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ScienceDirect

Procedia CIRP 136 (2025) 892–897

www.elsevier.com/locate/procedia

35th CIRP Design 2025

Communicating financial impact: A prototype for assessing customer value in remote operation support services

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Abstract

While many manufacturers invest in IoT solutions, two-thirds struggle to generate revenue due to challenges in measuring and communicating customer value of service solutions. A common mistake is prioritizing technical feasibility of such smart services without aligning innovations with customer value or willingness to pay. In collaboration with a leading machine manufacturer, this paper addresses this issue by developing a prototype designed to measure and communicate the financial impact of customer value, providing sales teams with a practical tool. This approach forms the foundation for assessing and conveying the value of smart services, supporting sales teams in their efforts.

Keywords: Customer value, smart services, manufacturing, remote operation, prototype artifact

1. Introduction

Manufacturing companies are facing intensifying global competition due to the commoditization of their products [1], [2], prompting them to seek innovative ways to maintain their competitive edge [3], [4]. The advancement of digitalization, the Internet of Things (IoT) [5], and Industry 4.0 [6] has led to increasing interest in smart services as part of product-service systems (PSS). These services leverage connected systems and advanced machine intelligence to create value through intensified collaboration between customers and providers during product usage [7].

Despite theoretical acceptance, companies often make the mistake of initiating projects to develop smart PSS based solely on technical feasibility without delivering significant customer value or aligning efforts with customers' willingness to pay [8], [9]. The primary challenge in selling smart services as part of a PSS lies in effectively conveying the value proposition to ensure successful sales. Grubic and Peppard [10] emphasize this gap, identifying ineffective communication of service value as a key barrier to smart service adoption: "articulating and calculating the benefits [...] demands a 'leap of faith' as it is very hard to prove the value of the technology that aims to prevent things from happening" [10, p. 163]. A 2019 benchmarking study found that over 70% of participating manufacturers were investing in IoT solutions, yet two-thirds were unable to generate significant revenue from these investments [11], despite their substantial financial potential [12]. This indicated a gap in translating the benefits of smart services into efficient quantification and communication of their value [12], [13]. Participants were willing to identify value; however, they found quantification too difficult or costly due to time constraints, limited data access, and the complexity of assessing performance impact. Consequently, these barriers often made the process more expensive than the expected profit margin or value.

Existing literature indicates that the issue of communicating and predicting customer value of such services remains insufficiently addressed. Examining the challenge of predicting the key quantitative benefits of Remote Operation Support

10.1016/j.procir.2025.08.152

(ROS) Services could empower sales teams to communicate these benefits to customers. This study aims to develop knowledge and provide guidance on effectively communicating and predicting the individual customer value and financial impacts of ROS Services. The objective of this research is to address the following research question (RQ): *"How can the quantitative customer value of ROS Services be communicated through a prototype artifact?"*

To answer this RQ, we analyze the quantitative impacts of ROS Services on customers' financial status (i.e., the necessary information to be provided in the artifact), and then examine how a artifact should be designed to effectively communicate these quantitative impacts (i.e., the actual artifact design). In this research, we use a leading manufacturer in the sheet metal industry as the unit of analysis to develop a prototype artifact that helps communicate the individual value ROS Services create for each customer. This prototype specifically focuses on articulating the financial impact on customers while incorporating customer-specific context variables. Our results support companies struggling to effectively communicate these benefits by helping them identify where financial customer value is created, predict individual customer value, and effectively articulate it. This knowledge can support companies clearly communicate the benefits of smart services to customers, ultimately aiding sales teams in their efforts.

2. Background and related work

Smart services involve aggregating and processing data from digitally interconnected physical objects, known as smart products, to create additional value [14]. Early proponents highlighted that smart services surpass product-related services such as maintenance or upgrades in terms of customer value and cost efficiency [15]. To offer smart services the products must exhibit smartness and connectivity. The term "smart" typically refers to key characteristics such as the ability to take pre-emptive actions, make decisions autonomously [15], and provide seamless connectivity between systems and components [16]. Smart services depend on these capabilities of smart products, including real-time data collection, location tracking, and self-optimization [17], [18]. In a manufacturing context, key capabilities of smart services involve communication, remote monitoring, and optimization of machine operations. Remote access to smart products allows for their control and management from a distance, facilitating remote maintenance where issues can be diagnosed and rectified without physical presence [18], [19].

As a specific type of smart services, remote services – provided over a geographical distance [20] – are becoming increasingly important for manufacturing companies [21]. Factors contributing to this trend include a shortage of skilled workers, workplace changes, and the growing complexity of tasks [22]. Remote services are delivered over digital interfaces, allowing delivery regardless of the physical distance between the provider and the customer [23]. Unlike traditional services, remote services eliminate the need for contact and the simultaneous physical presence of both the service provider and the service object during the delivery process [24].

Current methods for innovating such services have not fully addressed the issue of communicating and predicting their customer value. The Smart Service Canvas [25], for instance, emphasizes customer-centricity but focuses on qualitative needs without quantitative value assessment. Similarly, value-based pricing studies propose methods like conjoint analysis to gauge customer value but lack practical methodological guidelines [26]. A study provides a framework for measuring IoT solution value, with value levers for initial quantification; however, it does not address their impact on financial status. Furthermore, it fails to identify the most effective KPIs to convey value to customers [27]. A personalized PSS design framework using digital twins and extended reality emphasizes customer inclusion and visualizes customer input on virtual prototypes [28]. Building on this, our work focuses on visualizing the financial value of smart services, such as remote operation, enhancing PSS by highlighting individualized customer benefits and economic value. Other industries like tourism include specific features like sustainability in communicating customer value but also lack thorough quantification of that value [29].

3. Methodology

We based our methodological approach for designing an artifact that supports sales teams in providing quantitative benefits added by a ROS on the design science research (DSR) paradigm [30]. In this light, we structured our research process into five steps, following the guidelines outlined by Kuechler & Vaishnavi [31] and vom Brocke et al. [32].

Throughout our study, we conducted six expert interviews, five workshops and multiple informal discussions with TRUMPF SE + CO. KG (hereafter: TRUMPF) serving as our unit of analysis. The company was suitable to answer our RQ for three main reasons: (1) its leadership in smart manufacturing, (2) its established ROS Service, and (3) its current focus on optimizing customer value and communicating it. TRUMPF's ROS Service provides remote support to their customers by detecting and resolving machine errors quickly, thereby increasing production time and operational efficiency. It also allows customers to reduce the need for specialized staff during night shifts, further cutting personnel costs while maintaining high performance.

The first step in our DSR study involved identifying the problem space and the value of the potential solution [32]. This was achieved through a combination of six expert interviews, personal discussions with service owners and sales representatives of TRUMPF, and a literature review, which we aggregated in specific pain points, goals and requirements of the different stakeholders.

In the second step, we formulated ideas for solutions that effectively address the problem in alignment with stakeholders' needs. Throughout this process, we engaged in various activities such as informal discussions and six semi-structured interviews with experts from TRUMPF.

In step three, the design and development of our artifact, we first held one workshop to brainstorm, categorize, and organize the value levers, ultimately identifying the key customer benefits. We then analyzed the financial implications of each lever, assessing its quantifiability and impact on the customer's balance sheet or income statement to determine the financial impact of the ROS Service in two more workshops. Through informal discussions, we then identified six key KPIs that were most relevant to the ROS Service, which were further reviewed and refined through six expert interviews to ensure they were aligned with customer expectations, sales strategies, and overall relevance. In a final workshop, we decided on only four KPIs and developed initial quantification formulas to tailor them to customer-specific factors. Additional discussions with the service team helped to iterate and refine these calculations. Based on the four KPIs and their calculation formulas, we designed the actual artifact in the form of a dashboard. The implementation was based on the knowledge gained earlier, combined with insights from further interviews and discussions on preliminary versions of the artifact implementation, leading to the final implementation presented in this paper.

Finally, in the fourth and fifth steps, the artifact was demonstrated and evaluated to assess how effectively it addresses the identified problem. Dummy values derived from test customers of the ROS Service, along with insights from the sales team, were used as input values for our calculations, and its results were integrated into our prototype artifact for demonstration purposes. The evaluation session involved a focus group consisting of two service owners and two members of the sales team, using both quantitative and qualitative criteria to measure the artifact's performance. After the evaluation session, we reflected within the author team on the project outcomes to outline theoretical and practical implications for future applications.

4. A prototype for calculating and communicating customer value of ROS Services

4.1. Problem space

Many manufacturing companies, including TRUMPF, face challenges in transitioning from selling physical products to smart services [1], [2], particularly in communicating [10] and quantifying the value of these services [13], [33]. The literature shows that companies struggle to generate revenue from IoT solutions due to difficulties in demonstrating customer value, as its quantification is costly, complex, and hampered by challenges in accessing customer data [33].

So far, the sales staff of our analysis unit promotes their smart service only by relying on qualitative arguments like "saved time" and "increased productivity" rather than quantifying their financial potential. As a complex service, the ROS Service *"requires a lot of explanation,"* but sales representatives are often disincentivized due to the effort involved, as one interviewee noted: *"The challenge is the lack of incentive compared to the effort required to explain it [...]. The representative has to go into a lot more detail, but at the same time, he's selling a much smaller amount and is therefore less incentivized" (R&D Manager).*

Shifting from qualitative to quantitative arguments is crucial to support the sales team, enabling them to more effectively explain the ROS Service's benefits. At the current state, without a clear financial demonstration, the sales team struggles to showcase its value, as stated by one interviewee: *"The quantitative argument is missing."* This reflects both the team's limited experience and uncertainty about how to communicate the service's financial impact: *"how does the service impact finances? I believe we currently lack both the creativity and the tools to provide the necessary evidence."* The lack of concrete evidence or success stories hampers trust, both with customers and within the sales team, affecting their ability to market the ROS Service effectively.

To summarize the identified current problems, Table 1 provides an overview of the three main actors, their pain points, and the resulting requirements for our DSR study.

Table 1. Goals, pain points, and requirements of main actors.

Actor	Service owner	Sales representative	Customer
Goal	Establish a profitable service.	Reduce effort in selling a quality product.	Optimize their productivity and profitability.
Pain points	Difficulty in quantifying financial benefits, leading to challenges in building trust.	Lack of trust and uncertainty in communicating benefits, high effort versus low incentives to promote service.	Lack of trust and evidence regarding the quality of the service.
Requirements	A tool to help the sales team effectively communicate the quantitative benefits.	Proof/success stories and a tool to convey quantitative benefits with minimal effort.	Proof/success stories to demonstrate the efficiency and quality of the service.

4.2. *Identifying the relevant KPIs*

In the workshop with the product manager of our analysis unit, we applied Baltuttis et al.'s IoT framework [27] to identify four value levers for the ROS Service:

Creating additional production time. ROS Service enables faster error detection and resolution, reducing unplanned downtime and optimizing machine runtime, thus increasing production time and flexibility.

Enhancing planning capability. Reduced idle time improves delivery reliability and production planning, minimizing disruptions like delays or production stoppages.

Reducing personnel costs. TRUMPF handles trouble-shooting during night shifts, reducing the need for highly specialized staff and allowing customers to hire less qualified, lower-cost personnel while improving working conditions.

Increasing productivity. ROS increases the number of products produced per time unit, boosting overall productivity without raising input costs.

Two additional workshops with the Financial Services Sales Manager explored how these levers impact the P&L statement and balance sheet. Key financial metrics identified were revenue, personnel expenses, and operating profit for the P&L, along with fixed assets and equity for the balance sheet. Based on these discussions, we focused on KPIs that included these metrics that best quantify efficiency and effectiveness.

During interviews, the KPIs were validated with service owners and the sales team. While financial KPIs were appreciated for their ability to facilitate comparisons and provide clearer representation, sales members raised concerns about customers' reluctance to share sensitive data. As a result, we settled on four KPIs: personnel expenses, ROI, increased production time, and payback period. These balanced operational and financial indicators effectively captured the benefits of the ROS Service without relying on sensitive financial data.

4.3. Calculation of the relevant KPIs

After determining the four KPIs, our goal was to develop a calculation method that would be easy for the customers and the sales team to understand, while remaining realistic and accurate. During this process, we realized that the calculations for production time and labor costs needed to vary depending on whether the customer has an On-Site Operator (OSO) or not. The operational conditions for these two scenarios differ because the ROS Service operates differently in each case. Without an OSO, both the component where the customer resolves issues themselves and the ability for remote operators to guide the OSO are eliminated. This requires us to adjust the calculation methods accordingly. Additionally, we found that the ROI and payback period are directly linked to production time and personnel expenses. While the formulas for calculating ROI and payback period remain the same for both scenarios (with or without an OSO), the actual values differ due to variations in production time and personnel expenses.

Production time. Production time refers to the amount of time a machine is actively running and producing without interruptions, also known as downtime. Downtime occurs when the machine is stopped due to errors, maintenance, or any other reasons, which reduces the machine's productive output. The calculations vary across four use cases, depending on whether the customer has an OSO and whether they use the ROS Service.

Use case 1: The customer has an OSO and is not using the ROS Service. In this scenario, the OSO handles all troubleshooting during downtime. For example, if there are 6 standstills (i.e., times the machine stops) during a shift, and each takes 20 minutes to troubleshoot, the total downtime for that shift is 2 hours. With an 8-hour shift, 6 hours are productive. Multiplied by the number of shifts per year, this gives the total annual production time.

Use case 2: The customer has an OSO and is using the ROS Service. In this case, ROS Service helps the OSO by troubleshooting many issues remotely, reducing the time spent on each standstill. Based on probabilities from our analysis unit, most issues are solved remotely, some are resolved with guidance, and others by the OSO alone. This means that, depending on how each standstill is solved, the total downtime decreases, resulting in more productive time.

Table 2. Relevant factors for calculating production time for use case 1 & 2

Relevant factors
(1) $\boldsymbol{Number\ of\ standstills\ per\ night\ shift}$
(2) $\boldsymbol{Average\ duration\ of\ troubleshooting\ of\ standstill}$
(3) $\boldsymbol{Hours\ per\ night\ shift}$
(4) $\boldsymbol{Number\ of night\ shifts\ per\ year}$

Use case 3: The customer does not have an OSO and is not using the ROS Service. Without an OSO or ROS, downtime is determined by how long the machine operates before a standstill occurs. The Mean Time Between Standstills (MTBS) represents the average time a machine runs before stopping. Here, the machine only runs during the MTBS period, after which it remains idle for the rest of the shift.

Table 3. Relevant factors for calculating production time for use case 3

Relevant factors
(1) $\boldsymbol{Mean\ Time\ Between\ Standstill}$
(2) $\boldsymbol{Number\ of\ night\ shifts\ per\ year}$

Use case 4: The customer does not have an OSO and is using the ROS Service. In this scenario, ROS Service was identified to remotely solve 50% of standstills. After a standstill occurs, there's a chance the remote operator resolves it, restarting the machine for another MTBS period.

The calculation is based on a probability diagram, where each scenario reflects the number of consecutive standstills resolved, with each scenario having a different production time and corresponding probability. Using this information, the expected production time per night shift is determined. Additionally, the more consecutive standstills the ROS Service resolves, the more production time is regained.

Table 4: Relevant factors for calculating production time for use case 4

Relevant factors
(1) $\boldsymbol{Expected\ production\ time\ per\ night\ shift}$
(2) $\boldsymbol{Number\ of\ night\ shifts\ per\ year}$

Personnel Expenses. Personnel expenses refer to the costs associated with employing workers, specifically their wages during night shifts when machines are operated. The calculation depends on whether the customer uses the ROS Service.

Use case 1: The customer has an OSO and is not using the ROS Service. Personnel expenses are calculated based on how much the OSO is involved in machine operation: If an operator works full-time during night shifts and earns €20/hour, working 8-hour shifts across 240 shifts per year, the total cost is substantial.

Use case 2: The customer has an OSO and is using the RSO Service. The ROS Service reduces the OSO's involvement, decreasing personnel expenses. This means the company saves on wages due to less operator involvement.

Table 5. Calculation of personnel expenses for use case 1 & 2

Calculation
(1) $\boldsymbol{Operator\ involvement}$ $\times$ $\boldsymbol{Wage\ per\ hour\ for\ a\ night\ shift\ employee}$ $=$ $\boldsymbol{Personnel\ expenses\ per\ hour}$
(2) $\boldsymbol{Personnel\ expenses\ per\ hour} \times \boldsymbol{Hours\ per\ night\ shift}$ $= \boldsymbol{Personnel\ expenses\ per\ night\ shift}$
(3) $\boldsymbol{Personnel\ expenses\ per\ night\ shift}$ $\times$ $\boldsymbol{Number\ of\ night\ shifts\ per\ year}$ $=$ $\boldsymbol{Personnel\ expenses\ during\ night\ shifts\ per\ year}$

Use case 3 & 4: The customer does not have an OSO and is (not) using the RSO Service. In scenarios where the customer does not have an OSO at night, whether they use the ROS Service, there are no personnel expenses to consider. Since the customer incurs no personnel costs for night shifts prior to implementing the ROS Service, there are no potential savings on these expenses because there are no existing costs to reduce.

Payback Period. The payback period refers to the amount of time it takes for the company to recover the cost of investing in the ROS Service through the savings it generates. A key focus was calculating the annual cash inflow, particularly how much one additional hour of production is worth to the customer. We simplified this by using the machine's hourly rate during standstill, which includes costs like depreciation, interest, and space costs that are avoided when the machine is running, along with the saved personnel expenses.

Table 6. Calculation of the payback period

Calculation
(1) $\textit{Initial investment costs} = \textit{Hardware costs}$
(2) $\textit{Machine hourly rate during standstill}$
$\times$ $\textit{Additional production time per year}$
$=$ $\textit{Saved machine hourly rate per year}$
(3) $\textit{Personnel expenses per year}$
$-$ $\textit{Additional production time per year}$
$=$ $\textit{Saved personnel expenses rate per year}$
(4) $\textit{Average annual cash flow}$
$=$ $\textit{Saved machine hourly rate per year}$
$+$ $\textit{Saved personnel expenses}$
$-$ $\textit{ROS Service price per year}$
(5) $\textit{Payback period}$
$=$ $\textit{Initial investment costs}$
$\div$ $\textit{Average annual cash flow}$

Return on Investment (ROI). ROI measures the profitability of the ROS service, showing how much return the company received for its investment over a given period of time (e.g., one year).

Table 7. Calculation of the ROI

Calculation
$(1) - (4)$ as in Table 6.
(5) $\textit{ROI} = \textit{Average annual cash flow}$
$\div$ $\textit{Initial investment costs}$

4.4. Design of the prototype artifact

The KPI calculations thus guided our design of a prototype artifact intended to effectively display and communicate customer-specific benefits, supporting the sales team in addressing them. We structured the artifact into three key sections: a data input page, a KPI overview page, and four KPI-specific pages for deeper explanations. The data input page as seen in

Fig. 1 is split into customer-specific data, filled in during sales meetings with the customer, and basic calculation data, entered by the analysis unit through the ROS Service team or sales representatives. The system then stores this data for easy future access by clicking on the save button.

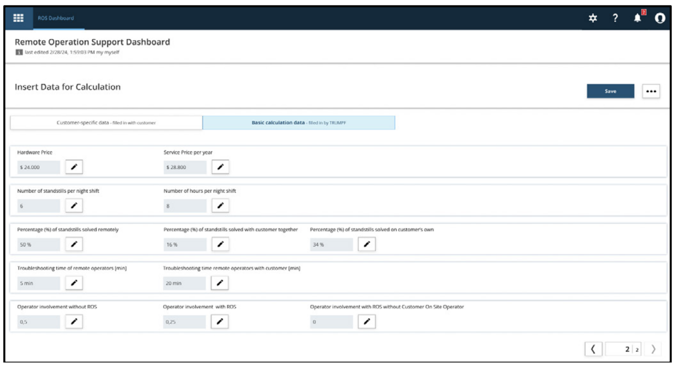

Fig. 1. Data input page

The overview page (Fig. 2) provides a general view of customer-specific input values and key KPIs, including production time, personnel expenses, payback period, and ROI, while comparing scenarios with or without an OSO during the night shift. Users can easily switch between scenarios and adjust input data directly on this page, offering flexibility for real-time adjustments during discussions.

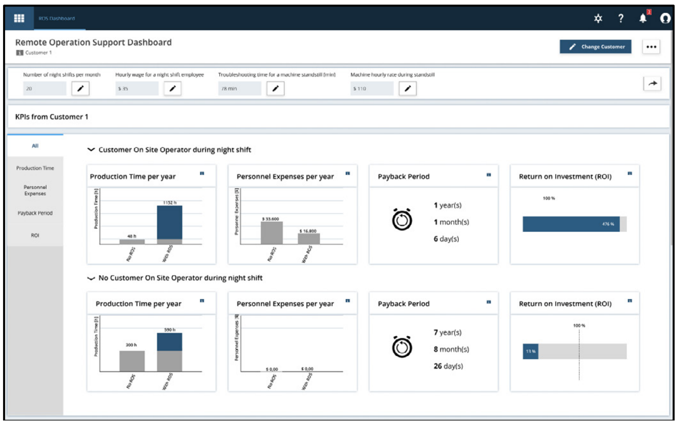

Fig. 2. Overview page

KPI-specific pages (example provided in Fig. 3) dive deeper into individual metrics, offering detailed calculations and step-by-step breakdowns. These pages enhance transparency by displaying how KPIs are calculated using customer data, building credibility and trust. Additionally, users can toggle between different operational scenarios and view detailed explanations, making analysis more accessible and user-friendly.

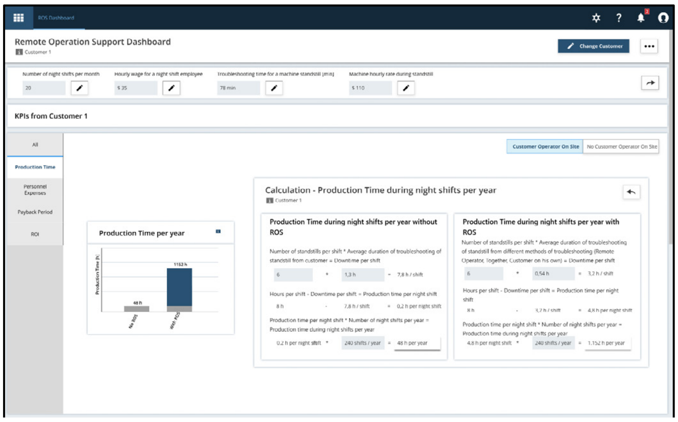

Fig. 3. KPI-specific page with detailed calculations

Overall, the prototype effectively communicates the value of ROS Services by focusing on clear, transparent KPI representation, simplifying the process for both customers and sales representatives.

4.5. Demonstration and evaluation

The demonstration used mock data to simulate real-world scenarios and showcase the prototype's functionality. In the evaluation, service owners and sales team members rated the prototype on understandability, completeness, ease of use, efficiency, and effectiveness. On a 10-point Likert scale, the prototype's effectiveness scored a 10 and other criteria averaging 8.75 to 9.75. The prototype was praised for its transparency, efficiency, and ease of use, while suggestions for improvements focused on data entry clarity and navigation.

5. Conclusion and outlook

Our research aimed to address the challenge of effectively communicating the customer value of ROS Services, particularly in the context of our analysis unit TRUMPF SE & Co. KG. Despite the potential of smart services, many companies struggle to quantify and convey their value, often leading to missed revenue opportunities. To tackle this, we developed a prototype artifact designed to assist sales teams in clearly demonstrating the financial benefits of ROS Services through customer-specific KPIs helping smart PSS to achieve market success. The prototype integrates calculation methods tailored to each customer's circumstances, enhancing transparency and trust. It was evaluated through interviews, workshops, and focus groups, receiving positive feedback on usability and sales potential, though challenges like data availability and team adoption remain.

Further real-world testing with customer data is crucial to validate the prototype's accuracy. Direct customer engagement, essential in PSS development, will provide insights for refinement, while exploring diverse customer needs and tailored communication strategies will enhance its effectiveness. Continuous iterations of testing and improvement will prepare the prototype for full implementation. In conclusion, our research provides a structured approach and prototype artifact to quantify and communicate the value of ROS Services, laying a foundation for future research and practical applications that help companies demonstrate the financial benefits of smart services to enhance sales success.

References

[1] Baines T, Lightfoot H, Peppard J, Johnson M, Tiwari A, Shehab E, et al. Towards an operations strategy for product-centric servitization. Int J Oper Prod Manag 2009;29:494-519.

[2] Saccani N, Visintin F, Rapaccini M. Investigating the linkages between service types and supplier relationships in servitized environments. Int J Prod Econ 2014;149:226-38.

[3] Qi Y, Mao Z, Zhang M, Guo H. Manufacturing practices and servitization: the role of mass customization and product innovation capabilities. Int J Prod Econ 2020;228:107747.

[4] Humbeck P, Mangold S, Bauernhansl T. Future scenarios of value creation in mechanical engineering – derivation of recommendations for action. Procedia CIRP 2020;93:844-9.

[5] Georgakopoulos D, Jayaraman PP. Internet of things: from internet scale sensing to smart services. Computing 2016;98(10):1041-58.

[6] Lee J, Kao HA, Yang S. Service innovation and smart analytics for Industry 4.0 and big data environment. Procedia CIRP 2014;16:3-8.

[7] Dreyer S, Olivotti D, Lebek B, Breitner MH. Focusing the customer through smart services: a literature review. Electron Markets 2019;29(1):55-78.

[8] Ebel M, Jaspert D, Pöppelbuß J. Smart already at design time – pattern-based smart service innovation in manufacturing. Comput Ind 2022;138:103625.

[9] Heinz D, Benz C, Silbernagel R, Molins B, Satzger G, Lanza G. A maturity model for smart product-service systems. Procedia CIRP 2022;107:113-8.

[10] Grubic T, Peppard J. Servitized manufacturing firms competing through remote monitoring technology: an exploratory study. J Manuf Technol Manag 2016;27(2):154-84.

[11] Friedli T, Classen MJ, Osterrieder P, Stähle L. Smart services – transformation of the service organization: benchmarking report. St. Gallen: University of St. Gallen; 2019.

[12] Kurtz J, Zinke-Wehlmann C, Lugmair N, Schymanietz M, Roth A. Characterising smart service systems – revealing the smart value. Serv Manag Res 2023;7(2):112-28.

[13] Grubic T. Remote monitoring technology and servitization: exploring the relationship. Comput Ind 2018;100:148-58.

[14] DIN. DIN SPEC 33453:2019-09. Entwicklung digitaler Dienstleistungssysteme. Berlin: Deutsches Institut für Normung; 2019.

[15] Allmendinger G, Lombreglia R. Four strategies for the age of smart services. Harv Bus Rev 2005;83(10):131-41.

[16] Beverungen D, Breidbach CF, Poeppelbuss J, Tuunainen VK. Smart service systems: an interdisciplinary perspective. Inf Syst J 2019;29(6):1201-6.

[17] Beverungen D, Müller O, Matzner M, Mendling J, vom Brocke J. Conceptualizing smart service systems. Electron Markets 2019;29(1):7-18.

[18] Gerl S. Vorgehensmodell zur systematischen Entwicklung innovativer industrieller Smart Services. In: Gerl S, editor. Innovative Geschäftsmodelle für industrielle Smart Services. Wiesbaden: Springer Fachmedien Wiesbaden; 2020. p. 67-97.

[19] Sterk F, Stocker A, Heinz D, Weinhardt C. Unlocking the value from car data: a taxonomy and archetypes of connected car business models. Electron Markets 2024;34(1):13.

[20] Voigt KI, Steinmann F, Bauer J, Dremel A. Condition monitoring as a key technology – an analysis of requirements for new business models for remote services. Presented at: Symposium für Vorausschau und Technologieplanung; 2013.

[21] Wünderlich NV, Wangenheim FV. Die zukünftige Entwicklung von Remote Services in Deutschland: Ergebnisse einer Delphi-Studie. In: Holtbrügge D, Holzmüller HH, Wangenheim FV, editors. Remote Services. Wiesbaden: Deutscher Universitäts-Verlag; 2007. p. 181-93.

[22] Birk J, Krauss M. Remote operations in der Prozessautomatisierung. atp 2017;57(1-2):60-7.

[23] Wünderlich NV, Schumann JH, Wangenheim FV, Holzmüller HH. Management und Marketing ferngesteuerter Dienstleistungen: konzeptionelle Verortung, betriebswirtschaftliche Herausforderungen und künftige Forschungsaufgaben. Z Betriebswirtsch 2011;81(9):977-1001.

[24] Wünderlich NV, Schumann JH, Wangenheim FV, Holzmüller HH. Ferngesteuerte Dienstleistungen: betriebswirtschaftliche Spezifika, Terminologie und Herausforderungen für das Management. In: Holtbrügge D, Holzmüller HH, Wangenheim FV, editors. Remote Services. Wiesbaden: Deutscher Universitäts-Verlag; 2007. p. 3-26.

[25] Pöppelbuß J, Durst C. Smart Service Canvas – a tool for analyzing and designing smart product-service systems. Procedia CIRP 2019;83:324-9.

[26] Schuh G, Leiting T, Schrank R, Frank J. Value-based pricing von Smart Services im Maschinen- und Anlagenbau. In: Schuh G, editor. Smart Services. Forum Dienstleistungsmanagement. Berlin: Springer; 2022. p. 255-75.

[27] Baltuttis D, Häckel B, Jonas CM, Oberländer AM, Röglinger M, Seyfried J. Conceptualizing and assessing the value of Internet of Things solutions. J Bus Res 2022;140:245-63.

[28] Mourtzis D, Angelopoulos J, Panopoulos N. Personalized PSS design optimization based on digital twin and extended reality. Procedia CIRP 2022;109:389-94.

[29] Font X, English R, Gkritzali A, Tian W. Value co-creation in sustainable tourism: a service-dominant logic approach. Tour Manag 2021;82:104200.

[30] Hevner AR, March ST, Park J, Ram S. Design science in information systems research. MIS Q 2004;28:75-105.

[31] Kuechler W, Vaishnavi V. On theory development in design science research: anatomy of a research project. Eur J Inf Syst 2008;17:489-504.

[32] vom Brocke J, Hevner A, Maedche A. Introduction to design science research. In: Vom Brocke J, Hevner A, Maedche A, editors. Design Science Research: Cases. Cham: Springer; 2020. p. 1-13.

[33] Töytäri P, Keränen J, Rajala R. Barriers to implementing value-based pricing in industrial markets: a micro-foundations perspective. J Bus Res 2017;76:237-46.