technological services that supplement firms' product (technological or not) supply.

In this respect, Roy (2000) and Sakao and Shimomura (2007) aim to propose a new discipline in the engineering field, called "Service Engineering" (SE). Roy (2000) focuses on the analysis of the design of goods and services that reduces environmental impact while being economically feasible and acceptable for users. Sakao and Shimomura (2007) investigate eco-design and define service engineering as a discipline aimed at increasing the value of products and reducing environmental impact by focusing on services. They propose a service model in which the key variable clave is the change in the recipient's satisfaction, suggesting a computer-assisted design tool called "SERVICE EXPLORER" that effectively satisfied consumer requirements.

Morelli (2003) maintains that the design of a PSS can be seen in a context in which: (a) is a proposal for a new combination of technology based on functional parameters selected by the designer; (b) the interaction between the service designed and the client is not mediated by the industrial product. The first condition helps to focus on design, while the second defined the activity of designing a PSS as a multidimensional activity in which design aspects are related to organisational and social aspects. In product design, technological elements and social aspects represent two different moments in the product's life cycle. This is shown in the sub-division of responsibilities between design, product engineering, system development, marketing and other disciplines.

On the other hand, sustainability as the central topic of research regarding PSS is approached in a total of 6 papers, 5 of which refer both to eco-efficiency and sustainability, and the other paper to sustainability alone.

Roy (2000) discusses the concept of sustainability of PSS and establishes that the key element of sustainable PSS is that they are designed and marketed to provide clients with a given outcome without them necessarily having to possess or physically purchase the products. "These sustainability ideas have developed from 'cleaner and greener' improvements to processes and products to socio-technical system changes and new product-service mixes" (Roy, 2000). Four types of PSS are thus established:

1. Result services, the objective of which is to reduce existing systems' use of materials by selling a "result" instead of a product. One example is the sale of a clean clothing service instead of a washing machine.
2. Shared utilisation services aim to increase the use of parts of a system by the shared use of the product or products required. In the previous sample, it would involve sharing facilities in a communal clothes washing centre or commercial laundry instead of having washing machines in individual homes.
3. Product-life extension services; the primary function of these services is to increase the useful life of products or materials through maintenance, repair, reutilisation and recycling, thus reducing the energy and resources required to provide a given function. A simple example would be a personal computer firm that supplies or sells and also maintains and updates computers, as well as collecting them when no longer useful, for recycling.
4. Demand side management (occasionally referred to as minimum cost planning or integrated resource management) aims to reduce demand instead of increasing supply, o supplying at the lowest financial and environmental cost.

Morelli (2003) focuses on the development of a PSS as support for a new working method based on the intensive use of information and technological communications. PSS is defined as an integrated set of products of services capable of satisfying a consumer's needs. Manzini and Vezzoli (2003) also refer to the integral satisfaction of consumer needs, yet they see it as an innovation strategy, according to the case analysis contained in their paper. These definitions show the evolution of PSS from the traditional marketing perspective to the product management perspective. Ultimately, it refers to the extension of the service component around the product, for business activities that were traditionally product-oriented, or to the introduction of new service components in product businesses that were initially service-oriented. In this context, the term "strategic design for sustainability" represents the ability to create new configurations or types of stakeholder that develop an integrated product, service and communication system that is consistent with medium and long-term sustainability. This life cycle-oriented design concept in PSS is also adopted by Aurich et al. (2006), albeit only for technological products.

The ratio between the product and service components in a PSS can vary according to technological development, economic optimisation and changing consumer needs, among other factors. The common characteristic in them all, however, is that they are conceived and supplied as products, which are designed taking a series of economic and technological criteria into account.

Maxwell and van der Vorst (2003) develop a method for the development of sustainable products and service in order to provide a pragmatic orientation to business and industry, and to include this approach in existing corporate strategy and so-called clean production. Cook et al. (2006) delve deeper into the transfer of knowledge from academia to industry in relation to PSS, based on the premise that the adoption of technology and market push are factors that have been shown to be insufficient, as the existing technological paradigms do not provide a socially optimal solution in view of what is needed to improve sustainability. In this respect, the authors develop a methodology for the transfer of the concept from UK academic circles to industry, identifying the factors that define sustainable production and consumption methods.

The third factor, "*Service dominant logic*", comprises studies that develop the conceptual framework of service dominant logic (SDL), basically from a marketing perspective. The seminal study on this topic is Vargo and Lusch (2004a), the first authors to consider the re-definition of the basic characteristics of services (heterogeneity, intangibility and simultaneity) nor from the traditional production viewpoint but from the service dominant logic perspective. The second of the papers included in this third factor, Normann and Ramirez (1993), do not distinguish between product and service, yet they consider the idea of creating value creation systems for stakeholders by mobilising clients to help to create their own value through the firm's supply. This paper is seen as the most influential in the development of the value co-creation concept. Other authors subsequently question the concept of the term service and its basic characteristics, defining it from the consumer's perspective, based on the concept of value in use (Lovelock and Gummesson, 2004; Edvardsson et al., 2005).

All the studies included in this factor support the thesis that the central proposal in service dominant logic is that the client becomes a co-creator of value. Yet prior to 2003 little was known of how clients are involved in the co-creation of value. Payne et al. (2008) develop a model for the understanding and management of the co-creation of value. This model is based on a summary of research on services, value for the client and relational marketing based on the centrality of processes in the co-creation of value. The model shows an interconnected set of processes and how they recur in co-creation.

Lusch et al. (2007) sustain that service dominant logic challenges administration on all management levels to be at the service of all stakeholders; they understand that SDL is a logic or perspective that recognises the firm and its stakeholders in order to seek co-creation of value through mutual service provision. The study developed by these authors is based on the nine seminal proposals of SDL, eight of which were developed by Vargo and Lusch (2004a) and the ninth by Lusch et al. (2007). Although this paper is the most involved in the explanation of this factor, it can be concluded after analysis that this is the result of extending the seminal studied by the same authors to define service as an entity proper and the basis of competition in terms of competitive advantage.

Once the first studies developed the concept of joint value in use, co-creation and service dominant logic instead of products, the following study goes one step further and develops the foundations of the science of services. So the discipline is developed chronologically, and based on the importance of the papers in the factor. In this respect, service dominant logic is the theoretical background on which the science of services is based. The authors established that their objective is to classify and explain the different existing service provision systems, and how service systems interact and evolve to co-create value.

Although the aforementioned papers basically focus on the concept and rationale of the science of services, the rest are related to existing areas of knowledge, analysing some aspects from a client-oriented marketing perspective (Vargo and Lusch, 2004b; Lusch et al., 2010; Michel et al., 2008; Grönroos, 2008) or in relation to strategic management, using resource and capability theory (Michel et al., 2008; Lusch and Vargo, 2006).

## 4. Conclusions

Servitization is a new topic that came to the fore less than twenty years ago. Most of the papers are not based on a specific theory, which is characteristic of new fields of research, where conceptual aspects are the priority (leading to different conceptual approaches).

Servitization of manufacturing has become a common business practice that enables clients to obtain product-service combinations adapted to their needs. In sum, it enables firms to position themselves better on the market (Baines et al., 2009a). Even though servitization has mainly been the subject of focus in relation to manufacturing, it may also be applied to other contexts: this is an emerging field with many interesting opportunities (Vendrell-Herrero and Wilson, 2016).

In this context, the literature on servitization has increased considerably, fed by different disciplines and theories; to date it has been dominated by case studies (Beuren et al., 2013). This concept requires more quantitative empirical studies, but a new trend in this direction can be detected. It can therefore be defined as an emerging research field, with many interesting opportunities (Lightfoot et al., 2013; Baines et al., 2016).

Many authors have contributed to the study of servitization, but there is no systematic list of contributions to the literature. There have been some literature reviews (Pawar et al., 2009; Berkovich et al., 2011; Lightfoot et al., 2013), but without using bibliometric techniques that consider the large amount of information available in the literature review, with data regarding the volume and impact of research activities and an analysis of the relationships and interactions between investigators and fields. This is particularly useful in a new field of research such as servitization.

The thorough analysis of "certified knowledge" (Ramos-Rodríguez and Ruíz-Navarro, 2004) adds rigour to the results. The methodology used enabled the identification of the lines of research that comprise the intellectual basis of the literature about servitization over the last thirty-five years, supplementing and improving the results of other studies that approached the topic from a qualitative perspective. Network analysis, by determination of closeness indicators, identified the most significant bibliographic references in the sense that they made the greatest contribution to configuring the intellectual structure of research on servitization.

According to the concepts of network theory, most networks contain nodes (people or organisations) that are central because their position provides them with better access to information and a greater opportunity to use it. The indicator of the degree of closeness (or centrality) of each node enabled the identification of the publications with the greatest impact, measured by closeness. Vargo and Lusch (2004a), Vandermerwe and Rada (1988), Wise and Baumgartner (1999), Oliva and Kallenberg (2003) and Baines et al. (2007) are in the first five positions regarding closeness.

The factorial analysis completed this study. It is usual to start with the co-citation matrix to perform the factorial analysis, although other techniques can also be used (Chen et al., 2010). Each identified factor represents a sub-field or intellectual theory, as we can see from the content of the important papers in this factor (Portugal Ferreira et al., 2014). The factorial loads tell us about the degree to which a reference really belongs to a factor. In general, the factors with the greatest impact are configured by the largest number of references, and the explained variance is greater. Not that, in this study, each reference was allocated to the factor in which its importance was greatest, although it is conceptually possible for a reference to contribute to more than one line of research and for the most significant (closest) references to be of less importance in the factor that they best explain, as seen in the analysis.

We obtained three clearly identifiable factors with three lines of research on servitization. Each factor represents a topic in the literature about servitization, identifying the following: (1) service strategy in industrial firms, (2) service innovation and (3) service dominant logic. These three factors are the topics contemplated in the literature about servitization in the 1992–2015 period. They can be related to the research communities identified by Lightfoot et al. (2013). Service strategy in industrial firms affects the service and operations management communities; service dominant logic affects the service marketing community, and service innovation affects product-service systems and service science.

It can be concluded that servitization affects firms in different areas, including strategy, marketing, operations, ICTs, firm performance, etc. Hence the existence of different research communities grouped around the identified intellectual bases, which respond to the logic of an emerging discipline, as they establish the conceptual bases regarding services (dominant logic), service innovation and, therefore, product-service strategies.

From a methodological perspective, the conceptual bases are constructed on theoretical contributions from different disciplines. As this is a new topic that has arisen in the last twenty years, most of the publications are not based on a specific theory; this is typical in new areas of research, where the priority is conceptualisation, seeking to construct a theory from case studies. The objective of this case methodology is not to obtain generalisable results but to results that enable the development of a theory (Eisenhardt, 1989; Yin, 2003). Logically, as the discipline evolves we begin to see quantitative studies and theoretical formulations.

Despite the objectivity of the applied methodology, it has some limitations that should be considered. The use of one database or another to obtain source documents (the citation sample) could condition the study's results. However, the bibliometric analysis focuses on the analysis of references (co-citation analysis) so the differences found using other

databases to obtain the citation sample would not be expected to bias the results. Moreover, most of the publications indexed in the WoS are also found in other databases, such as Scopus.

Another aspect to be considered is that, in many cases, the citations are the result of different factors that influence the investigator when conducting his or her study. The frequency with which a document is cited does not infer quality, as excellent papers can be less cited, but the frequency with which a reference is cited or co-cited is certainly indicative of its importance or significance when configuring a field of knowledge.

Another limitation is related to the fact that the first published studies have been available to the scientific community for longer, and therefore have had more opportunities to be cited. This could bias the results, but only to a certain extent, as influence is a construct that depends on time. In other words, for a paper to be defined as influential it does not only have to be cited, but this has to occur over a long period of time.

The use of bibliometric studies together with social network tools has enabled us to understand and analyse the scientific domain of servitization, and show the "state of the art" of research at any given time. This methodology can be applied to different periods of time to analyse its evolution, and to study the "state of the art" of each of the areas that comprise the intellectual structure of servitization; in themselves, they constitute a field of scientific research for the future.

## Acknowledgements

This research has been partially funded by the Regional Government of Madrid under the SICOMORo-CM (S2013/ICE-3006) project, by the MASAI (TIN-2011-22617) and ELASTIC (TIN2014-52938-C2-1-R) projects, financed by the Spanish Ministry of Science and Innovation, and by the Service Science, Management and Engineering-GES2ME Research Excellence Group (Ref. 30VCPIGI15) co-funded by Rey Juan Carlos University and Banco Santander.

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