A WEB-CRAWLING BASED STUDY ON SERVITIZATION: ANALYSIS OF SERVICE OFFERINGS BY GERMAN MANUFACTURERS OF MACHINERY AND EQUIPMENT

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ANALYSIS OF SERVICE OFFERINGS BY GERMAN 
MANUFACTURERS OF MACHINERY AND EQUIPMENT

Research Paper

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Abstract

The machinery and equipment industry is, next to the automotive industry, the sector with the highest turnover in Germany. Here, servitization is a crucial contribution to remain competitive. Nevertheless, the diversity of this industry is not sufficiently taken into account in the scientific community. To overcome this gap, this study utilizes a web-crawling based approach to analyze service offerings of German manufacturers, linking key company figures to investigate potential correlations. This contribution differs from conventional studies using databases that hardly contain any detailed service information of smaller manufacturers. The proposed approach derives a clearer picture of the current service portfolio, considering all company sizes and its degree of servitization, enabling comparisons between micro-, small-, medium- and large-sized manufacturers. In context of digital servitization, the study allows further conclusions about the range of so-called basic services or advanced services and how these are related to key company figures.

Keywords: Servitization, Web-Crawling, Study, Germany.

1 Introduction

Globalization and digitalization have influenced the manufacturing industry for decades. The formerly product-oriented industry shifts increasingly towards comprehensive solution offerings to compete internationally. Within a digital servitization process, manufacturers develop advanced offerings incorporating digital services, e.g. remote service applications (Kohtamäki et al. 2020). Digitalization not only shapes the manufacturers' portfolios and leads to profound changes in all processes within an organization (Appelfeller and Feldmann 2018). This transition comes with numerous challenges, especially affecting micro-, small-, and medium-sized manufacturers (SMM) (Michalik et al. 2019).

As opposed to SMMs, large manufacturers, in most cases, have the resources to handle large-scale transformation projects and to develop advanced industrial product service systems (IPSS) (Jesus Pacheco et al. 2019). The extent to which digital servitization measurably influences companies’ performance has not yet been sufficiently investigated (Rapaccini et al. 2020) and linked to firm size in the industrial machinery sector (Crozet and Milet 2017). Furthermore, the current research pays too little attention to the essential German sub-sector, mechanical and plant engineering, which is usually categorized as "manufacturing industry". However, this includes all manufacturing companies of, for example, consumables or technical semi-finished products.
Especially in the machinery and equipment sector, with a valuable installed base, there are numerous – but so far underutilized - opportunities to gain new service-based revenue streams, to differentiate in the market and to utilize machine data as a resource for new business models (Adrodegari et al. 2018). However, most studies include several sectors and barely differentiate between company sizes. Thus, findings can hardly be provided for SMM in the mechanical and equipment sector (Bollhöfer et al. 2016). That is surprising as the industry occupies a significant position in the German economy. With over 6,600 companies, 1,064 million employees, and annual sales of 229 billion €, it is Germany's largest industrial employer (VDMA 2020). However, the authors note that a focused analysis of SMMs and a detailed insight into its servitization degree and potential correlations to key figures is hardly found in the current literature. Therefore, further surveys, interviews, or analyses of databases are necessary. However, these conventional approaches are limited in their ability to analyzing large sets of data within a reasonable timeframe. Furthermore, Mastrogiacomo et al. (2019) emphasize that different perspectives, such as firm size and sector, lead to very different results regarding servitization.

One reason for this is the data supporting these studies, often collected by surveys or interviews (Seegy 2009; Rainfurth 2003; Queiroz et al. 2020). Others rely on databases like OSIRIS (Neely 2008; Mastrogiacomo et al. 2019) or result from non-public data collections, such as those provided by the Fraunhofer ISI (European Survey) (Lay 2014; Lerch and Maloca 2020). To ensure both a high sample size and broad coverage of even the smallest manufacturers, the authors utilized a web-crawling based approach. The approach integrates additional information from databases to facilitate the analysis of service offerings. Since the service offering is a strong indicator for servitization (Neely 2008), the integration of web-based information ensures corresponding data regarding the service portfolio, which is insufficiently available in databases for small manufactures regarding their business activities (Mastrogiacomo et al. 2020). The utilization of websites for data acquisition is reasonable, as, on the one hand, almost all German companies run a website (Saam et al. 2016). On the other hand, companies tend to communicate their core business activities as transparently as possible (Möller et al. 2019; Teece 2010).

Because the authors could not identify any web-crawling based approaches specifically investigating the service portfolio of manufacturers, the study begins by outlining the usefulness of the web-crawling approach. Then, the manufactures are analyzed for offerings using a service classification scheme and a differentiation between basic services (BAS) and advanced services (ADS) according to (Sousa and da Silveira 2017), ensuring a clearer picture of the servitization degree in equipment manufacturing industry. To derive insights about the correlation between services and a companies’ performance, the data are contextualized with key figures. Therefore, we ask the following two research questions:

**RQ 1** How accurate is a web-crawling approach for classifying services of companies in categories?

**RQ 2** What is the current status of servitization regarding service portfolio of micro-, small-, medium- and large-sized manufacturers and how are company key figures thereby affected?

The paper is organized as follows. Section 2 introduces the theoretical background, explaining the peculiarities of manufacturing industries. Additionally, it illustrates the relevance and foundations of industrial product-service systems and servitization in general. Section 3.1 explains the application of the web-crawling approach, i.e., the use of keywords and the evaluation of the accuracy by manual testing the web-crawling results. Section 3.2 briefly discusses the applied metrics measuring the degree of servitization as well as the classification of service types. Section 4.1 gives insight into the sub-sectors of machinery and equipment industry and its degrees of servitization. Sections 4.2 and 4.3 analyze the specific service portfolio alongside company sizes and correlate the findings with measurable performance indicators. Lastly, section 5 discusses the results, highlights their contributions, explains limitations and discusses avenues for further research.
2 Theoretical background

2.1 The machinery and equipment industry

The German mechanical and equipment industry has a high proportion of SMMs. Almost 98% of the industries’ enterprises are SMMs generating 20% of the industry revenue. With revenue of 270,469 billion €, the machinery and equipment industry is one of the highest turnover industries in the German manufacturing sector (Statistisches Jahrbuch Deutschland und Internationales/2018). There are two definitions of SMMs frequently applied when analyzing companies, particularly in the EU. The European Commission has defined companies with a maximum of 250 employees and a revenue of up to 50 million € as medium-sized (European Union 2003). The IfM Bonn, specializing in research regarding the German Mittelstand, suggests a threshold of up to 500 employees. This contribution is also oriented, whereby the limit for turnover is the same as in the EU definition. (Institut für Mittelstandsforschung Bonn 2016). However, for micro- and small-sized manufacturers, the thresholds for both definitions are 9 and 49 employees and 2 and 10 million € turnover, respectively. In addition to quantitative criteria, SMMs display several distinguishing qualitative features. For example, the company’s proprietor has considerable influence on every aspect of the business (Ihlau et al. 2013). In terms of organizational structure, SMMs are less formalized than large corporations. Contacts between employees are close and informal, simplifying customized solutions (Ihlau et al. 2013). That can compensate for the fact that SMMs often display a less diversified business model (Hildenbrand et al. 2006). SMMs also have a small market share, are therefore exposed to greater competition, and face higher risks in developing new offerings (Ihlau et al. 2013). In terms of resources, SMMs face barriers regarding both financial and human resources. These limitations potentially inhibit the development of innovations and the investments necessary to follow or even lead the market (Caldeira and Ward 2003). Thus, SMMs differ from larger enterprises and therefore require specific attention in research. The NACE classification specifies the activities in the machinery and equipment industry. NACE (Nomenclature générale des Activités économiques dans les Communautés Européennes) is the European standard classification of productive economic activities. It presents the entirety of economic activities in a subdivision, which allows the assignment of a specific code to the performing unit (NACE rev. 2 2008). Businesses are structured into divisions, subgroups, and classes. Division 28 of the NACE classification summarizes the activities of machinery and equipment manufacturing. It includes five groups and 21 sub-sectors that extend from the manufacture of engines to the manufacture of plastic and rubber machinery. It also explicitly excludes the manufacture of metal products for general use (code 25) and other manufacturing divisions (26, 27, 29, 30), which clearly sets the focus on manufacturers of equipment being the subject of this servitization study.

2.2 Industrial Product-Service Systems

Previous studies indicate a significant correlation between the service portfolio and a company's general economic condition (Sousa and da Silveira 2017). Therefore, a detailed study of the service portfolio of manufacturers is useful, which, combined with the product offering, represents the IPSS of a manufacturer. Goedkoop et al. (1999, p. 18) provide the earliest definition of IPSS, describing it as “a marketable set of products and services capable of jointly fulfilling a user’s need”. Providing IPSS transforms the entire business model, requiring reallocation of existing resources and generating new resources and capabilities as needed or through partnerships (Reim et al. 2015). The process of servitization and the various manifestations of IPSS can be considered along a product-service continuum (Oliva and Kallenberg 2003). A successful servitization process leads to former product manufacturers acting as solution providers (Baines et al. 2007). IPSS have gained attention as a means of differentiation in markets, where conventional strategies no longer offer sufficient distinction (Baines et al. 2007). However, the Service Paradox describes the phenomenon that “it appears more difficult for firms to make incremental profits by adding services than might be expected” (Neely 2008, p. 105).

Moreover, as manufacturers tend to offer product-related services, the success of these offerings still depends on the sale of traditional products (Benedettini et al. 2015). Over the last few years, the domain...
of servitization has been increasingly concerned with digitalization (Kohtamäki et al. 2020). Since the transformation to a solution provider is closely linked to the digitization of business processes and services, the distinction between basic (BAS) and advanced services (ADS) is of interest to analyze the degree of servitization (Sousa and da Silveira 2017). Thus, Sousa and da Silveira (2017) utilize several criteria to distinguish between both types. In the detailed definition ADS are distinguished from BAS by providing "services related to co-creating value that goes beyond basic product functionality" (Sousa and da Silveira 2017, p. 464). ADS are therefore an important differentiator for integrated solutions, which are needed for advanced IPSS (e.g. rental, software, connectivity, etc.). In this paper, these criteria are used to classify identified services as either BAS or ADS to obtain a clearer picture in terms of the degree of digital servitization, which poses different challenges and requires various transformation strategies (Queiroz et al. 2020).

2.3 Previous relevant studies on Servitization

In the last three decades, there have been many studies on servitization in the manufacturing industry. These studies can be divided into four categories: case studies, approaches utilizing databases, surveys based on questionnaires, and interview-based analyses. Case study analyses profit from a high level of detail, thanks to unique sets of information being collected through interviews or workshops. Conversely, these studies suffer from small sample sizes, potentially limiting the applicability of the results. It is not uncommon for case study analyses to be limited to one (Peillon et al. 2015; Michalik et al. 2018) or two (Schioenning Larsen et al. 2019) companies, with more extensive studies covering 17 enterprises (Fundin et al. 2012). Furthermore, past studies have also been limited to larger companies with over 500 employees (Schioenning Larsen et al. 2019; Fundin et al. 2012).

Among those approaches using databases, the OSIRIS (Neely 2008), COMPUSTAT (Fang et al. 2008), and CAPITAL IQ (Neely 2013) databases stand out as the most prominent examples, with national ones such as the French BRN (Crozet and Milet 2017) or German DAFNE (Bureau van Dijk 2019) database being the exception. The main advantage of database-assisted approaches is the large sample size acquired using automated data collection algorithms. Sample sizes in the thousands (Neely 2013; Crozet and Milet 2017; Neely 2008; Fang et al. 2008) upwards of 190,000 companies (Mastrogiacomo et al. 2019) included in the analysis are not uncommon. While this is favorable in the interest of validity, these studies remain superficial in some areas or spare out groups of interest such as SMMs, e.g. due to their limited presence in databases. These approaches often utilize verbose descriptions of the companies’ business models and main activities as they are found in databases, which are then analyzed using automated keyword detection programs. These approaches, for example, result in the classification of companies as “pure manufacturer” or “servitized” (Mastrogiacomo et al. 2019). Other studies examine the types of services and distinguish, for example, between “basic” and “advanced” services (Sousa and da Silveira 2017). Many of these studies also limit their sample to such organizations with more than 50 (Mastrogiacomo et al. 2019) or even more than 100 (Neely 2013) employees, mainly omitting the highly relevant group of SMMs.

Another type of study uses existing and very detailed data such as publicly available annual reports of companies (Huxtable and Schaefer 2016). However, these are not always suitable for further research, e.g. because of the limited availability of information on small companies and their business activities. Approaches utilizing questionnaires can offer detailed insights. The European Manufacturing Survey (EMS) (Fraunhofer Institute for Systems and Innovation Research ISI 2015) is one of the most prominent and most frequently used databases of surveys analyzing companies from the manufacturing sector (Bikfalvi et al. 2013; Dachs et al. 2014). These studies’ scope varies considerably from 14 data sets (Sakao et al. 2008) to upwards of several thousands of data sets (Dachs et al. 2014). For specific research questions, it is common to develop new questionnaires. The resulting feedback typically leads to 100 – 200 company data sets (Kohtamäki et al. 2020; Queiroz et al. 2020). While the results are reasonable, the development, execution, and evaluation of these questionnaires are very time-consuming for all parties involved. That is why periodical surveys, e.g. to follow up a trend, are rarely conducted.

Due to different fields of research, a variety of data collection methodologies exists. However, existing approaches are not sufficient to survey the status of the service portfolio in the German manufacturing industry (particularly SMMs in NACE 28 sector), taking into account a broad coverage of SMMs.
3 Method of analysis

3.1 Prepare a service classification scheme and the web-crawler

To prepare the web-crawler and the search terms, the authors rely on preliminary work from database-based studies (see section 2.3). For example, Neely (2008) examined over 10,000 companies regarding the degree of servitization. Several filters were applied to obtain only relevant data, e.g. by only considering companies with specific industry codes (e.g. SIC or NACE codes). Since manual analysis of this information is hardly manageable, the software uses pre-defined search functions and terms. Various publications provided relevant search terms for this purpose, from which we draw (Mastrogiacomo et al. 2019; Neely 2013; Dachs et al. 2014). Furthermore, that enables creating a classification scheme from the manually identified activities, which is later used to classify all automatically identified data sets. The authors also used search terms to determine the degree of servitization of companies. First, we draw the necessary company information from the DAFNE database, which contains data on more than one million German companies and allows for detailed filtering (Bureau van Dijk 2019). The query used to extract information from the database specifies that it should only consider those companies, which meet the following criteria:

1. Solvency status: Solvent.
2. Industry code: C28 - Industrial machinery and equipment (see chapter 2.1).
3. Number of employees (NOE): Companies reporting a figure in at least one of the previous five years.
4. Return on sales (ROS): Companies reporting a figure in at least one of the previous five years.
5. Sales: Companies reporting a figure in at least one of the previous five years.

These filter settings lead to a result of 4,907 companies exported into a format compatible with the most common spreadsheet programs. Among others, the information in this spreadsheet covers the URL, the sales, and the number of employees of the enterprises. For further analysis, companies with less than five employees had to be excluded. Either the relevant information was not available, or they had unusual financial ratios. That reduced the sample size to 4,564 manufacturers. To configure a web-crawler, which identifies each company's specific service offerings, a validation data set is useful for checking the suitability of the approach and improving it until an acceptable level of accuracy. Therefore, the authors randomly selected 50 manufacturers for manual review of their webpages.

Previously, a literature analysis was carried out to identify a list of companies with specific industry codes (e.g. Gaiardelli et al. 2014; Brax and Visintin 2018). During the manual review process, the service offerings are marked with the respective manufacturer. Also, keywords for this service were added directly to the service list. The investigation of 50 manufacturers has led to a saturation of the classification scheme. The results are a comprehensive Industrial Service Classification scheme with related keywords (see Table 1), compiled in both English and German, to avoid excluding manufacturers with German-only websites. This process was iterative, whereby the selected keywords were refined using the validation data set. Furthermore, for each service classification, a number is assigned indicating the acceptable distance (d) between two keywords to identify the service as "provided by the manufacturer" (zero means that one keyword is sufficient). The authors note that a relatively lean keyword list is effective in enabling low false-positive results, whereas false-negative results in proportion barely increase.

Next, the authors chose Scrapy as an open-source web-crawler (Scrapy 2020). It provides built-in functionality and basic infrastructure to observe all restrictions and technical barriers found on each website. The scripts of the Scrapy framework are developed in the programming language Python. The web-crawler only analyzes websites containing the following terms in the (sub-) URLs: "service", "after sales", "support", "aftermarket", "offer", and "solution". The selected terms are also derived from the manual analysis process. For example, www.example.com/subpage/solution/ contains the term “solution” in the third subsection and is suitable, whereas www.example.com/ourproducts/ is not. This prevents unnecessary queries. Moreover, tests without this limitation result in an accuracy of about 66%, which is insufficient for further analysis.
### Table 1. Industrial service classification scheme for web-crawling based analysis

The high failure rate can be explained by the fact that companies with services usually have a corresponding web presence in which the search terms are correctly identified. In websites without services and without a limitation of the search space, many false-positive terms are identified, which in context, are not related to a service but products.
Consequently, this procedure leads to a higher degree of accuracy, even if there is always the risk of filtering out a few companies that offer services. Using the restriction above and the search terms in Table 1, the accuracy increases to 91% with the validation dataset. Finally, further 50 new manufacturers were randomly selected to manually evaluate the web-crawler results. The results from the first validation dataset (1st dataset) and the evaluation dataset (2nd dataset) are shown in Table 2. The evaluated accuracy reaches 89%, which is suitable for further analysis.

<table>
<thead>
<tr>
<th>Service-ID:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>Total avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy (in %) 1st dataset</td>
<td>78</td>
<td>94</td>
<td>88</td>
<td>90</td>
<td>90</td>
<td>88</td>
<td>94</td>
<td>98</td>
<td>86</td>
<td>90</td>
<td>86</td>
<td>98</td>
<td>98</td>
<td>84</td>
<td>98</td>
<td>84</td>
<td>96</td>
<td>100</td>
<td>80</td>
<td>91 %</td>
</tr>
<tr>
<td>Accuracy (in %) 2nd dataset</td>
<td>86</td>
<td>94</td>
<td>70</td>
<td>94</td>
<td>100</td>
<td>86</td>
<td>86</td>
<td>98</td>
<td>92</td>
<td>82</td>
<td>76</td>
<td>70</td>
<td>94</td>
<td>100</td>
<td>70</td>
<td>94</td>
<td>96</td>
<td>100</td>
<td>100</td>
<td>89 %</td>
</tr>
</tbody>
</table>

Table 2. Accuracy of the service classification

The crawler only accesses publicly accessible content for scientific purposes and no data of any kind is stored or otherwise used. The algorithm marks keywords binary (i.e., does or does not offer a service) in a spreadsheet. In total, 4,244 of the 4,486 companies display valid web addresses. The algorithm has checked these web addresses for possible barriers, such as web-crawling restrictions and connection timeouts (-173) or languages other than English or German (-86). Finally, 3,985 valid websites remain.

3.2 Applied metrics for measuring servitization

This contribution utilizes two metrics: The degree of servitization and whether BAS or ADS are offered (see section 2.2). To measure servitization, Calabrese et al. (2019) propose three approaches: objective, contingent, and subjective. The contingent approach is based on key figures such as "number of customers", while the subjective approach requires interviews to collect certain key figures such as "production strategy". Thus, the data provided by the web-crawler only supports the objective approach. In this context, both the number of service types and the number of services can be measured. As the definition of service types is not consistent in literature (Calabrese et al. 2019), this analysis distinguishes the service types BAS and ADS, proposed by Sousa and da Silveira (2017). BAS include all activities ensuring product functionality, such as installation, maintenance, and spare parts. This study considers product-specific training as BAS because these services do not require complex or digital capabilities (services 1 – 9 in Table 1).ADS aim to co-create and network with the customer, utilizing more sophisticated solutions that interact with the customer and often include digital components such as remote services or platform solutions. The services 10-19 in Table 1 are considered as ADS. The degree of servitization is measured by the number of services, whereby a company that provides at least one service is classified as a service provider. This simplified approach follows other studies (e.g. Neely 2013; Crozet and Milet 2017; Mastrogiacomo et al. 2019) ensuring comparability.

4 Results

The dataset shows that 2,118 of 3,985 manufacturers provide at least one service. That leads to a servitization degree (manufacturers with at least one service and belonging to NACE 28 sector) of 53%, similar to previous database-based studies. In the concluding chapter, a detailed discussion follows on how this result relates to previous studies.

4.1 Insight into the industrial service landscape

Figure 1 shows BAS and ADS by sub-sector. There is a noticeable difference in the number of manufacturers without services, depending on the sub-sector. For example, the sector with NACE code 2820 (Manufacture of other general-purpose machinery) has the highest proportion of services at 70%.
By contrast, in the sector with NACE code 2891 (Manufacture of machinery for metallurgy), 44% of manufacturers offer services. Moreover, a deeper analysis of the sub-sectors revealed that these differences might not relate to the average employee numbers. Across all manufacturers, the average number of employees is 211, highlighting the nature of the German Mittelstand. The sub-sectors mentioned above (2820, 70% of services and 2891, 44% of services) have 120 and 128 employees on average. This indicates there may be sub-sector-specific circumstances that require or encourage service-oriented business models. Concluding, future research might focus on cross-industry approaches transferring best practices to similar sectors.

![Figure 1. Share of BAS and ADS by NACE 28 manufacturers (n=3,985)](image)

### 4.2 Service offering by manufacturer size

Figure 2 outlines the service provision by manufacturers’ size. The level of service provision goes along with the firm size. Research ignoring this may find a higher degree of servitization than in reality.

![Figure 2. Services of manufacturers (n=3,985)](image)

It is noticeable that the proportion of manufacturers with solely BAS remains constant for SMMs, while those with additional ADS are increasing. In the group of large manufacturers, these ADS are continuing
to grow and are displacing those with BAS. Based on the service classification scheme in Table 1, Figure 3 illustrates the prevalence of services among those manufacturers offering at least one BAS or ADS.

It indicates that BAS, such as hotlines, maintenance, or spare parts, are the most frequently provided services. ADS are found less often, with full-service contracts (26.1%) and remote services (20.5%) being the most common advanced offerings. Considering the company sizes, it becomes clear that SMM are positioned in basic services compared to large competitors. Large manufacturers offer ADS more than twice as often as SMM (e.g. Remote Services: SMM 11%-28% vs. large manufacturers 54%). SMMs appear to have more significant difficulties in digital servitization or do not consider the benefit of ADS. These are partly due to limited resources and the required know-how, which larger manufacturers are more able to provide (Lerch and Maloca 2020).

![Figure 3. Offerings of SMMs and large manufacturers with at least one service (n=2,118)](image)

### 4.3 Service offering and the manufacturers' performance

The available data from the web-crawling analysis and the DAFNE database allows the relation to company size (number of employees) with different key figures (see Table 3).

<table>
<thead>
<tr>
<th>Size</th>
<th>Manufacturers without Serv.</th>
<th>Manufacturers with BAS</th>
<th>Manufacturers with ADS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sales (€)</td>
<td>SPE (€)</td>
<td>ROS (%)</td>
</tr>
<tr>
<td>5-9</td>
<td>1,496,139</td>
<td>220,296</td>
<td>1.30</td>
</tr>
<tr>
<td>10-49</td>
<td>3,655,342</td>
<td>163,363</td>
<td>6.34</td>
</tr>
<tr>
<td>50-149</td>
<td>16,187,318</td>
<td>190,826</td>
<td>2.54</td>
</tr>
<tr>
<td>150-249</td>
<td>50,844,772</td>
<td>252,781</td>
<td>3.51</td>
</tr>
<tr>
<td>250-349</td>
<td>73,767,275</td>
<td>243,259</td>
<td>4.32</td>
</tr>
<tr>
<td>350-499</td>
<td>92,251,531</td>
<td>218,165</td>
<td>6.30</td>
</tr>
<tr>
<td>500-999</td>
<td>180,485,528</td>
<td>272,060</td>
<td>5.41</td>
</tr>
<tr>
<td>&gt;1,000</td>
<td>638,781,287</td>
<td>257,301</td>
<td>5.99</td>
</tr>
</tbody>
</table>

Table 3. Overview of key company figures by size group

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Figure 4 represents the results of this analysis and consists of three diagrams. The servitization process describes a shift in business logic from product-oriented to service-oriented business models (Vandermerwe and Rada 1988). Thus, to highlight differences between the three categories of manufacturers (no services, BAS, and ADS), the key figures are normalized to the values of manufacturers without services. The results are plotted by the size of the manufacturers.

The first diagram describes the return on sales of manufacturers, normalized to manufacturers without services. Since the database for this key figure does not include values for all manufacturers, the authors restrict their analysis to the remaining 798 manufacturers that provide usable data for the return on sales. However, this means that the smallest manufacturers (less than ten employees) are not included, as insufficient information is available. It is noticeable that smaller manufacturers (10 - 149) with ADS have lower return on sales than companies without services. Nonetheless, the BAS offering seems to impact ROS for manufacturers with 50-249 employees positively. ADS also deliver better ROS with 150-249 employees. The values become more concentrated in the next size categories, and it is hardly possible to derive a clear trend. It could even be concluded that the ROS figure seems to barely correlate with the service offering in the larger manufacturer categories. Yet, small manufacturers (10-49) with BAS or ADS have a considerably worse ROS. This tendency deteriorates in the next larger groups (50-149) for those offering ADS. In contrast, manufacturers with BAS have a significantly better ROS, which can still be seen in firms with 150-249 employees. Also, only from this size category onwards, manufacturers with ADS appear to move away from worsening ROS values.

The second diagram illustrates the sales per employee (SPE). It is noticeable that manufacturers with 5-149 employees offering ADS, have the highest SPE in this group. In the following size categories of 150-499 employees, no clear trend is apparent, whereby manufacturers with ADS showing better overall SPE values. For manufacturers with BAS, the figures first decrease (250-349) and then, with 350-499 employees, they even perform slightly better than in the competitions with ADS. From 500 employees upwards and beyond; however, it is noteworthy that manufacturers without services show better figures. Companies with BAS perform particularly poorly here, while those with ADS have at least similar values to manufacturers without any services at all. An explanation could be a drastic increase in the number of employees, especially in the group with more than 1,000 employees.
The third diagram compares the manufacturers' key figures, as explained above, with total sales. It is noticeable that a "u-shaped" relationship is plotted for manufacturers with ADS, similar to previous studies in terms of service revenue and company size (Dachs et al. 2014). Those with 5-149 employees seem to be much more successful than those without services. For groups with 150 - 499 employees, this advantage decreases rapidly, although on average the figures are still better than for manufacturers without services. For manufacturers with more than 1,000 employees, it is evident that ADS are almost a must for successful manufacturers; otherwise, sales will drop drastically. A similar picture emerges for manufacturers with BAS. In this case the "u-shaped" linkage is less prominent and, besides in the mid-size categories, it even results in lower sales figures compared to manufacturers without services. The reason why this is the case cannot be answered from the data. An explanation could lie in manufacturers struggling with low sales figures using BAS to support their product business, which is no guarantee of success in a challenging market environment.

Figure 5 examines the key figures in light of different service offerings. According to this analysis, manufacturers in the group without services have, on average, 65 employees. In the group with BAS there are 80 employees. In the group, with ADS the average number of employees rises to 605.

![Figure 5](Linkage between company key figures and service offering (n=3,985 except ROS, n=798))

To summarize, companies with BAS have better ROS. Simultaneously, the key figures sales and sales per employee barely differ between manufacturers with or without BAS, which could explain some manufacturers' hesitant position towards digitalization. Manufacturers with ADS show only the second-highest return on sales, but they have the strongest key figures apart from that. That can be attributed to the fact that manufacturers with ADS are primarily larger companies. The analysis of individual services regarding linear relationships to key company figures (Pearson correlation) provides further insights. A correlation coefficient (see Table 4) indicates the interrelation between the average existence of a service and certain key figures of eight manufacturer size groups (5-9, 10-49, 50-149, 150-249, 250-349, 350-499, 500-999, >1,000). The greater the absolute value of the coefficient, the stronger the relationship between the variables. The significance level indicates the probability that the determined correlation is correct. A p-value below 0.05 is considered significant, below 0.01 very significant. A high correlation between two variables does not imply a causal relation, but provides a first indication. First, it is noticeable that the significant correlations regarding the average presence of a service in the size groups and the figures for Sales and NOE are nearly identical. This is plausible since these key figures are strongly linked. It is further notable that the significant values for Sales and NOE are exclusively attributable to ADS. Therefore, the size of the company (which usually results in higher revenues and employee numbers) is closely correlated with the occurrence of ADS. In contrast, BAS are widely offered by all size groups, meaning there is no significant correlation. In the case of ROS, the occurrence of some services seems to correlate with the size of the company. Within this context, six BAS show significant correlations and three ADS, which may indicate that BAS in particular are more attractive from an investment perspective, which furthermore matches the values in Figure 4. This impression becomes even clearer by looking at the SPE figure, where only BAS show significant correlations. The size groups frequently offering BAS also have higher SPE on average than those with less BAS.
In summary, especially BAS correlate positively with the key figures ROS and SPE. On the other hand, the provision of ADS is going hand in hand with increasing sales or NOE, which illustrates the ongoing strong dependence on digital solutions and the size of the company. The fact that there is hardly any correlation between ADS and ROS and SPE could explain why many manufacturers prefer operating in the BAS area, since ADSs provide comparatively lower key figures here.

<table>
<thead>
<tr>
<th>Service</th>
<th>Pearson-Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sales</td>
</tr>
<tr>
<td>Help Desk or hotline</td>
<td>0.42</td>
</tr>
<tr>
<td>Repair and maintenance</td>
<td>0.48</td>
</tr>
<tr>
<td>Spare parts</td>
<td>0.43</td>
</tr>
<tr>
<td>Upgrades &amp; Improvements &amp; Remanufacturing</td>
<td>0.64</td>
</tr>
<tr>
<td>Product installation / start-up</td>
<td>0.39</td>
</tr>
<tr>
<td>Training and consulting</td>
<td>0.45</td>
</tr>
<tr>
<td>Inspection and diagnosis</td>
<td>0.59</td>
</tr>
<tr>
<td>Remote Services</td>
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</tr>
<tr>
<td>Documentation</td>
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<tr>
<td>Platform Services</td>
<td>0.76 *</td>
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<tr>
<td>Recycling and disposal</td>
<td>0.59</td>
</tr>
<tr>
<td>Financial services &amp; Leasing or Renting</td>
<td>0.83 **</td>
</tr>
<tr>
<td>Product-testing and -development</td>
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</tr>
<tr>
<td>Extended Warranty</td>
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<tr>
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<tr>
<td>Advanced Remote Services</td>
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<tr>
<td>Software development</td>
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</tr>
<tr>
<td>Use- or Functional Payment</td>
<td>0.77 *</td>
</tr>
</tbody>
</table>

Note: Significance with: **p < 0.01, *p < 0.05

Table 4. Correlation of services and key figures

5 Conclusions, Limitations and Outlook

In this study, a web-crawler is utilized that automatically analyses the service portfolio of German manufacturers. Further, a classification scheme including keywords was developed. The classification of manufacturers offering at least one service leading to a servitization degree of 53%, which is in line with previous studies. Within a worldwide survey, Mastrogiacomo et al. (2019) determined a service degree of 49% for the manufacturing industry within the NACE 28 sector. Neely (2013) calculates a servitization degree of 39.99% for the entire German industrial sector. Lerch and Maloca (2020) quantify the share of all manufacturing companies in Germany with a service-oriented business model at 42%. Based on surveys, Dachs et al. (2014) calculate that 88% of German manufacturers offer at least one service. This large discrepancy to other database-based studies leads to the conclusion that datasets containing brief descriptions of business activities might not provide all the information needed to investigate the servitization field. Furthermore, Mastrogiacomo et al. (2019, p. 3929) state, that the “differences can be partially explained by the different samples of analysed companies” and “by the different data collection method (primary vs. secondary data)”. However, it depends on the purpose of the method: When comparing different industries or countries, such approaches are quite useful, since methodical errors affect the entire field of investigation. Nevertheless, these studies use different methods (e.g. database-based analysis or surveys). Thus, a direct comparison to this contributions’
results is not reasonable and can merely be interpreted as an indicator, that the accuracy of the web-crawler is suitable, which is also addressing RQ 1. The proposed approach in this contribution assumes that service offerings presented on the manufacturers’ website actually exists in practice. Although most manufacturers operate websites (Saam et al. 2016), this does not necessarily result in an appropriate representation of the real service portfolio. At least in the e-commerce domain several studies conclude that the quality of information is an important factor for sustainable customer satisfaction (Rasli et al. 2018). Transferring this to manufacturers, one could assume, that they strive to map their service portfolio near to reality to avoid compromising customer satisfaction in service delivery. However, this assumption is a clear limitation and further qualitative research (e.g. interviews or surveys) is needed to clarify whether the web-based information corresponds to reality. Nevertheless, this limitation might also apply to other survey methods in which information can be incorrectly provided.

Addressing RQ 2, the degree of servitization correlates with the company-size, as previous studies suggest. While 41% and 47% of micro- and small-sized manufacturers offer services, the share rises to 68% and 84% respectively for medium- and large-sized manufacturers. Further, it can be noted that advanced and digital services in particular are still the domain of large companies, with basic services tending to be offered in all size categories. These BAS appear to be primarily related to the key figures of sales per employee and return on sales, which suggests that offering BAS is more lucrative, especially for SMMs that have limited resources. Furthermore, small manufacturers, managing to offer ADS, can also show positive key figures, but deliver poor return on sales values, which can possibly be explained by high investments. The result that a u-shaped curve was identified in the sales figures for manufacturers both with BAS and, to a much greater extent, with ADS, indicates that the transition to a solution provider might come with numerous hurdles, especially for SMM. Further effects must be taken into account in more in-depth analyses. For example, a certain number of small manufacturers with ADS could be subsidiaries and spin-offs of large companies, e.g. to reorganize digitalization activities of large companies and to expand their business field. In addition, SMMs in niche markets may offer ADS more profitably. Further research is needed to explain the identified u-shaped curve in Figure 4.

There are further limitations. The algorithm is evaluated with an accuracy of 89%, meaning that either some manufacturers were assigned a service that they do not provide, or the algorithm overlooked services. Even if the results still seem plausible, the choice of keywords influences the outcome. Moreover, the DAFNE database's data did not provide insight into service revenues, meaning that merely indirect conclusions can be drawn based on overall performance. Lastly, the study has a strict focus on the German market and only considers a sample size that is a fixed snapshot in time. Meaning, that only those companies were included that were listed in the database at the time of the study.

This study demonstrates, as scientific contribution, that web-crawling tools can be used in the field of servitization as a complementary source of primary data and further provides a detailed picture of the degree of servitization in the German machinery and equipment industry. Therefore, this contribution lies the basis for future research. An outlook and potential avenue for this would be to extend the scope of the analysis to more countries individually or globally. Furthermore, the integration of additional key figures, such as service revenue or profit, is a logical step. The results also show that the success of a manufacturer is not only dependent on the mere ambition providing digital services, but that basic services can also represent a successful business model. Thus, future servitization research should take a more differentiated view of transformation strategies and other environmental factors. Regarding managerial implications, the results may assist practitioners to categorize their own company in terms of servitization based on their relevant sub-sectors. In contrast to broad statements about the service portfolio in the entire manufacturing industry, a detailed picture is provided that practitioners may use for benchmarking. The key figures in relation to company size or service portfolio also assist to challenge their own company's performance and to identify fields of action.

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