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# The Influence Of Information Technology On Industrial Services In The Manufacturing Industry – A Literature Review And Future Research Directions

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# THE INFLUENCE OF INFORMATION TECHNOLOGY ON INDUSTRIAL SERVICES IN THE MANUFACTURING INDUSTRY – A LITERATURE REVIEW AND FUTURE RESEARCH DIRECTIONS

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## Abstract

*In the last 40 years, industrial organizations have optimised their production processes through information technology (IT). Nowadays, manufacturing firms are confronted with shrinking margins, service-demanding customers, and increased competition that are associated with the structural shift from a product-dominant to a service-dominant economy. In order to answer the changed market conditions, those firms started to offer industrial product-service systems that refer to customer life cycle oriented combinations of products and services realised in an extended value-creation network. Since enterprise information systems (IS) are designed and optimised for production planning, a clear lack in functionality and integration for industrial services can be ascertained. In particular, the life cycle management for product-service systems is not adequately covered in current standard software solutions. Firms heavily rely on individual software instead. Due to the cross-disciplinary field of research, it is important to have an overview of the extant literature. Therefore, we present a structured literature review grounded in an established literature review framework. The results suggest that extant literature lacks depth in covering the specificity of industrial services in IT solutions supporting life cycle management. We propose further research in requirements engineering, IT architecture, IT infrastructure, IT governance, and sourcing.*

*Keywords: service science management and engineering, service science, information systems, literature review*

# 1 INTRODUCTION

The service sector is on the rise; employees working in business services in Germany account for 42% of the total workforce compared with 27% in the 1970s (Wölfl 2005). Furthermore, the fraction of industrial product-related services is increasing for all Organisation for Economic Co-operation and Development (OECD) countries except Luxembourg (OECD 2011). In 2000, product-related services accounted for 22.5% of the sales volume in the German electronic engineering industry (Stille 2003). The paradigm shift from a product-dominant to a service-dominant logic (SDL) can hardly be refuted (Vargo & Lusch 2008). Economic exchange is not based on products anymore but on services (Vargo & Lusch 2004). Over the last thirty years, academics as well as practitioners have begun to investigate services as a distinct phenomenon with its own body of knowledge and rules of practice (Spohrer & Kwan 2009). Their approaches are revitalised under the emergent discipline of service science, management, and engineering (SSME).

Traditional manufacturing firms have recognised the structural change in the industry and the shift towards the service-based economy. In response to the attendant challenges in terms of shrinking margins, service-demanding customers, and increased competition, numerous customer solutions now include service components (Oliva & Kallenberg 2003). Accordingly, firms strive to professionalise their portfolios with the aim of providing integrated customer solutions (Tuli et al. 2007). Nonetheless, organisations struggle to implement business services that are complementary to their existing product portfolios (Oliva & Kallenberg 2003). This phenomenon is known in literature as "service paradox" (Gebauer et al. 2005), i.e., it appears more difficult than expected to make incremental profits by adding services (Neely 2008). The reasons are complex and manifold; however, two of them are especially conspicuous. First, the current implementation of standardised enterprise systems fails to adequately cover the required functionality of industrial services (Dietrich 2006), since the enterprise application software is designed for production (Campbell-Kelly 1995; Light et al. 2001) and retail planning (Teo & Wong 1998). Second, the resources necessary to form product-services bundles are distributed cross-departmentally in the enterprise. As a consequence, services require inter- and cross-organisational collaboration to achieve the desired service orientation. In view of the implementation issues of business services, IT can help to support and integrate resources in order to create valuable business services with customer involvement (Thomas et al. 2007). However, the resulting solutions are associated with in-house software development that requires valuable, and therefore expensive capabilities (Väyrynen 2010). Combining products and services in so called product-service systems involves specific requirements for the life cycle management (Berkovich et al. 2011). For that reason, Becker et al. (2010) posit a framework (figure 1) that assigns services to the corresponding life cycle of the product. Services in the initial start-up stage refer to pre-sales activities such as problem analysis, consultant services (Menschner et al. 2011), and financial offerings (Becker et al. 2010). Literature dedicated to the operation stage is primarily concerned with services that uphold the operability of the physical component (Becker et al. 2010). During the disposal stage, service activities include replacement, recycling, and disassembling (Becker et al. 2010).

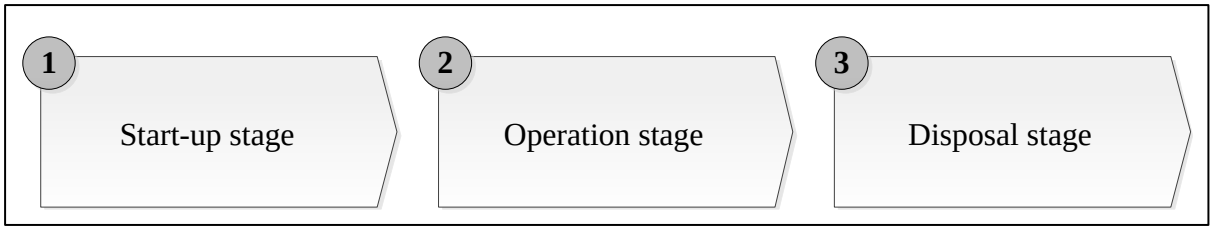


*Figure 1. Life cycle of product-related services based on Becker et al. (2010)*

Despite the IT support for the service industry (Bitner et al. 2000; Saloner & Shepard 2004; Teo & Wong 1998) the impact of IT on product-service systems is only sparsely addressed in extant literature (Becker et al. 2010; Berkovich et al. 2011). Prior literature reviews target SSME (Beverungen 2011; Spohrer & Kwan 2009), conceptual modeling of product-related services (Becker et al. 2010), interdisciplinary perspectives on IT and service science (Bardhan et al. 2010) as well as IT services (Demirkan et al. 2009) but neglect the IT support of product-related services in the manufacturing industry. Hence, we propose a literature review to investigate the potential of IT to facilitate SSME, which is structured according to the following research questions:

(1) *What are the relevant definitions for product-service systems?*
(2) *What is the current state of knowledge on product-service systems in IS research?*
(3) *How is the IS support of life cycle management addressed in extant literature?*
(4) *What are potential fields for future research endeavours?*

Such a review represents an "essential first step and foundation when undertaking a research project" (Baker, 2000) and aims to "uncover the sources relevant to a topic under study" contributing to the relevance and rigour of research (vom Brocke et al. 2009). While relevance refers to the avoidance of investigating what is already known (Baker 2000), rigour is concerned with the effective use of the existing knowledge base (Hevner et al. 2004). This literature review aims to provide an overview of relevant definitions, clarify the role of IT, point out the current state of knowledge by classifying the literature from an IS perspective, and deduce a detailed agenda for future research endeavours.

# 2 LITERATURE REVIEW

According to vom Brocke et al. (2009), rigour is essential when initiating research; on that basis they suggest a documented five-step literature review process. This literature review is conducted and structured in line with this framework. The scope is clearly defined, followed by a conceptualisation of the research topic. After presenting the process of literature search, a detailed literature analysis is accomplished. Synthesising the major results, a matrix and a table are used to classify the academic work in the field. Taking into account the aforementioned aspects, a research agenda is proposed.

## 2.1 Definition of Review Scope

The literature review is based on a taxonomy for literature reviews (vom Brocke et al. 2009) such as that proposed by Cooper (1988), which recommends six characteristics, each of which contains certain categories. Some of these characteristics are mutually exclusive (4 and 6), while others (1, 2, 3, and 5) can be combined independently (vom Brocke et al. 2009). The grey shaded categories in table 1 represent focal points of this literature review.

| Characteristic | | Categories | | | |
|---|---|---|---|---|---|
| (1) | Focus | Research outcomes | Research methods | Theories | Applications |
| (2) | Goal | Integration | Criticism | Identification of central issues | |
| (3) | Organisation | Historical | Conceptual | Methodological | |
| (4) | Perspective | Neutral representation | | Espousal position | |
| (5) | Audience | Specialised scholars | General scholars | Practitioners | General public |
| (6) | Coverage | Exhaustive | Exhaustive and selective | Representative | Central / Pivotal |

*Table 1. Taxonomy of literature reviews based on Cooper (1988)*

## 2.2 Conceptualisation and Terminology

According to vom Brocke et al. (2009), a review must begin with "a broad conception of what is known about the topic" (Torraco 2005). In this light, it seems reasonable to develop a common understanding of the definitions. Definitions on services, service systems and product-service systems are deduced from the aforementioned literature reviews. Additionally, operations management (OM) researchers and practitioners suggest taking product-service solutions and bundles into consideration. Answering research question 1 (*what are the relevant definitions for product-service systems?)*, the working definitions and paraphrases of the key terms are provided in table 2.

| Focus | Definition | Author(s) |
|---|---|---|
| Service | *[…] is a time-perishable, intangible experience performed for a customer acting in the role of a co-producer […]* | (Fitzsimmons & Fitzsimmons 2005) **MKTG (Textbook)** |
| | *[…] as production processes wherein each customer supplies one or more input components for that customer's unit of production […]* | (Sampson & Froehle 2006) **OM (Journal)** |
| | *[…] as the application of competence (e.g., knowledge, resources, etc.) for the benefit of another entity […]* | (Vargo & Lusch 2004) **MKTG (Journal)** |
| Service system | *[…] a work system is a system in which human participants or machines perform work using information, technology […] to produce products and services for internal and external customers […]* | (Alter 2010) **IS (Journal)** |
| | *[…] represents any value co-creation configuration of people, technology, value propositions connecting internal and external service systems […]* | (Maglio & Spohrer 2008) **MKTG (Journal)** |
| Product-service solution | *[…] customer-supplier relational processes comprising customer requirements definition, customization and integration […], and their deployment and post-deployment […]* | (Tuli et al. 2007) **MKTG (Journal)** |
| | *[…] involves the provision of tailored combinations of products and services as high-value integrated solutions that address the specific needs of large business and government customers […]* | (Davies et al. 2006) **OM (Journal)** |
| | *[…] solutions create integrated and customized offerings that solve […] customer problems […]* | (Sawhney et al. 2006) **MGT (Journal)** |
| Product-service bundle | *[…] along a continuum from pure product to pure service providers and thought of manufacturing firms moving along that axis […]* | (Oliva & Kallenberg 2003) based on (Chase 1981) **OM (Journal)** |
| Product-service systems | *[…] is an integrated solution […] and provides services to […] users without necessarily transferring the ownership of the product […]* | (Goh & McMahon 2009) based on (Alonso-Rasgado et al. 2004) **OM (Journal)** |
| | *[…]industrial PSS [product-service systems] are defined as customer life cycle oriented combinations of products and services, realized in an extended value creation network […]suppliers & partners […]* | (Aurich et al. 2006) based on (Mont 2002) **OM (Journal)** |

*Table 2. Overview of selected product-related service definitions*

There is an ongoing academic as well as practitioner debate about services and related products. Research scholars considers service science from distinct perspectives, such as OM, management (MGT), marketing (MKTG), and IS (Bardhan et al. 2010; Beverungen 2011; Maglio & Spohrer 2008; Rai & Sambamurthy 2006; Spohrer & Kwan 2009). The conceptualisation of *services* thus heavily depends on the academic imprint of the researchers. Consistent to the SDL, MKTG scholars consider services as the application of competence (Vargo & Lusch 2004). The traditional view of services, however, seems restricted since it treats services as residual, i.e. as value-added services offered to

enhance goods or products (Bardhan et al. 2010). Organisations engage in exchange to access the benefits of operant resources such as competencies, skills, and knowledge. Goods can act as a transmitter of operant resources, or they might be intermediate products. While the former refers to embedded knowledge, the latter are used by other operant resources as appliances in the value-creation process, which implies that customers are co-producers of services for themselves (Spohrer & Maglio 2008). Grounded in the SDL, IS scholars define services as the application of competence and knowledge with the aim of creating value between providers and receivers (Spohrer et al. 2007). However, this value can arise from the interaction of *service systems* that comprise people, organisations, technology, and shared information. The ultimate goal of service science is to lay the groundwork to advance the ability to design, refine, and scale service systems on behalf of business organisations and society (Bardhan et al. 2010).

Extant literature on OM and MGT tends to combine products and industrial services in terms of bundles, solutions and systems. Scholars fostering the term *product-service bundle* structure their consideration along the continuum from pure products to pure services (Oliva & Kallenberg 2003), while Davies et al. (2006) refer to *product-service solutions* that involve "the provision of tailored combinations of products and services as high-value integrated solutions that address the specific needs of large business". A similar definition is applied by Sawhney et al. (2006), while Tuli et al. (2007) prompt a broader approach in terms of customer-supplier relational processes such as requirements definition and deployment phases. The definition of *product-service systems* contributes to the debate by adding the life cycle aspect. Aurich et al. (2006) refer to "customer life cycle oriented combinations of products and services, realized in an extended value creation network". Although Sampson and Froehle (2006) try to consolidate the theoretical views on services, no consensus has been reached on a general definition of services (Metters 2010). Sampson and Froehle (2006) conclude that customer involvement is the only element of the definition taken into consideration by all relevant theoretical approaches. Intangibility, heterogeneity, inseparability, and perishability (Lovelock & Gummesson 2004) are representative characteristics (Sampson & Froehle 2006).

## 2.3 Literature Search

In view of the notion that the process of literature search plays a fundamental role in crafting a thorough review on a topic (Zorn & Campbell 2006), this paper follows the four-phase approach proposed by vom Brocke et al. (2009) and depicted in figure 2. Each phase is incrementally organised as it involves both search and evaluation tasks (Levy & Ellis 2006). The corresponding documentation ensures reliability and repeatability of the search process (vom Brocke et al. 2009). The consequent evaluation is then accountable for the selection of articles relevant to the research topic.

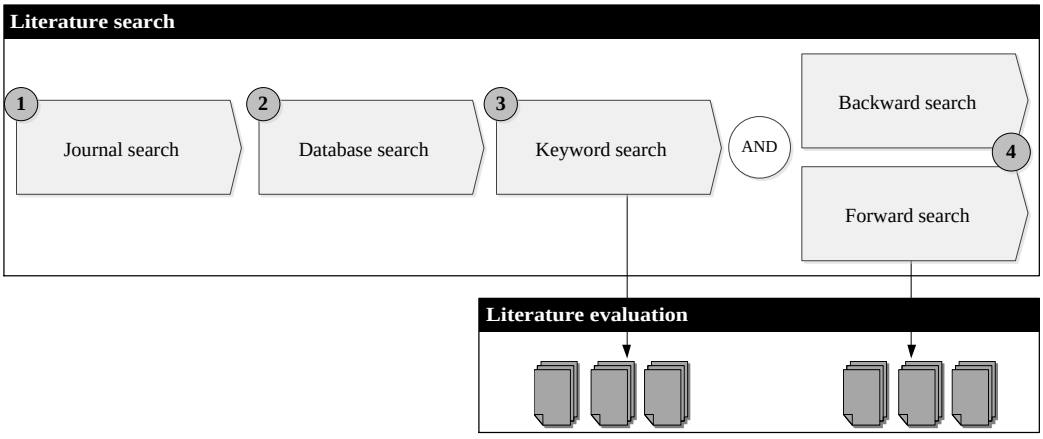


*Figure 2. Literature search process based on vom Brocke et al. (2009)*

The **journal search** is the first step in the literature search process. It is commonly recommended to focus on journal articles and high-ranked conference proceedings, based on the fact that they have been peer-refereed before publication (Rowley & Slack 2004; Webster & Watson 2002). Since the comprehensiveness of the top-tier journals is crucial for the quality of the literature search, primarily those scholarly databases that provide access to the top journals are queried (Webster & Watson 2002). Consistent with vom Brocke et al. (2009), we chose relevant journals proposed by Willcocks et al. (2008), the Association for Information Systems (AIS) World MIS Journal Ranking for IS and Management literature, and Olson (2005) for OM, and we chose Baumgartner & Pieters (2003) for MKTG literature. The selection of relevant conferences is supported by the AIS World database (AISeL) and comprises the *International Conference on Information Systems (ICIS)*, the *European Conference on Information Systems (ECIS)*, the *Hawaii International Conference on System Sciences (HICSS)*, the *American Conference on Information Systems (AMCIS)*, and the *Pacific Asia Conference on Information Systems (PACIS)*.

Equipped with the relevant journals, it is now possible to select and evaluate proper databases. The **database search** ensures exhaustiveness in coverage since all relevant top journals are taken into consideration. Accordingly, the following databases have been selected: *EBSCOhost, ProQuest (ABI/INFORM), Emerald, ScienceDirect, and Web of Science*.

The third step is a **keyword search**, in which the databases identified are queried using relevant keywords (Xiao & Benbasat 2007). Researchers recommend the use of precise search phrases (Rowley & Slack 2004) in addition to a precise documentation of the applied keywords (vom Brocke et al. 2009). The keywords are derived from the relevant definitions as outlined in the foregoing section.

| Database | Service science AND (IT OR IS) | Product service bundle AND (IT OR IS) | Product service system AND (IT OR IS) | Product service solution AND (IT OR IS) | Net hits |
|---|---|---|---|---|---|
| EBSCOhost | **4** (94) | **0** (5) | **7** (35) | **1** (8) | **5** |
| ProQuest | **8** (96) | **0** (5) | **1** (55) | **0** (5) | **9** |
| Emerald | **0** (75) | **0** (16) | **0** (15) | **0** (3) | **0** |
| ScienceDirect | **3** (189) | **0** (2) | **4** (441) | **0** (46) | **7** |
| AISeL | **20** (145) | **0** (1) | **3** (3) | **3** (7) | **22** |
| Web of Science | **10** (589) | **3** (21) | **7** (506) | **2** (471) | **17** |
| Net hits | | | | | **47 (60)** |

*Table 3. Results of the keyword search*

Bearing in mind these requirements, we present the results of the keyword search in table 3, which maps the search phrases with the corresponding source database and the number of hits for the time period from 1990 to 2011. In order to select the relevant articles (in bold) the total number of hits (in brackets) were derived through individual evaluation of the titles and abstracts. However, neither the database nor the search phrases are mutually exclusive and consequently double counts had to be removed manually to achieve the net hits.

The applied framework suggests proceeding with a **forward** and **backward search** as the final step of the search process. Since no consensus has been reached on the terminology, forward and backward searches are particularly important in identifying relevant literature sources that are well recognised across disciplinary borders. Further textbooks are taken into consideration. As a result, this search yields 34 relevant articles deriving a sum of 81 scholarly articles.

# 3 LITERATURE ANALYSIS AND SYNTHESIS

With the aim of deriving a research agenda, the most difficult part of conducting a literature review lies in synthesising the information selected and critiqued (Parker et al. 1998). The reader should be informed about what has been learnt and what patterns can be identified (Webster & Watson 2002).

For classification purposes, we employed a two-dimensional matrix as depicted in table 4. While the first dimension addresses research question 2 (*what is the current state of knowledge on product-service systems in IS research?*), the second dimension targets formal meta-information about the articles in line with the applied taxonomy of Cooper (1988). It is not within the scope of this paper to outline all possible categories; instead, the focus lies on those that are relevant. The categories are mutually exclusive.

| **Characteristics** | | **Categories** | | | | | |
|---|---|---|---|---|---|---|---|
| **(1) Service science & IS** | **Applied term** | Service system (30) | Product service system (10) | Product service bundle (4) | Product service solution (9) | | |
| | **IT objective** | Efficiency (26) | | Value-adding (34) | | | |
| | **Customer role** | Non-customer involvement (18) | | Customer input (25) | | Co-creation (37) | |
| | **B2B vs. B2C** | B2B (62) | | | B2C (7) | | |
| | **Industry** | Manufacturing (30) | | Service (18) | | Information technology (15) | |
| | **Life cycle stage** | Start-up (21) | | Operation (18) | | Disposal (1) | |
| | **Standardisation of applied IS** | Individual (8) | | | Standard (2) | | |
| | | | | | | | |
| **(2) Meta-information** | **Focus** | Research outcomes (31) | | Research methods (1) | | Theories (20) | Applications (22) |
| | **Goal** | Integration (19) | | Criticism (4) | | Central issues (54) | |
| | **Audience** | Specialised scholars (47) | | General scholars (26) | | Practitioners (3) | General public (3) |
| | **Theoretical lens** | System theory (9) | | Unified service theory (2) | | SDL (23) | |
| | **Literature domain** | IS (52) | | OM (10) | MGT (6) | MKTG (8) | |
| | **Literature type** | Journal article (47) | | Conference proceedings (26) | | Textbook (5) | Other (2) |
| | **Research method** | Literature review (7) | Case study (19) | Survey (8) | Conceptual (29) | Illustrative (8) | Mathematical modeling (1) |

*Table 4. Matrix for literature analysis*

The characteristics and categories of the **service science and IS dimension (1)** are deduced from three sources: literature in OM, MGT, IS, and MKTG, interviews with senior managers from the enterprise application software industry and interviews with service science researchers. In total, seven characteristics can be identified. The *applied term* indicates which of the derived keywords is applied in the article. We consider the *IT objective* category since IT usually targets efficiency or value-adding goals in the IT business-value discussion (Melville et al. 2004). Also, the *role* of the *customer* is addressed due to its crucial meaning reflected in its appearance in several service definitions (Sampson & Froehle 2006; Sawhney et al. 2006; Spohrer & Maglio 2008). The creation of value can only take place interactively with customers (Vargo & Lusch 2008) in terms of consumers (*B2B*) or companies (*B2C*) (Becker et al. 2010). The characteristic *industry* specifies the primary industry sector in which

the investigated firm is operating. To analyse the *life cycle* aspect of product-related services, we draw on a framework (Becker et al. 2010) that assigns services to the corresponding life cycle stage of the product. The concrete IS support of product-related services is addressed in terms of *standard* or *individual* software and was in particular suggested by the practitioners from the software industry.

The second dimension contains the **meta-information (2)** and adopts the first three characteristics as proposed by Cooper (1988): *focus*, *goal*, and *audience*. In order to understand research outcomes, the applied *theoretical lens* is listed. In line with Alavi & Carlson (1992), we included three dimensions to provide further insights about the *literature domain*, the *type of literature*, and the *research method.* With the aim of classifying extant literature, the authors have counted articles containing particular phrases. However, an interpretation has not been conducted.

The results of the literature analysis are presented in a framework as depicted in table 4. In total, 81 relevant articles were found and classified according to the particular categories. Amongst them, 40 articles cover at least one stage of the product *life cycle* and the accompanying services. The majority of the articles are focused on *outcomes*. While 53 articles aim to address *central issues*, only four articles posit *criticisms*. Most research contributions (47) target *specialised scholars*. Extant literature prefers the *SDL* (23) as theoretical lens, whereas the *unified service theory* (2) and the system theory (9) are negligible. 52 articles are *IS* publications, while *OM* (10), *MKTG* (8), and *MGT* (6) account for a small number of results. Numerous articles are from *journals* (47) and *conference proceedings* (26), whereas *textbooks* (5) and *other* forms (2) represent just a small portion. In relation to the research method, there are 7 *literature reviews*, 19 *case studies*, 8 *surveys*, 8 *illustrative* and 29 *conceptual* articles. Only one article applies *mathematical modeling*. Conspicuous aspects of the results are presented in subsequent sections and are structured according to general findings and findings on the life cycle management of industrial services.

### 3.1 General findings

The cross-disciplinary character of service science prompts a differentiated view on the definitions. The term service is subject to considerable change and has a long tradition in MKTG and OM (Chase 1981; Hill 1977). The service debate has been revitalised by the seminal work of Vargo and Lusch (2004), fostering a paradigmatic shift as they propose that services and not products are the basic unit of economic exchange. 23 articles build on their work applying the SDL as theoretical lens.

However, the combination of products and industrial services leads to another direction. Oliva and Kallenberg (2003) even see a paradigm change from transaction-based services to relationship-based services. They claim that manufacturing firms begin their service endeavours with the installed base and then extend their portfolio through professional services such as training, consulting, and spare parts management. After dealing with these aforementioned transaction-based services, manufacturing organisations shift their focus to relationship-based activities such as sophisticated maintenance and operational services (Oliva & Kallenberg 2003). Tuli et al. (2007) posit a process-centric view considering customer solutions as relational processes comprising requirements definition, customisation and integration, deployment, and post-deployment stages. Based on these results, Neely (2008) derives empirically a classification of product-service systems. Each form of product-service systems possesses a different focus, i.e. integration, product, use, service, and result orientation.

A common pattern is observable in numerous articles. OM literature specifies a problem in the product-service domain in a concrete instance (e.g. bullwhip effect, synchronised supply chain or integrated life cycle management). The application of IT moderates the association between that challenge and the business performance while MKTG provides the theoretical lens.

The level of abstraction of the articles is structured in line with Österle (2010) (strategy, process and system). It ranges from product-service strategies (Gebauer et al. 2005; Neely 2008) over business processes (Goh & McMahon 2009; Paluch & Blut 2011) to dedicated IT systems (Günther et al. 2009). Most articles (30) reside on a procedural level that, for example, analyses a remote maintenance

process and the appropriate IT support (Zolnowski et al. 2011). Twenty eight articles discuss the topic on a strategic level, whereas only 17 articles can be positioned on a system level.

### 3.2 Findings on the life cycle management of industrial services

| Stage | Sub stage | Article | Individual Software | Standard Software |
|---|---|---|---|---|
| **Start-up stage** | **Service strategy** | Alter (2011) | | |
| | | Bensch et al. (2011) | | |
| | | Brohman et al. (2009) | | |
| | | Davies et al. (2006) | | |
| | | Gebauer et al. (2005) | | |
| | | Grace et al. (2008) | | |
| | | Holmström et al. (2010) | | |
| | | Karimi et al. (2001) | | |
| | | Menschner et al. (2011) | | |
| | | Schmidt-Rauch and Nussbaumer (2011) | x | |
| | | Schrödl and Turowski (2011) | | |
| | | Schweitzer et al. (2010) | | |
| | | Spohrer and Maglio (2008) | | |
| | **Service innovation** | Chae & Olson (2011) | | |
| | | Dominguez-Péry et al. (2011) | | |
| | | Sawhney et al. 2006 (2006) | | |
| | | Ye et al. (2011) | | |
| | **Requirements engineering** | Amberg et al. (2008) | x | |
| | | Becker et al. (2010) | | |
| | | Becker et al. (2011) | | |
| | | Berkovich et al. (2011) | | |
| **Operation stage** | **Maintenance** | Bitner et al. (2000) | | |
| | | Günther et al. (2009) | | x |
| | | Nyman et al. (2008) | | |
| | | Oliva and Kallenberg (2003) | | |
| | | Paluch and Blut (2011) | x | |
| | | Thomas et al. (2007) | x | |
| | | Thomas et al. (2008) | x | |
| | | Väyrynen (2010) | x | |
| | | Westergren (2010) | x | |
| | | Zolnowski et al. (2011) | x | |
| | **System Integration** | Erl (2005) | | |
| | | Galup et al. (2009) | | |
| | | Lee (2005) | | |
| | | Lim and Palvia (2001) | | |
| | | Marks and Bell (2006) | | |
| | | Mueller et al. (2010) | | |
| | | vom Brocke (2007) | | |
| | | Wang et al. (2010) | | |
| **Disposal stage** | **Recycle** | Beverungen et al. (2008) | | x |

*Table 5. Concept matrix*

We draw on the framework developed by Becker et al. (2010) (depicted in figure 1) that assigns services to the corresponding life cycle stage of the product. Three stages and six sub stages have been selected to answer the third research question (*how is the IS support of life cycle management*

*addressed in extant literature?).* Forty articles cover at least one particular phase of the life cycle. Each stage is explained below including research tendencies. Table 5 maps the articles to the life cycle stages and the sub stages to the IS support referred to as individual and standard software.

Services in the initial *start-up stage* refer to pre-sales activities such as problem analysis, consultant services (Menschner et al. 2011), and financial offerings (Becker et al. 2010). Design, engineering, and innovation processes also play a major role during this stage (Bullinger et al. 2003).Twenty one of the life cycle oriented articles account for the start-up stage. *Service innovation* and its potential is an emerging research topic (Rai & Sambamurthy 2006), for which 10 articles can be positioned on a strategic planning layer (*service strategy*), where scholars consider innovation as a holistic approach with the aim of planning and optimising service processes, e.g. by employing sourcing activities in service networks (Brohman et al. 2009; Schrödl & Turowski 2011). Another stream is centred around *requirements engineering* (Amberg et al. 2008; Becker et al. 2011; Becker et al. 2010; Berkovich et al. 2011) creating more attention in literature than customer feedback processes (Barnes et al. 2005).

In the start-up stage typical business processes include financial services for capital-intensive production of goods as well as the development and application of service-level agreements (Dietrich et al. 2008). However, software support for these processes is sparsely addressed. 21 articles can be assigned to the initial stage and thereof only 2 articles address the IS support. Individually developed software is the dominant approach during the start-up stage. In this light Schmidt-Rauch and Nussbaumer (2011) study IT-enabled co-creation at the service encounter in the travelling and finance industry by developing prototypes to support the advisory function. Amberg et al. (2008) report a gap between the challenges posed by the industrial service business and the actual implemented requirements. They continue that diversity in the application landscape can be reasoned with the knowledge specificity of the processes along the life cycle.

Literature dedicated to the *operation stage* is primarily concerned with services that uphold the operability of the physical component (Becker et al. 2010). 10 articles deal with *maintenance* activities comprising preventive maintenance, maintenance and repair, line operation, logistics, documentation, and training. Call centre and help desk activities in service encounters (Bitner et al. 2000) take a backseat to the utilisation of modern state-of-the-art monitoring (Paluch & Blut 2011) and maintenance services (Günther et al. 2009; Thomas et al. 2007). For this reason, extensive in-house software solutions (Väyrynen 2010) are applied to control and integrate smart devices (Westergren 2010) into the corporate IT architecture. IS scholars postulate a system-centric integration (Davies et al. 2006) perspective to analyse and solve problems articulated by practitioners and researchers from the OM field. 8 articles consider the IT architecture that provides the necessary *systems integration*, but neglect the software and infrastructure implementation. For example, scholarly literature investigates the relationship between SOA and business performance (Mueller et al. 2010) or proposes that SOA is a suitable approach to support service processes (Bardhan et al. 2010).

The IS support of operation processes is primarily provided through custom-build software. In particular, 6 maintenance processes are enabled by *individual software* solutions, whereas one singular article reports on a standard software solution. Custom-build interfaces allow communication between installed base, manufacturing execution systems and standard software modules such as ERP (enterprise resource planning) and CRM (customer relationship management). Further sophisticated remote services enable service delivery regardless the geographical location (Zolnowski et al. 2011) or mobile devices support the service staff to maintain the installed base (Thomas et al. 2008; Thomas et al. 2007). Both can contribute to co-creation with customer involvement. Individual software requires specific capabilities. Väyrynen (2010) identified 20 capabilities related to software development as well as to software business that are also valid for manufacturing firms. She concludes that requirement engineering and cost control capabilities are essential for the software service business. *Standard software* solutions can be partly ascertained by Günther et al. (2009). In their study they investigate IT infrastructure solutions in the manufacturing industry. Further they have analyzed the IT architectures of seven case companies in order to understand the positive effects of tight shop-floor integration. The architectural IT solutions comprise standard software modules such as ERP and data

warehouse as well as highly customized components, e.g. manufacturing execution systems and control systems. Given standardised IT components, Günther et al. (2009) conclude that tailoring the IT to firm-specific requirements is still a need for each manufacturer.

During the disposal stage, service activities include replacement, recycling, and disassembling (Becker et al. 2010). Research contributions for this stage are scarce. A single article addresses this stage and takes part in the sustainability discussion. Beverungen et al. (2008) have designed a SOA for the recycling of electronic equipment based on standardised IT systems. They conclude that SOA can provide the flexibility required by product-service systems.

# 4 RESEARCH AGENDA

After exploring the definitions and discovering the current state of knowledge from an IS perspective, it seems reasonable to target the final research question (*what are potential fields for future research endeavours?*). The results of the literature synthesis confirm the lack of enterprise application standards for the service business as proposed by Dietrich (2006). The enterprise software support of product-service systems is sparsely covered in the start-up stage, while the disposal stage does not enjoy much attention at all. For the operation stage, extant literature outlines that in-house developed software (Väyrynen 2010) is prevalent. Standard software solutions can rather be part of a mid-term perspective. We propose research in the following 6 fields derived from scholarly literature and specified in concrete research questions. Each research field correspond to the sub stages of the life cycle (Becker et al. 2010).

1) Analyzing existing requirements engineering approaches, Becker et al. (2010) conclude that conceptual modeling should combine event-driven process chain and service blueprinting. Berkovich et al. (2011), instead, focus on the integration of requirements engineering into the development process and the handling across different life cycle stages of product-service systems. They posit that an extension of the life cycle management is required to efficiently support the service part in product-service systems, leading to research issues: *What are the specific needs associated with industrial product-related services? What are the IT requirements for manufacturing firms entering the service business?*

2) After analysing the IT requirements of manufacturing firms further investigation is necessary on the design of analytical models that help to plan and execute standardized business services (Dietrich et al. 2008). Then reference models can be developed serving as a basis for concrete software prototypes. Beverungen et al. (2008) suggest that "standardising services" allows "a sound integration of products and services". Hence, we propose further research in the IS domain to adequately support business services through standardised enterprise application software: *What are reference models for the IT architecture of standardised business services?*

3) Regarding the operation stage literature scholars suggest additional research on the design and adaption of an IT architecture that supports maintenance activities. An initial approach to classify monitoring services has been conducted by Palut and Blut (2011). They investigate determinants of remote service satisfaction. Thomas et al. (2007) analyse a maintenance service by implementing a mobile solution for the plant and construction industry. They posit further research on the design of IS to improve customer quality despite technological complexity. Rather than focusing on the process level, the authors also facilitate research on the system level. Thus we propose more research to provide additional insights into the IT architecture and IT infrastructure that enable the communication and business execution between the installed base and the manufacturer's system (Günther et al. 2009): *What are best practices for product-service systems? Which is the appropriate IT architecture to support product-service systems?*

4) Zolnowski et al. (2011) outlines the need for a coordinated installed base management. They stress the importance of machine data. In order to take advantage of the machine data, they claim that

business analytics might give critical insights on customers and hence provide decision support. Further those data can be applied to improve corporate production, while knowledge management systems give the customers guidance for the appropriate usage of the machines. However, the success of knowledge management initiatives heavily depends on the managerial ability to make customers and employees contribute (Kankanhalli et al. 2005): *What is the potential of business intelligence and mass data analysis to give decision support? How can knowledge management systems help to overcome information asymmetries?*

In order to facilitate the development of standards for the IS support of product-service systems the authors primarily target requirements engineering, IT architecture and IT infrastructure. However, literature scholars also propose research in terms of IT governance and sourcing.

5) Some researchers study the product-service systems on a rather strategic layer with the aim of end-to-end optimization of the service business. Gebauer et al. (2005) analyse service strategies to overcome the service paradox and stipulate further research in the positioning of a firm in terms of behavioral and organizational theories. Building on their work, Tuli et al. (2007) reveals research gaps on contractual relationships, while Neely (2008) concludes that the organizational capabilities associated with product-service systems are under-researched. IT governance models are deemed promising for the management to control the relationship between suppliers and service providers. In this light, researchers might consider the questions: *What are the differences between the extant vendor management and the management of service suppliers and providers? Which adoptions are necessary to achieve a similar maturity?*

6) The sourcing of services is sparsely covered. Oliva and Kallenberg (2003) implicitly refer to sourcing by describing the final stage of transition to a service provider as "taking over the operation of the customer". Dietrich (2006) describes a "significant level of subcontracting" in the service context. In particular, the usage of sourcing reference models might provide useful insights to develop a better understanding about the factors influencing a sourcing decision. The management of a service network has created more attention in the community. Moreover researchers address the network dimension in service science (Brohman et al. 2009). When services are orchestrated through a network, it is quite important to ensure quality, leading to the questions: *What are the key performance indicators needed to monitor supplier performance in a service network? What is the suitable IT architecture to support service orchestration?*

# 5 CONCLUSION

This paper aims to analyse the body of knowledge of industrial product-related services and the management of their life cycle. Hence we conducted a structured literature review in line with a literature review framework while providing the relevant definitions for conceptualisation. Summing up, we analysed 81 articles on industrial product-related services and structured our findings according to the life cycle. Research question 1 (*what are the relevant research perspectives for product-service systems?*) was answered by rendering the relevant definitions, while research question 2 (*what is the current state of knowledge on product-service systems in IS research*) was approached through a deep analysis of the body of knowledge on the search as well as the classification. Research question 3 (*how is the IS support of life cycle management addressed in extant literature?)* strengthens the relevance of the life cycle management as proposed by experts from the enterprise application software industry. We conclude that extant literature lacks depth in the area of IS support for the life cycle management of industrial services. The enterprise software support of product-service systems is sparsely covered in the start-up stage. For the operation stage, extant literature outlines that in-house developed software (Väyrynen 2010) is prevalent. Standard software solutions can rather be part of a mid-term perspective. The disposal stage does not enjoy much attention. Subsequently, we outlined six potential research options structured along the life cycle with the aim of answering research question 4 (*what are potential fields for future research endeavours?).* Requirements engineering represents a

promising field to start the research endeavour since it will provide additional insights about the how and why manufacturing firms are applying individual software. After that we can continue research on developing reference models that cover the explored needs. Reference models and best practice analyses help to derive standardised building blocks which, in turn, serve as a basis for concrete software prototypes. The economic value of standard enterprise software lies in the compensation of knowledge asymmetries between manufacturing firms and customers on a reasonable cost level. Machine data allow the manufacturing firm to optimise the production, while the customer gains insights about the qualitative improvement of the installed base management. Additional research fields might cover sourcing through the service network, governance models for coordination and integration frameworks.

However, some restrictions are apparent when considering the results of this paper. Although the relevant journals and conference proceedings are subject to the database search, there is no guarantee that all relevant articles are taken into account. This holds particularly true since we emphasise the IS perspective. Furthermore, the terms applied as well as the selection are subjective to the authors, unless they are deduced from extant literature. Other keywords may lead to considerably different results. It could be argued whether the life cycle stages as proposed by Becker et al. (2010), provide the appropriate framework to classify and analyse industrial product-related services. Alternatively, the conceptualisations of Neely (2008), Tuli et al. (2007), and Sawhney et al. (2006) appear to be quite promising. Following vom Brocke et al. (2009) the applied literature review approach emphasises a structured review process with a strong methodological focus.

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