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The successful commercialization of a digital twin in an industrial product service system

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Abstract. This paper describes the design, development and commercialization of a digital twin in an industrial product service system (industrial PSS). The twin was one of a number developed as part of a Smart Twin project in Switzerland with multiple industrial partners. The case here follows a commercialization process for digital twin-enabled services and will highlight some of the critical success factors. The service provided with the support of the digital twin was based on the reliable and predictable operation of a server room. Equipment in the room comes from several original equipment manufacturers (OEMs), and a system integrator manages the system. The approach is to apply action research as the methodology on a single case and then to identify and assess the aspects where Service Dominant (S-D) logic supported or hindered the development of the new digital technology-based service that was being co-created between the supplier and the customer. The analysis of the case confirmed that S-D logic supported the development of Smart Service offerings and showed that value co-creation can be developed.

Keywords: Smart Services, S-D logic, Industrial Product Service Systems.

1 Introduction

The purpose of this paper is to describe the design, development, and commercialization of a digital twin in an industrial product service system (industrial PSS) based on a real case. The case is a Swiss firm which has developed and commercialized a Digital Twin as a service. The researchers had the opportunity to support and observe the development of these services. Along the way, the firm used experimental methods for design and development. In commercialization traditional methods were used, with which the firm encountered several barriers, therefore adapting the approach. Closer investigation of this use case may allow other firms to develop new digitally

enabled services. The barriers to development and commercialization are different for digital services, with a greater focus on value co-creation and co-delivery than with traditional services. Therefore, this investigation aims to identify the key success factors (and barriers) which need to be understood to design, develop, and commercialize digital smart services. The motivation was to understand how, where, and why S-D logic assisted or hindered the co-development and delivery of Smart Services.

2 Theoretical background

Industry 4.0 and the internet of things (IoT) are enabling manufacturing firms and system integrators to offer new value propositions to their customers. Anderson [1], stated in 1998 that to build a value proposition for a customer, it was first essential to understand what they valued and how they created value. Firms can use the data from their existing equipment to gain deeper insights that can lead to competitive advantages [2]. One way to seize the opportunities of data insights is the Digital Twin [3]. Digital Twins are, in general, a digital representation of a physical object or a process [4,5], providing a link between the virtual and the physical [3].

Industrial Product and Service Systems, consisting of many actors across different organizations, machines, and services, includes the design and commercialization of digital services. Industrial PSS has mainly been investigated from the product perspective; very little is written about it in the context of S-D logic [6]. This field now offers the opportunity to investigate the commercialization of digital services in an industrial context, making it possible to examine themes such as ecosystem analysis, actors and their motivation [7], value propositions in an S-D logic context, and value sharing and co-creation [6,8].

Servitization has been studied for over 30 years [9]. However, today there has been a step-change with digitally enabled servitization [10]. The emerging digital capabilities of original equipment manufacturers (OEMs) increase opportunities to develop smart services using digital technologies such as IoT and advanced data analysis. Kohtamäki [11] identified a range of business models relevant to servitization and highlighted the importance of value creation within the value proposition. West et al., (2018) [12] assessed the smartness of services using S-D logic premises by analyzing the service ecosystem, service platform and value co-creation, independent of the type of firm. The use of S-D logic supports the value discovery described by Anderson [1].

3 Research methodology

Although multiple case studies are considered in order to build more robust theory [13] due to their potential for triangulation, single case studies can be more effective to describe complex interactions among several variables characterizing the problem under investigation [14]. Voss et al., [15] suggest single case approaches demonstrate more effective learning on long term cause and effect relationships. The data-driven servitization project by the company highlighted in this case analysis was initiated by a Swiss innovation project between numerous Swiss universities acting as research

partners, and multiple other implementation partners. Consequently, throughout all stages of this project continual reviews and constructive discussions took place to verify the direction of the project and assist all implementation partners to overcome any shared complications.

Action research methodology was applied for the reflections on the digital twin roadmap; evidence included identifying the tools used at each stage of the roadmap, and considering their usefulness, as well as the challenges and opportunities identified at that particular point. In this paper, a single case-based approach was used and analyzed on the timeline of the design, development, and commercialization. The main reason for selecting this approach is the scarcity and inconsistency of practical insights on design and commercialization challenges in industrial PSS literature.

Action research is a practically-oriented approach for small projects that aim for fast progress. It incorporates change as a characteristic that allows discoveries on the go, using the framework: plan, act, observe and reflect. The process is cyclic with multiple iterations from researchers and practitioners. [16].

4 Case analysis

The starting point for the case is shown in Fig. 1, which presents the digital twin development roadmap developed by the commercial manager for the firm and provides evidence from each of the phases described below. The development was the first digital service for what was a traditional building and facility management firm in Switzerland. This family firm delivers its core values through the execution and delivery of high-quality services such as, building planning, construction, and long-term management of multiple facilities. Therefore, the idea to pursue a servitized activity came about from a desire to integrate their current services with industry 4.0 and improve the already high quality of their broad range of services.

4.1 Stage 1: Motivation

The initial motivation for the project came from the firm's strategy to "do something digital" and to maintain a longer-term relationship with their customers after the handover of a project. The outcome here was to find a solution that supported the daily work routines through the application of smart services. This was intended to create a competitive advantage for the firm by capturing a partner for the longer term. The challenges it created were that both parties needed to understand digitalization, and for the firm there was a need to acquire new resources.

The major dimensions of service platform and value co-creation were considered important when moving from the strategic decision to "do something digital with customers over the longer term". Working with the customer to co-create a service was considered essential for both parties.

4.2 Stage 2: Understand and ideate

Application of the Data2Action framework [17] and additional research identified the processes that cause the most frequent pains for the building occupier. The problems were detailed in collaboration with the actors, and their roles were identified before moving on to an ideation stage. The opportunities came from understanding the processes and pains from many different perspectives. The challenges were collecting the information and describing it clearly without assumption. The framework [18] supported solution ideation with its four perspectives for services.

Collaborative working created a shared view of the problem, from many actors' perspectives. It also provided input into the initial view of the architecture for the solution, and the co-creation and co-delivery of value between actors (multiple) within the system became more evident.

4.3 Stage 3: Solution evaluation

The partners created ideas around a common set of problems, using a set of different service design tools that were previously integrated into the Data2Action framework [17]. A decision matrix (effort vs value) was used to reduce the number of possible solutions. Storytelling supported the testing of early prototypes within a universal language that all were able to share. The integration of the business model into the storytelling provided a validation tool to confirm whether the service could be delivered (or not) and how. Nevertheless, there were some critical challenges associated with solution testing and evaluation, and many were based around value identification and agreement on the value quantification in the co-creation environment.

S-D logic focuses on value in use (outputs) rather than the inputs into the process, and this supported the development of services with 'availability' comsmitments rather than ones based around basic inputs (e.g., call out times). The value co-creation here was described (often the process was based around three or more actors), it also supported the definition of the rules of exchange and the accommodation of multiple roles as there was a degree of resource integration. The use of the term 'beneficiary' was helpful when assessing the different situations and the perspective of the value that was co-created.

4.4 Stage 4: Development of a sales roadmap

This phase focused on defining the offer into a form that could be commercialized. The service was clearly defined, and the roles and readabilities clearly described. Customer segmentation and competition analysis were developed, leading to an action plan with a clear aim and timeline. The required resources for the execution of the roadmap were identified in detail and labelled as core/non-core.

The focus on value in use and co-creation of value supported the development of the sales roadmap. Discussions between the parties supported the revenue model and the identity of the firm's core activities and tasks that the customer was best suited to deliver. Revenue models that provided a gain/pain share were preferred to support

value co-creation. Roles and responsibilities were clearly defined, also detailed resource integration while keeping an architecture that was designed to be flexible.

4.5 Stage 5: Commercialization

The objective was to have a system that was in commercial operation. Based on this, a cost model was built to integrate all of the firm's resources; the design was modular to support different levels of resources. A performance-based agreement was designed that described the obligations of all parties, along with the governance processes to deal with changes flexibly. This flexibility created a challenge, as it resulted in slightly adjusting or moving tasks and obligations to another party within the agreement; this was not appreciated by the legal team. The discussions around revenue models provided opportunities for capturing the value that was co-created.

Legal advisors were unsure of how to apportion roles, responsibilities and obligations – they sought clarity on how to support this based on S-D logic, as they had been trained on Goods-Dominant logic. The framework [12] sustained the co-creation of value, although discussions were needed to understand its practical use and reference to S-D logic. Some of the aspects valued by the customer and used in the revenue model were more akin to Goods-Dominant logic than pricing based on S-D logic principles.

	Desired outcome	Tools	Challenges	Opportunities
Stage 1: Motivation	- Developed understanding of Digitalisation within the business context - Get the support of senior management - Set the foundation for the company future	- SWOT analysis - 5 Forces - Ecosystem mapping	- Understand Digitalization - Raise awareness for smart service opportunities among management - Incorporate Digitalization into company strategy - Acquire resources from management	- Redesign of the company strategy - New business opportunities with smart services - Gain competitive advantage through Digitalization
Stage 2: Understand and ideate	- Understand the system of processes and assets and their interconnection - Comprehend the customer value	- Data2Action Model - Customer Journey Mapping - Avatar Journey Mapping - Personas - Customer Value Proposition - Internet research	- Understand Digital Twins and their potential - Understand smart services - Getting the different viewpoints to fully understand value	- Adapt new tools to support value understanding - Process optimization potentials - New Smart Services opportunities
Stage 3: Solution evaluation	- Narrow down which use cases should be further developed - Develop the requirements the Digital Twin may deliver	- Case Actor matrix - Use case table framework - Solution ranking matrix - Prototyping and testing - Scenario story mapping	- Choosing the right ideas to pursue - Value determination of the smart services - Investments without a backed-up value purpose - Convincing management to continue investing resources	- Master uncertainty management - Understand and sell intangible (nonmonetary) and uncertain value
Stage 4: Development of a sales roadmap	- Roadmap containing activities to systematically develop and sell smart service offering - Marketing materials - Customer segmentations	- Service mission & vision - Action plan - goals & timeline - Definition of target markets & customer segment analysis. - SWOT & Competition analysis - Resources & market position	- Creating USP - What makes us different to larger competitors? - Showing the value of the smart services - Building thrust with the customers	- New revenue streams - Higher margins - Understanding the costs of the smart services - Growth in service business
Stage 5: Commercialization	- Pricing model (value sharing) - Sales process designed for value co-creation - Close sales	- Cost structure analysis - Marketing materials	- Understanding the costs of the smart services - Identify willingness to pay of the customer - Contract development	- Closed sales - Customer relationship - ROI on project

Fig. 1. The detailed roadmap developed and provided by the firm

4.6 Outcome and Reflection from Commercialization

The two key beneficiaries of the case studied proposed the best approach to pass the digital twin and its services through the procurement process. This approach involved presenting a full package offer, with all service offerings clearly split and, more importantly, detailing the values the customer receives. The structure and pricing for this offer were developed through sampling comparable offers from competitor service providers while also correlating proposed services with current service level agreements. The process of developing a final offer with all functional aspects of the service and the metrics to measure outcomes, sparked discoveries of value and supported the construction and the fees for the customer.

Two departmental directors (service recipients) presented this detailed service proposal to all other relevant head management individuals. The offer was presented directly to the key individuals that make the final purchasing decisions. The process used bypassed the procurement manager and, as such, reduced the opportunities for a rejection or alternative offers. This suggests that procurement may not be well equipped for buying Smart Services and that a new sales channel may be required.

5 Discussion

The case here mirrors the findings of Anderson (1998) [1], who describes the importance of understanding what customers value. The theme is then to identify, create, and deliver value. The case confirms that the process is complex and requires iteration and further confirmation from the customer. The five-step development road map of the firm with the iterations demonstrated the complexity of the process and the poor understanding of value (initially) from both parties.

Co-creation and testing of the solutions proposed is an example of open innovation [19], which assisted the design of the Smart Service as well as important aspects such as the development and testing of the revenue model. It is unlikely that traditional 'closed' innovation would have led to the proposed solution. It is also in line with Service Design that focuses on development and testing with different stakeholders within the system, in particular the active beneficiaries and providers [7]. The roadmap and the tools used supported the design and commercialization.

The use of S-D logic helped identify the value (and form) that could accrue or be destroyed in the industrial PSS. It also helped understand each actor's motivation, and the consideration of co-creation/co-delivery supported the development of the service processes. Data access and ownership concerns were identified and could be negotiated, based in part on the actor motivations and from the detailed understanding of the resources and operation. Value creation/destruction supported the net value for the beneficiary, helping with both pricing and budgeting.

The customer's procurement actors required more traditional pricing models, so the firm had to translate the value from the S-D perspective to a more traditional product view on pricing. The consequences of this were that many value co-creation propositions were lost. The use of the framework [18] supported ideation by creating four questions. The derivation of the S-D logic axioms [12] made the approach more

useable in terms of value discovery. The major difficulties from the 'value in use' model were based around the value discovery in different situations and the equal weighting of all situations.

5.1 Theoretical and practical contribution

S-D logic is a powerful concept to identify value creation and destruction in a complex industrial PSS. However, it needs both the marketing and the engineering points of view to be understood simultaneously. The value capture process then helped to define the reasonable target cost for the development of the digital twin. Service Design supported pragmatic application of S-D logic so practitioners could apply the approach. The framework [18] aided the development of different customer value propositions and the ultimate route to the commercialized customer value proposition with its revenue model/fee structure.

One of the managerial implications challenges the traditional cost-plus or value-in-exchange approaches, as they do not identify the actual value created. The application of S-D logic supported the identification of the value created, and the identification of relevant KPIs that assess and measure the value of the smart services.

6 Conclusions and recommendations

The concept of S-D logic helped to describe and develop the complex value propositions that unfolded when taking a broader industrial PSS perspective in combination with open innovation and co-development. During the motivation phase, the concept of S-D logic was used by management to create the foundation to understand value co-creation. Building this understanding for individuals who didn't know about S-D logic proved to be complicated. Particularly in the commercialization phase, people without this knowledge couldn't grasp the value of the Smart Service offerings. Traditional value assessment methods of procurement were not able to cope with the S-D logic value propositions, and the firm had to translate the value propositions to meet procurement guidelines, which lost some of the value. This provides additional challenges for detailed service delivery measurements. The major limitation of this work is that it is from a single case. More in-depth research of S-D logic in the context of industrial PSS is needed, along with new methods to operationalize S-D logic.

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