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Changes to Knowledge Management in Manufacturer Digital Servitization: priorities and challenges

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Abstract: Digital servitization marks a strategic shift for Original Equipment Manufacturers (OEMs), transitioning from product-oriented models to integrated service-based offerings. This transformation, driven by smart Product-Service Systems (PSS) and digital technologies, profoundly impacts Knowledge Management (KM). As servitization increases data and knowledge complexity across products, services, and interactions, effective KM processes become critical enablers. However, their role in digital servitization remains underexplored. Through a qualitative analysis of seven case studies, this research examines how KM processes evolve to support service management in OEMs. Findings identify three priority domains of intervention—Field Service Management, Customer Service, and Inquiry to Order—where KM optimisation is essential. The study highlights key challenges of KM in PSS delivery, offering insights to enhance KM strategies in digital servitization.

Keywords: Knowledge Management; Digital Servitization; Product-Service System; Service Management.

1. INTRODUCTION

Manufacturers have significantly adapted their strategies, capabilities, and structures to expand their service offerings. This shift, known as servitization, involves transitioning from product-dominated offerings to integrated Product-Service Systems (PSS) that better address customer needs (Baines et al., 2017). Servitization can enhance differentiation, strengthen customer relationships, generate new revenue streams, and support sustainability and the circular economy (Spadafora & Rapaccini, 2024). Initially, this strategic transformation proved challenging as manufacturers struggled to reorganize their processes and supply chains to deliver satisfactory PSS (Porter & Heppelmann, 2014). However, digital technologies have become key enablers of servitization, facilitating the introduction of new services, improving service quality, and reducing operational costs. Their integration has accelerated servitization, leading to data-driven offerings, digitally enabled business models, and advanced PSS (Huikkola et al., 2022). The literature refers to this evolution with terms such as digital servitization, smart PSS, smart solutions, and Product-Service-Software Systems (PSSS) (Kohtamäki et al., 2022). A common theme across studies is the transition towards smart solutions that create and capture value through monitoring, control, optimisation, and autonomy (Kohtamäki et al., 2021). Successfully implementing advanced PSS requires rethinking business models, adapting hybrid product-service portfolios, and restructuring organizational processes, assets and resources (Töytäri et al., 2018). While many of the challenges associated with designing smart solutions to servitize one's own offerings have been extensively studied (Kohtamäki et al., 2019), the complexity of information and business knowledge management resulting from such strategic transformation remains a relatively underexplored area.

Digital servitization is a complex transformation, and many manufacturers struggle to fully implement it due to capability gaps, product-centric mindsets and cultures (Kowalkowski et al., 2016), as well as the growing complexity of operations and supply chains. Adding services inherently means adding knowledge (Leoni, 2014). Original Equipment Manufacturers (OEM) face considerable challenges in managing the large volumes of data generated by products, services, digitalized processes, and interactions with customers, suppliers, and partners. In this context, the ability to create, store, share, and use knowledge effectively is fundamental for supporting digital servitization and ensuring the success of new business models. These difficulties make Knowledge Management (KM) a critical success factor for servitization strategies, driving the need for a comprehensive adaptation of KM processes to effectively address service management (Belal et al., 2022). However, as the literature reveals, there is insufficient evidence and lingering strong doubts about how OEMs can optimise their KM processes to effectively address these challenges (Pizzichini et al., 2023). In light of this gap, the research aims to fill the deficiencies in the scientific literature, through qualitative analyses based on multiple case studies, and seeks to advance knowledge by exploring how KM processes can support and enable digital servitization within OEMs. In this paper, we present the results of the exploratory study on the identification of critical services for KM and the delineation of the main challenges, thereby answering the following research questions:

RQ1: *Which digital servitization domains should prioritize effective knowledge management to achieve significant potential benefits?*

RQ2: *Within these domains, what are the most critical challenges for knowledge management processes?*

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The rest of this article is structured as follows: Section 2 outlines the theoretical background, Section 3 describes the research methodology, and Section 4 presents findings from the case studies. Section 5 discusses the results and concludes with proposals for future research, as well as theoretical and practical contributions, and limitations.

2. THEORETICAL BACKGROUND

2.1 Digital Servitization

In recent years, many manufacturers have embraced servitization to offer integrated solutions of products and services, commonly termed product-service systems. This transition requires a shift from transactional, product-focused business models to service-integrated approaches, such as subscription or pay-per-use models (Kohtamäki et al., 2022), positioning manufacturers as solution providers to benefit both the customer and the equipment supplier. Through servitization, manufacturers aim to differentiate themselves, boost revenue streams, increase profitability, enhance operational performance and improve market value, while simultaneously reducing dependence on product life cycles (Porter & Heppelmann, 2014). This customer-centric approach improves satisfaction and retention by offering personalized services that support the entire product lifecycle, such as maintenance, remote assistance, and continuous performance monitoring (Baines et al., 2017).

Furthermore, the uniqueness of the current servitization wave lies in its expansive scope and the transformative impact of digitalization in enhancing service offerings. The growing adoption of digital technologies has led manufacturing firms to embrace digital servitization, a specific type of servitization that leverages information technologies to improve existing services, create new ones, and drive higher value generation and capture (Kohtamäki et al., 2019). This evolution is realized through the adoption of new (digital) business models, innovative methods of (co)creating value, the extraction of actionable knowledge from data, and simultaneous improvements in both operational and environmental performance to secure competitive advantages (Baines et al., 2009). The literature differentiates these advanced offerings from traditional PSSs, often labelling them as smart PSS or smart solutions, which are defined by their reliance on data from connected devices to generate actionable insights on asset productivity, optimisation, operations and maintenance. These data-driven capabilities enable descriptive, diagnostic, predictive, and prescriptive insights, supporting the development of tailored and high-value service propositions (Huikkola et al., 2022). While traditional PSS already pose significant challenges in managing the associated information, the advent of digital servitization and smart PSS has exponentially increased the need for robust knowledge management processes. These are essential to effectively handle the vast volumes of data and knowledge required for operational success (Rapaccini et al., 2024).

2.2 Knowledge Management in Digital Servitization

Digital servitization marks a paradigm shift, enhancing OEMs' ability to design, develop, and deliver advanced services. This evolution extends beyond traditional product offerings, fostering innovation and value creation within interconnected business ecosystems (Spadafora & Rapaccini, 2024). It highlights the growing need for effective knowledge management across various service levels, from basic (e.g., spare parts, warranties) to intermediate (e.g., maintenance, help desks, training, in-field services, condition monitoring) and advanced services (e.g., customer support agreements, risk-sharing and outcome-based contracts) (Baines & Lightfoot, 2014). For each of these services, the implementation of advanced PSS requires organizational, operational, and cultural changes, which have a profound impact on business strategies. Business processes become more complex, necessitating greater collaboration between internal functions (e.g., design, production, sales, and service) and external stakeholders, such as suppliers, partners, and customers (Pizzichini et al., 2023). Customer relationships undergo a fundamental transformation, shifting towards continuous interaction for the co-creation of value. OEMs must develop new competencies, integrate digital technologies, and orchestrate multidisciplinary teams to be successful in delivering smart data-driven solutions rather than mere products (Kowalkowski et al., 2016). These solutions demand the management of an extensive knowledge base, including technical information (e.g., product lifecycle data), customer insights (e.g., business needs, preferences, and feedback), and operational knowledge (e.g., service delivery and integration into solutions). KM therefore plays a strategic role in exploiting the significant volume of additional information generated by digital servitization, often requiring real-time processing in distributed contexts.

Integrating product, service, and software innovations into cohesive smart solutions, while aligning diverse development and deployment strategies and capabilities, poses significant challenges (Kohtamäki et al., 2021). KM, encompassing the four processes of creation and capture, storage and retrieval, transfer and distribution, and use and application (Alavi et al., 2024), can become a pivotal lever for overcoming the mental, cultural, and capacity barriers to PSS implementation (Töytäri et al., 2018). Effective KM enables organizations to update, integrate, and exploit existing knowledge repositories (exploiting) while simultaneously integrating new data generated by connected technologies (e.g., IoT and AI), new business models, and partnerships (exploring) (Leoni, 2014). A robust KM can indeed enhance ambidexterity, competitiveness, operational efficiency and effectiveness, and support innovation and collaboration processes. Despite the extensive literature on digital servitization, studies dedicated to its impact on OEM knowledge management processes, critical factors involved and best practices to address these challenges remain limited (Belal et al., 2022). To fill this gap, this research aims to advance knowledge on this topic, exploring how KM processes can change and be optimised to enable and support OEM digital servitization.

3. RESEARCH METHODOLOGY

3.1 Research strategy

This study employs a qualitative multiple-case study approach to examine knowledge management processes in original equipment manufacturers undergoing servitization. The

research employs a theory-building empirical strategy, combining desk research of the scientific literature with seven in-depth, case-based studies (Voss et al., 2002). The multiple-case study method was selected to inductively investigate complex early-stage phenomena within real-world contexts, especially in cases where the distinction between the phenomenon and its context remains unclear (Hair et al., 2016). The findings presented in this paper are primarily derived from participatory exploratory workshops conducted with all case study participants, followed by semi-structured interviews—one for each case. The interviews were transcribed, then coded and analysed following the three-order model of Gioia's methodology (Gioia et al., 2013).

3.2 Case selection

The study involved seven OEMs operating in different manufacturing sectors, all engaged in servitization initiatives. Table 1 provides an overview of the case companies and the informants interviewed. The case selection was guided by three main criteria: (i) the adoption of product-service systems, (ii) the presence of strategic initiatives marking the transition from a product-oriented to a service-oriented model, and (iii) the emergence of KM-related challenges. Directors, managers and practitioners directly involved in service delivery and/or knowledge management processes were selected as interviewees for each case study, enabling a shared understanding of the main challenges (Eisenhardt & Graebner, 2007).

Table 1 – Overview of case company informants

Firm ID	Firm description	N. informants	Participants job title
A	Sawing machines and metal cutting solutions	1	• Service Manager
B	Machinery for ceramics, packaging, and F&B	3	• Service Engineering Manager • Service Engineering Specialist • R&D Project Manager
C	Industrial machinery for precision manufacturing	2	• Sales & Service Executive • Service Manager
D	Catering and industrial kitchen equipment	1	• After Sales Manager
E	Textile machinery for weaving	1	• Chief Sales & Service
F	Energy transition technology for oil and gas	4	• Digital Products Executive • Knowledge Services Leader • Site Operations Leader • Commercial Operations Leader
G	Food processing and packaging solutions	3	• Connected Experience Director • Core Services Director • Service Desk Manager

3.3 Data collection

Data collection was conducted in two main phases. In the first phase, two exploratory workshops of one hour each were conducted with all participants, providing an initial point of contact with the case studies. These workshops facilitated a shared analysis of the main changes caused by digital servitization on KM, helping define the research context and problem setting while identifying three relevant domains of intervention for further exploration. In the second phase, semi-structured interviews were conducted with participants from each case study to gain deeper insights into the identified domains. To enhance the credibility of the findings, data triangulation was applied across sources and types, integrating interview data with secondary materials such as company presentations and publicly available documents (Yin, 2014). This approach improved data reliability and enriched the contextual understanding of informants' responses. Both the interviews, lasting approximately one hour each, and the workshops were recorded, transcribed and analyzed.

3.4 Data analysis

The data analysis was conducted in two distinct stages, consistent with the data collection methods. The exploratory workshops were analyzed through shared inductive reflections and interpretations among the researchers to identify emerging patterns and synthesize domains of interventions (Thoring et al., 2020). These findings provided a foundation for structuring the subsequent interviews and developing a grounded theory. Using the MAXQDA software, the interview transcripts were subjected to an initial qualitative analysis according to Gioia's methodology. The coding of the large amount of qualitative data obtained from the interviews, and the development of the theory through the three-order model supported the analysis and enabled the identification of critical challenges to KM processes. Given the early-stage nature of the second analysis stage and to ensure conciseness, this article does not include details of the coding process or the three-order model developed.

4. FINDINGS

The first phase of this research, characterized by exploratory and participatory workshops with the representatives of seven case studies, aimed to outline the study context within servitization and identify the most critical areas for knowledge management. These workshops revealed that the processes typical of digital servitization heavily depend on KM to ensure service effectiveness, efficiency, and personalization. Drawing on the various types of services that OEMs can offer, individualized by Baines & Lightfoot (2014), those causing the greatest change in KM processes and the most pronounced challenges were identified. Among the services identified, priorities were delineated based on their potential to achieve significant benefits through improvements in KM. Subsequently, domains of intervention were defined to combine and synthesize the identified services and their associated business processes. These served as a foundation for the second phase of the research, guiding the qualitative coding of the interview and the theoretical development using the Gioia's methodology to identify the critical challenges that require greater attention. The findings presented here are essential to address the research questions, refine the problem setting, and develop the research framework around KM process changes for optimising service management in OEMs.

4.1 Emergence of Domains of Intervention

The inductive interpretation of the exploratory workshop transcripts led to the identification of three main application units, representing services deemed critical from a KM

perspective of an OEM. These are referred to as *Domains of Intervention*:

1. *Field Service Management (FSM):* This encompasses all on-site activities performed at the customer's location, such as installation, maintenance, technical support, repairs, troubleshooting, machinery upgrades, and post-service management. The role of FSM in servitization is pivotal and goes beyond problem resolution and equipment life-cycle extension to include proactive actions, continuous performance monitoring, data collection, and thus enhanced customer satisfaction.

2. *Customer Service (CS):* This embraces all customer interaction-focused activities and serves as the primary contact point between the company and its customers. Its objectives include managing inquiries, issues, complaints, and providing remote support via phone, email, web portals, or virtual assistance. In servitization, CS is not only a reactive channel for addressing customer requests but also a strategic asset for strengthening relationships, enhancing loyalty, and continuously collecting feedback to refine and improve service offerings.

3. *Inquiry To Order (ITO):* This refers to the set of processes linking the initial customer inquiry to the finalization of an order. It spans the provision of information, the engineering of a tailored offer, and the confirmation of the order. In servitization, ITO represents the initial step in customer interaction, configuring solutions personalized to customer needs, delivering added value, and ultimately creating customer satisfaction.

These domains of intervention were found by the case studies to be representative of both essential operational areas, and critical units for effective KM in a manufacturer aiming to provide servitized offerings. FSM, CS and ITO are integrated processes that play a key role in the transition to service-oriented business models, based on the creation of long-term value through customer-centred smart solutions.

4.2 Key Challenges of KM in the Domains of Intervention

The identification of the three domains of intervention provided a clear research context and facilitated the development of a framework for conducting, coding and analysing subsequent interviews. This framework ensured that the investigation focused on the most critical factors of digital servitization practices affecting KM processes, referred to as *Key Challenges.*

Field Service Management (FSM)_ KM in the context of field service management is a significant enabler, allowing the effective management of technicians' know-how and documentation throughout the lifecycle of field processes. KM is crucial for enabling rapid decision-making, facilitating knowledge transfer among operators, streamlining and accelerating workflows, and integrating data generated by connected machines. Findings highlight six key challenges for KM in FSM:

1. *Connected Machines*: Connected machines generate valuable data that can improve KM practices and enhance the quality of solutions offered. Nevertheless, the adoption of tools and technologies to integrate these data into operational decisions remains limited.

2. *Post-Intervention Reports*: Reports generated after field interventions represent a potential goldmine of knowledge. However, due to time constraints or lack of awareness, their systematic integration into organizational repositories is often poor or inconsistent.

3. *Apprentice and Senior Training*: Training for both junior and senior technicians is critical to achieving efficiency and effectiveness in interventions. However, it is often deprioritized, viewed as a time burden, and conducted using inadequate tools, which hinders effective knowledge transfer.

4. *Skills Management*: Technicians should possess a varied mix of skills, technical expertise for problem-solving, interpersonal for customer interactions and technological competences to effectively use digital tools. These skills are difficult to fully instil and track across technicians for effective deployment.

5. *Community of Practices*: Technicians often transfer and develop knowledge through informal communities of practice, relying on casual communication or word-of-mouth in the workplace. While effective in promoting knowledge sharing, this method lacks the formalization, structure, and scalability needed for robust KM systems.

6. *On-site Activities*: Technicians frequently lack access to necessary knowledge during on-site interventions or face difficulties due to limited availability of agile tools. Consequently, they rely heavily on personal experience, improvising solutions to diverse problems.

Customer Service (CS)_ KM in customer service is essential for addressing fragmented knowledge across various service partners and overcoming difficulties in retrieving relevant information from past service tickets. Robust KM in this context influences the personalization and continuous improvement of services, integrating customer request data to enhance satisfaction and loyalty. The findings emphasize three key challenges:

1. *Fragmented Knowledge*: Information about products, customers, suppliers, and collaborators is often only partially managed or distributed across disparate systems and tools, with limited accessibility. This fragmentation extends across multiple teams and service partners.

2. *Service Tickets Management*: Service tickets, whether resolved successfully or not, represent a central source of knowledge regarding customer issues, requests, and corresponding solutions. Unfortunately, they are often inadequately centralized, tracked, and utilized to build a structured knowledge base.

3. *Service Quality Impact*: The inability to capitalize on available information can negatively affect the customer experience, compromising the overall quality of provided

solutions. Implementing effective KM to support CS remains a recurring challenge.

Inquiry To Order (ITO)_ KM in inquiry to order processes plays a pivotal role in facilitating the seamless and accurate transfer of knowledge between technical and commercial teams, ensuring the precision and competitiveness of the solutions offered. KM supports quick decision-making related to customer inquiries, requirements analysis, offer design, and the integration of data from various supply chain departments. Findings identified two key challenges of interest:

1. *Coded Attributes*: KM of items (e.g., technical specifications and commercial parameters) is essential for providing accurate and timely responses to customer requests. However, most solutions lack codified attributes, leading to inefficiencies in offering consistent pricing, specifications, and delivery timelines.
2. *Stock Out*: The lack of updated knowledge on inventory and materials results in problems, delays, and negative impacts on customer experience and operational performance. Effective KM that integrates real-time information on resources and customer requirements enhances the ability to propose feasible and high-quality solutions.

These findings underline the critical importance of changes in KM processes in order to address the challenges caused by digital servitization within each identified domain of intervention, and thus succeed in this strategic transformation.

5. DISCUSSION AND CONCLUSION

Effectively and efficiently conducting knowledge management processes is a critical challenge for any manufacturing company. For OEMs involved in a digital servitization journey, the ability to achieve robust KM is fundamental (Leoni, 2014). Given the limited scientific literature on the changes by digital servitization on the KM processes of OEMs (Belal et al., 2022), this research contributes to advancing knowledge on servitization and KM by exploring how its processes can support and enable service management.

Finding 1 – Domains of Intervention_ The analysis of exploratory workshops confirmed the significant impact of digital servitization transformation on the need to manage an increased volume of information. It also highlighted that well-implemented KM processes can substantially support and enable this strategic change. As shown in Figure 1, the volume of data and information within the knowledge bases managed by OEMs expands significantly when transitioning from a product-oriented to a service-oriented approach. Manufacturing firms aiming to offer data-driven smart solutions must not only continue to process product-related KM throughout the entire product lifecycle, but also that related to services encompassing the new information required to deliver them effectively. The case studies identified three critical domains of intervention for KM in servitization, enabling to answer the first research question (RQ1): Field Service Management, Customer Service and Inquiry To Order. Each of these domains represents a set of services, application units, and core areas, which are crucial for OEMs who want to successfully servitized their offerings, and at the same time a set of priorities in terms of the benefits achievable through effective KM changes. FSM, CS, and ITO represent contexts that require robust product- and service-oriented knowledge management, along with the effective use of digital technologies to enable and support it. They directly encompass some key base and intermediate services among those that can be traced back to the OEMs' servitized solutions, but also prerequisites necessary to enable further services and/or advanced services.

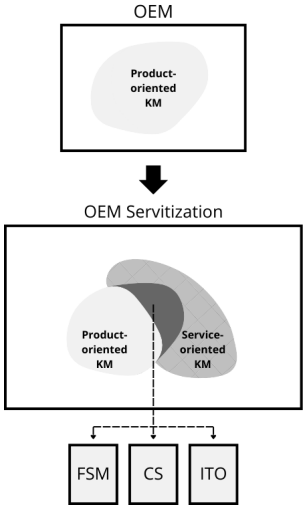

Figure 1 - Changes to OEMs' KM in digital servitization.

Finding 2 – Key Challenges_ The coding and analysis of subsequent interviews revealed numerous difficulties in the KM processes related to FSM, CS, and ITO. Preliminary exploration and analysis of the findings highlighted several key challenges and factors requiring attention for regarding KM within the domains of intervention. Since only an initial qualitative analysis was conducted to identify critical areas and factors related to KM processes, this second finding is presented in a preliminary and exploratory manner. Although preliminary, the results remain relevant and outline key challenges for targeted priority improvement initiatives. They provide partial answers to the second research question (RQ2) and establish a foundation for more detailed future investigations into the critical areas and complexity factors within the three domains.

It is possible to state that the ability to change and adapt KM processes play a significant role in mitigating the key challenges of digital servitization, thereby influencing the success and improvement of this transformative strategy. In fact, many of the critical challenges identified within the priority domains reflect some of the prerequisites, related to the knowledge management, to support and enable essential operations to deliver advanced services outlined by Baines & Lightfoot (2014). This identifies a promising avenue for future validations and analysis, upon which we propose further study of key challenges that KM change interventions should address. Future research developments should also focus on identifying opportunities for integrating innovative technologies, such as Generative Artificial Intelligence

(GenAI), into existing KM processes to make them more effective and efficient for digital servitization. Indeed, GenAI represents a promising digital technology capable of contributing significantly to the support and enablement of KM (Alavi et al., 2024), and consequently, to the success of digital servitization. This hypothesis, however, requires further exploration to propose solutions that can guide both theory and practice in the context of servitization.

From a theoretical perspective, this study advances the comprehension of the transformative impact of digital servitization on KM processes by identifying the most challenging services that OEMs tend to integrate into their smart solutions. It extends the understanding of KM difficulties in the context of digital servitization, shedding light on critical areas in related processes, and providing a foundation for future research investigations. From a practical perspective, the findings offer relevant insights into factors OEMs should address to enhance their KM practices, aiming to support and enable those processes linked to service management. The results presented in this paper are primarily derived from participatory exploratory workshops and reflect an early phase of the research. Although semi-structured interviews provided additional context, their coding process has not yet been completed and will be further refined by methodological and analytical advancements. This limitation implies that the interview-based findings are not fully structured but serve as a starting point for more in-depth analyses.

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