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Advanced Services for Sustainability and Growth

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Edited by:
Dr Ali Bigdeli, The Advanced Services Group, Aston Business School
Professor Tim Baines, The Advanced Services Group, Aston Business School

THE ADVANCED SERVICES GROUP

Aston Business School
BIRMINGHAM UK

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Aston Business School
Aston University
Aston Triangle
Birmingham
B4 7ET

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The Advanced Services Group is situated in Aston Business School and is a centre of excellence in research and practice in the field of advanced services and servitization. It provides education, training and research, helping manufacturers and technology innovators to develop services-led strategies and implement them in their businesses.

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Advanced Services Growth 3. This project will underpin new growth in manufacturing SMEs in the Black Country of the UK – it will be achieved through a series of business support interventions to help these SMEs to develop business models for advanced services that 'co-create' value for themselves and their customers.

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Introduction

The Spring Servitization Conference (SSC) is dedicated to understanding how organisations can develop and adapt their business models through servitization and advanced services. Since its inception, the mission of SSC has been to play a key role in the development of a better understanding of servitization and to demonstrate the potential impact upon businesses and society. SSC continues to fulfil this mission and provide the major forum for academic researchers from across disciplines including operations management, strategic management, service innovation, marketing, information systems, etc. to constructively share and debate their findings, generate new ideas, network and forge research partnerships.

The past four years, have seen the event visit Manchester (UK), Lucerne (Switzerland), Copenhagen (Denmark) and Linköping (Sweden), we were planning to bring it back to Birmingham, where it all began more than 10 years ago. However, due to the COVID-19 pandemic, we were forced to move the conference online. SSC2020 went ahead together with the first World Servitization Convention (WSC). WSC attracted business executives who are engaged in the organisational transformation towards servitization and are inspired to become an advanced services provider. It combines both exhibitions with live demonstrations from large and SME manufacturers, and industry presentations and workshops from leading experts in the field.

Acknowledgements

We would like to thank all contributors, both new and returning colleagues, reviewers, delegates, sponsors and staff, for their continued commitment to the Spring Servitization Conference and its objectives despite the uncertainty and challenges generated by the COVID-19 pandemic.

Professor Tim Baines & Dr Ali Z. Bigdeli

The Advanced Services Group, Aston University, UK.

September 2020

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TREBLE INNOVATION FIRMS: OPENING INNOVATION FRONTIERS IN MANUFACTURING

Ferran Vendrell-Herrero, Oscar F. Bustinza & Marco Opazo-Basáez

ABSTRACT

Purpose: Previous research has mostly analyzed service innovation in isolation, whilst this study aims at comparing profit position of firms adopting simultaneously product, process, and service technological innovations (i.e., treble innovation firms) to firms that 'only' adopt product and process innovation (dual innovation firms).

Design/Methodology/Approach: We test our hypotheses on a random and representative survey to 423 Spanish manufacturing firms. We implement propensity score matching techniques.

Findings: 62% of firms are dual innovators and 22% are treble innovators. Our results support our hypotheses presented. We find causal evidence supporting that treble innovation firms are more profitable than dual innovation firms. Our results also confirm that open innovation positively moderates the relationship between treble innovation firms and performance.

Originality/Value: This is the first study that estimates profit gains of implementing product, process and service innovation (i.e., a treble innovation strategy) simultaneously.

KEYWORDS: Open Innovation, Service Innovation, Resource Based View, Manufacturing firms, Returns on Sales.

1. INTRODUCTION

Product companies resort to emerging technologies from the digital world to offer a wide range of technological innovations, and thus obtain greater value from the product throughout its lifecycle (Opazo-Basáez et al. 2018). Such innovations do not only entail product and process innovations, but also service innovations that lend the firm considerable extra capacity to create value (Bustinza et al. 2017). On an increasingly competitive and globalised market, firms integrating product, process, and service innovations described as *treble innovators* are becoming more common. The growing renown of these types of firm is, in itself, significant because it reinforces the notion that these different types of innovation complement each other (e.g., Visnjic et al. 2016). Accordingly, this research aims to assess quantitatively both, profit position and open innovation adoption of treble innovation firms.

This paper draws on the Resource-Based View (RBV) of the firm. This theory states that firms need to control and exploit limited, inimitable and valuable resources in order to increase its competitive advantage (Teece 2006).Therefore, in accordance to this theory and an evolutionary perspective of innovation (Hannola et al. 2018) in which tangible and intangible resources are deemed complementary to each other, we hypothesize that treble innovation firms are more profitable than firms that already possess product and process innovations (dual innovators) (H1).

The theoretical rationale of RBV and open innovation has marked discrepancies. Contrary to what open innovation postulates, RBV posits that the firm needs to maintain control over its most valuable resources and retain them internally. Despite this apparent incongruity, a recent formal model developed by Alexy et al. (2018) has enabled these two theoretical views to find a convergence point. Their conceptual model suggests that open innovation and RBV fit properly under two conditions: (i) when the use of external knowledge implies a significant saving in terms of developing internal innovation, or (ii) when open innovation enables intangible resources that remain protected in the organisation to be systematically exploited with supply chain partners. Based on this argumentation, we also hypothesize that treble innovation firms can benefit more from open innovation, as they need to develop and manage more innovation resources (H2). Figure 1 graphically exhibits this conceptual model.

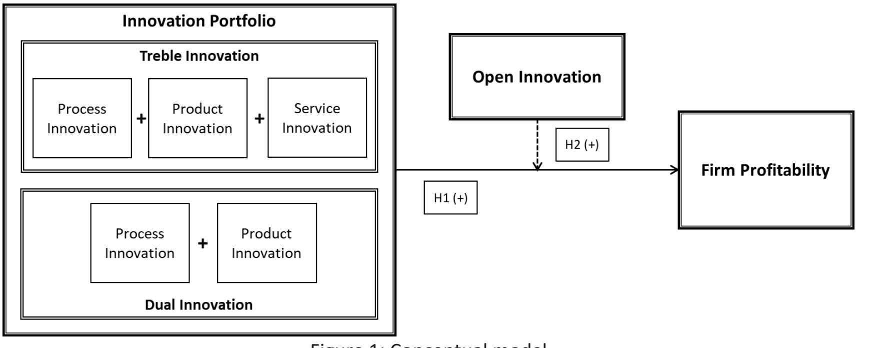

Figure 1: Conceptual model

2. EMPIRICAL APPROACH

2.1 Data and variables

To identify firms' population we use the Bureau Van Dijk's database service, accessing contact, accounting and financial information on a large set of firms with good representation of all strata of the business population. We limited our study to the population of Spanish firms with more than 50 employees, operating in industries with manufacturing NAICS codes 31, 32 and 33 (~7,000 firms). Firms were contacted in 2018 via Computer-Aided Telephone Interviewing. We obtained 423 complete responses with sectoral and size composition close to that in the total population. Once the survey was completed, it was merged with SABI database to ensure that the monetary values of interest (e.g. dependent variable is return on sales) were fully objective.

Following previous studies, we asked to the firms the following question for each specific innovation: "*During the last three years, did your firm introduce any new or significantly improved product/process/service on the market?*" To be classified as a treble innovation firm, the company had to respond positively to having all three innovation types (product, process and service); to be classified as dual, the firm had to respond positively to the questions on process and product innovation and negatively to the question on service innovation. It is important to state that service innovation includes only advanced services (Jovanovic et al. 2019; Porter and Heppelmann 2014). For assuring the advanced composition of services, a specific question was constructed for such purposes. Of the 423 firms, 92 (22%) were classified as treble innovation firms and 264 (62%) as dual innovation firms. The remaining 67 firms were non-innovators or had other innovation profiles. Figure 2 Panel A compares the revenues of the treble and dual innovation firms in our sample. Figure 2 Panel B does the same for total factor productivity (TFP) .The evidence indicates that treble innovation firms make a larger volume of sales and have higher productivity than dual innovation firms.

Firm performance follows previous literature. In our study, the dependent variable is Returns on Sales (ROS), computed by dividing the firm's earnings before interest, taxes, depreciation, and amortization (EBITDA) of the firm's annual revenues. As profitability varies significantly over the years, we averaged ROS for the last two years (2017-2018). The advantage of this variable is that it enables direct interpretation of the firm's profit margin. The firms in our sample have an average ROS of 8.7%; that is, the firm retains 0.087 cents per euro sold in the form of profit.

Our moderating variable, Open Innovation (OI), adapts the Laursen and Salter (2006) counting measurement of breadth in external sources of knowledge for innovation activities. Our measure contains two substantial differences. Firstly, the original measure of Laursen and Salter (2006) uses sixteen information sources (IS). However, those sixteen sources of external knowledge can be synthetized in three. Two of them make reference to existing knowledge within the supply chain, (i) cooperation with suppliers, the (ii) use of consumer feedback and information, and the third one covers other knowledge that goes beyond the supply chain and can be accessed through consulting firms, institutions or regulatory bodies in the form of contracting (iii) acquisition of external knowledge (contracts). Secondly, Laursen and Salter (2006) use a single and generic innovation outcome, but consistent with our framework we collect differentiated use of external knowledge in process, product and service innovation. Overall, this means that whilst Laursen and Salter (2006) calculates the breadth in open innovation using sixteen specific sources of external knowledge used to create a generic innovation outcome (∑IS range between 0 and 16), our measure has 3 generic sources of external knowledge for 3 specific innovation outcomes. Our procedure enable, for example, to acknowledge a difference in open innovation breadth between firms that use suppliers' knowledge for developing different innovation outcome (say process and product) to firms that use supplier's knowledge for developing only one innovation outcome (say process). Our open innovation index equals the sum of all external information sources plus one (∑IS+1). The index thus has a minimum of 1 (no sources of external innovation) and a maximum of 10 (all possible sources of external innovation).

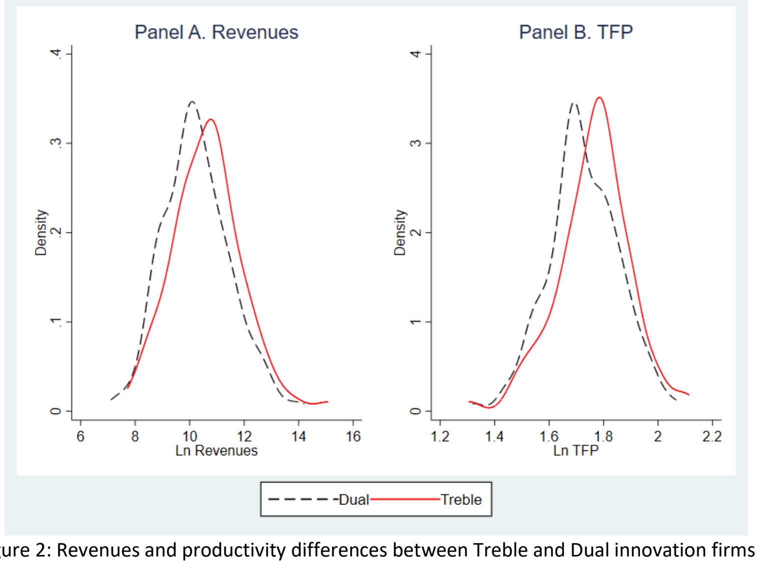

Figure 2: Revenues and productivity differences between Treble and Dual innovation firms

Our model also contains a series of control variables including industry dummies, state dummies, number of employees, TFP and R&D over revenues.

2.2 Empirical approach

Controlling for firm characteristics such as open innovation, productivity, size, or investment does not entirely rule out the possibility that the relationship between treble innovation and firm profitability is affected by the presence of confounding variables (i.e., the possible existence of unobserved firm characteristics that cause both decisions) or reverse causality (i.e., causality could run from profitability to treble innovation, since more profitable companies may have more resources available to invest in innovation). We attempt to mitigate possible estimation bias by implementing treatment models based on propensity score matching (PSM). This procedure yielded a matched subsample of 168 firms (84 Treble vs. 84 Dual). Figure 3 represents the result of the matching process. It reports kernel distribution of propensity scores before (Panel A) and after (Panel B) implementing the matching procedure and indicates a good level of matching. Kolmogorov-Smirnov test specify that distributions are statistically different before matching and statistically indistinguishable after matching.

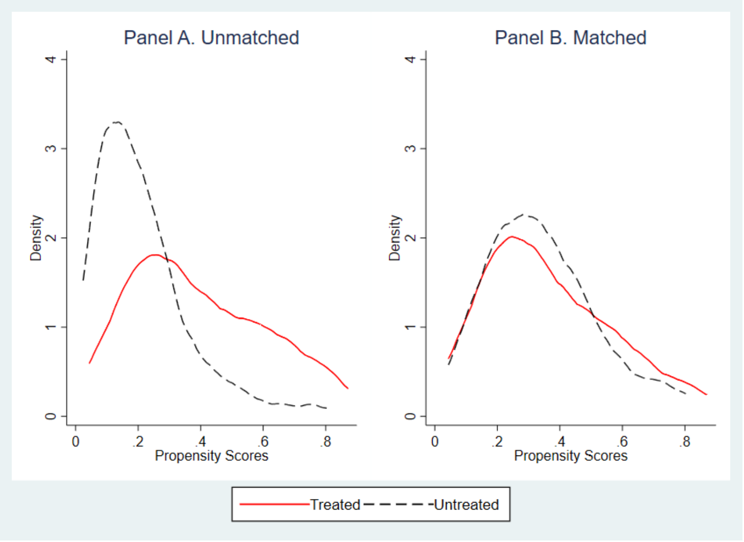

Figure 3: Propensity score matching (Treble vs Dual)

Once propensity score matching is defined, we can estimate three different parameters of the treatment effect: (i) the average treatment effect (ATE) measures the profit addition of treble innovation in a firm randomly selected from the population, that is, the expected increase in outcome if all firms were to implement the study treatment, (ii) the average treatment effect on the firm treated (ATET) measures the effect of implementing treble innovation in the subsample treated, and (iii) the Doubly Robust (PSM-DR) model estimates the treatment (Treble vs Dual) and the outcome (ROS) models simultaneously.

Our study also seeks to understand how treble innovation firms can resort to open innovation strategies to increase their profitability. We establish linear and quadratic interaction effects between treble firms and our open innovation index (OI).

3. RESULTS

Table 4 further explores this relationship by estimating the ATE, ATET, and DR parameters based on the matched sample. For the ATE and ATET models, we report the control group effect, which indicates the potential outcome mean for the control sample, in our case dual innovators. This value ranges from 0.059 to 0.064, implying that dual innovators earn on average 5.9 to 6.4 cents per euro sold. The coefficient is statistically significant, in most cases at 1%. More importantly, the treatment coefficients obtained in the ATE and ATET models reinforce the results in the linear regression analysis in Table 3 but stress a causal relationship between treble innovation and profitability. For example, the ATET coefficient shows a profit gain from adding advanced services in dual innovation firms of 4.7 cents per euro sold. In sum, the ATET model shows that whilst dual innovation firms earn on average 5.9 cents per euro sold, treble innovation firms earn on average 10.6 cents per euro sold, being the difference (4.7) statistically significant. Both the causal relationship between treble innovation and performance, and the size effect become more robust after performing the doubly robust analysis. The DR parameter is nearly the same as the ATET and remains highly significant. According to the DR parameter, treble innovators earn 4.3 cents (p-value = 0.032) per euro sold more than dual innovators, respectively. Together, the results obtained with the matched sample support Hypothesis 1. More importantly, they indicate unbiased causality. Introducing advanced services in dual innovation firms increases firm performance, not the other way round.

Table 1. Propensity Score Matching and Doubly Robust

	PSM		PSM-DR
Dep. variable: Return on Sales (ROS).	ATE	ATET	DR
	Treble vs. Dual		
Treatment effect (Treble)	0.038**	0.047**	0.043**
	(0.035)	(0.038)	(0.032)
Control group effect (Dual)	0.064***	0.059***	--
	(0.000)	(0.000)	--
Observations	168	168	168
R^2	--	--	0.2319

P-values in parentheses (based on robust standard errors).
*** p<0.01, ** p<0.05, * p<0.1

Another purpose of this paper is to understand how open innovation can boost profitability in treble innovation firms. We determine this by incorporating linear and quadratic interactive effects between the generic treble dummy variable and the open innovation index. The results of this analysis are reported in Table 2. We start with the linear interactive effect between treble and open innovation, Model 1. As expected in Hypothesis 2, the parameter is positive, but the coefficient is largely insignificant. If we examine the quadratic effect, however, the results become very significant, indicating that the role of open innovation in moderating the relationship between treble innovation and firm performance follows a U-shape.

Table 2. The moderation role of open innovation

Dep. variable: Return on Sales (ROS).	Model 1	Model 2
	Treble vs. Dual	
Treble	-0.0093	0.0710*
	(0.7297)	(0.0542)
Open Innovation (OI)	-0.0061	-0.0059
	(0.1893)	(0.2017)
OI*Treble	0.0097	-0.0375**
	(0.3249)	(0.0165)
OI2*Treble		0.0060***
		(0.0010)
#Workers/100	0.0005	0.0003
	(0.7074)	(0.8169)
R&D	-0.0003	-0.0003
	(0.7975)	(0.7985)
TFP	-0.0014	-0.0018
	(0.8754)	(0.8317)
Constant	0.0725	0.0754
	(0.2445)	(0.2122)
Observations	356	356
R-squared	0.074	0.078
Industry dummies	YES	YES
State dummies	YES	YES

P-values in parentheses (based on robust standard errors). *** p<0.01, ** p<0.05, * p<0.1

Our results support Hypothesis 2, since they demonstrate that high levels of open innovation are desirable for firms with differentiated offerings (treble). To obtain a deeper understanding of the resource retrenchment effect, however, this result should be considered in combination with the firm's level of internal R&D expenditure. The resource retrenchment argument suggests that open innovation is most profitable when firm differentiation (treble) is coupled with a reduction in innovation costs (R&D expenditure). But is this argument consistent with our evidence? Figure 4 clarifies this question. The dotted line, which indicates the average R&D expenditure (over sales) of treble firms, is situated at 6.4%. The continuous blue line shows the average R&D expenditure of treble firms for each level of open innovation. Treble firms with low levels of open innovation (OI = 1 & OI =2) thus seem to spend more on R&D than the other treble firms, whereas firms with medium levels of open innovation (OI of 3-8) seem to be very close to average R&D spending. At the other extreme, however, treble firms with high levels of open innovation (OI = 9 or OI = 10) have very low levels of R&D expenditure, signaling some substitution effect between open innovation and internal R&D investment. If we combine Panels A and B in Figure 5, our evidence seems to align perfectly with value migration and resource retrenchment, since the benefits of open innovation require the presence of highly differentiated offerings (treble) and a reduction in R&D expenditure.

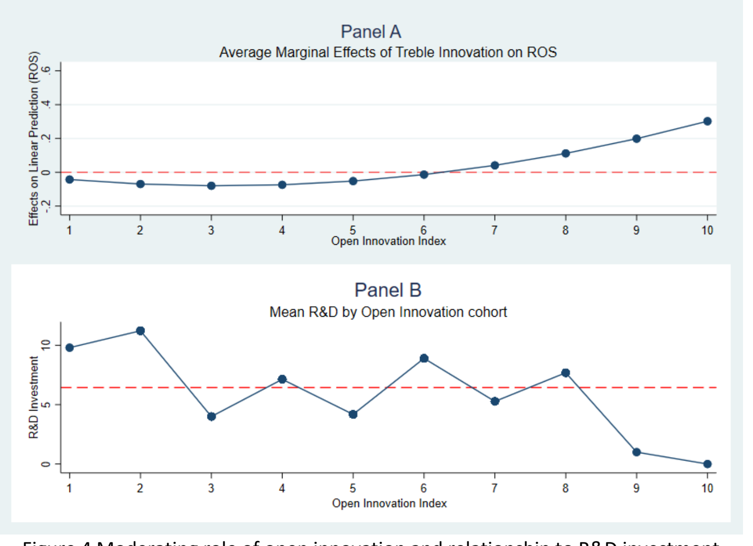

Figure 4 Moderating role of open innovation and relationship to R&D investment

4. CONCLUSIONS

4.1. Theoretical implications

This study contributes to the innovation and operations management literatures by proposing a novel conceptual angle on the field of synchronized adoption of different types of innovation (Damanpour 2014). Whereas previous studies focused on analyzing technological innovations generally characterized as process and product developments, our study integrates service innovations in product firms as another important technological innovation. One significant implication of this focus is the creation of a new concept that distinguishes manufacturing firms that adopt these innovations simultaneously (which we refer to as *Treble innovation firms*). "Treble" firms inherit innovation methods developed along the different industrial revolutions. These firms have disposed to introduce

improvements in production processes (machinery-based innovation), product differentiation and design (information-based innovation), and customer orientation (knowledge-based innovation).
This article also advances the theoretical and empirical development of the RBV framework. Firstly, it considers innovation outcomes as VRI resources, reinforcing the idea that the firm's strategic resources are complementary in character (Teece 2006). Secondly, and more importantly, this study helps to resolve the apparent contradiction between the RBV and open innovation. Our empirical analysis is the first to validate the theoretical model developed by Alexy et al. (2018), which argues that the postulates of open innovation are fully consistent with the RBV as long as the former permits systematic reduction of R&D expenditures (resource retrenchment) and/or increases the value of other VRI resources that the firm possesses (value migration). Finally, this study contributes to the growing field of inquiry into implementation of services in manufacturing industries, or servitization. With a few exceptions (Visnjic et al. 2016), prior studies in this field evaluate service business model innovation in manufacturing as an isolated element of the firm's innovation policy. Overall, these arguments suggest that service infusion success might be contingent on the development of an innovation portfolio rather than a single innovation endeavor. The data collected for this study show, however, that service innovation is extensively linked to other technological innovations.

4.2. Managerial Implications

This study has implications for directors, innovation managers, and manufacturing firms. According to the results, the innovation strategy should be seen more holistically, including various technological components in the firm's resources that will ultimately bear fruit in the form of a greater operating margin. Process, product, and service innovations should thus be seen as complementary. Clearly, it is not viable for many firms to develop multiple innovations internally. We thus recommend that firms (especially small and medium-sized firms) develop collaboration agreements with other agents in the supply chain, including customers, suppliers, and competitors. Access to external knowledge through a clear policy of open innovation should enable the firm to be more competitive. For such a strategy to work, it is important to control R&D expenditure. Our results suggest that, in the case of treble innovation firms, internal R&D and open innovation should be seen as substitutive, not complementary.

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AUTHORS

Dr Ferran Vendrell-Herrero
Department of Management, University of Birmingham, Birmingham, UK, B15 2TT
+44 (0) 121 414 8563, f.vendrell-herrero@bham.ac.uk.

Prof Oscar F. Bustinza
Department of Management, University of Granada, Granada, Spain, 18071
+ 34 958 241000, oscarfb@ugr.es

Dr Marco Opazo-Basaez
Department of Marketing, University of Deusto, Bilbao, Spain, 48014
+34 944 139 000, marco.opazo@deusto.es

THE IMPACT OF ENVIRONMENTAL TURBULENCE ON THE SERVITIZATION DECISION

Alejandro G. Frank; Néstor F. Ayala; Glauco H.S. Mendes

ABSTRACT

Purpose: This study addresses industry conditions as antecedents on the Servitization choice by unpacking uncertainty into two specific sources: market and technological turbulence.

Design/Methodology/Approach: We hypothesize that the uncertainty sources will make product firms adopt more customized services rather than standardized services. We test the hypotheses in two different ways: first, by analysing the association of environmental turbulence with the adopted level of service customization and, second, by considering the association of these environmental turbulence sources with three service business dimensions that support service-centric business model in product firms: service offering, service resource base and service activity system. Our study is based on a quantitative study of 104 product firms.

Findings: The empirical evidences support most of our hypotheses, showing that product firms increase service customization and develop more service-centric business models when they face uncertain business conditions.

Originality/Value: We expand previous findings on industry conditions and servitization modes by providing a detailed perspective of the uncertainties source effects and the mechanisms behind product firms' adoption of certain forms of services. Managers can learn how to deal with Servitization in specific environments and what they should consider in terms of business model dimensions.

KEYWORDS: Servitization; service business model; service customization; market turbulence; technological turbulence; switching costs.

1 INTRODUCTION

Historically, studies have seen Servitization as a matter of internal decisions and efforts made by product firms based on their resources and capabilities (Eloranta and Turunen, 2015). A narrow stream of the literature has considered the business environment and industry conditions as important antecedents of Servitization. For instance, Fang et al. (2008) demonstrated that the shift of product firms to service offering increase firm value in high industry turbulence. Cusumano et al. (2015) focused on the types of services product firms may offer, showing that they depend on the industry lifecycle stage and the related uncertainty conditions, while Visnjic et al. (2019) followed this reasoning by analysing the specific effects of environmental uncertainties on the type of service adopted by product firms. Therefore, these studies have shed light on the industry conditions for the adoption of different types of services.

Our study follows this stream on industry conditions by unpacking uncertainties sources into two specific types of the innovation context: market and technological turbulence (Calantone et al., 2003). While market turbulence encompasses the rate of change in customer demands; technological turbulence refers to the rate of change in new products, services and process requirements due to the development of new technologies (Calantone et al., 2003). Although these two uncertainty sources have been largely studied in the product innovation field, and there is a common agreement in the Servitization literature concerning the influence of environmental uncertainties on servitization strategies (e.g. Forkmann et al., 2017; Turunen and Finne, 2014); there is a lack of evidences about the association of these uncertainties sources with the level of service customization a product firm will adopt and the resulting focus of the company's business model. We hypothesize that these uncertainty sources will make product firms adopt more customized services in the Servitization strategy. We ground this general hypothesis in the capability-based switching cost perspective, which considers that customers develop switching costs when they invest time and effort to develop capabilities related to the solution offered (product, services or both). We propose that, under market and technological turbulence, servitized product firms will increase the level of service customization rather than standardization as a mechanism to intensify the relationship with the customers, creating switching costs that prevent the loose of customers and to anticipate market and technological changes. We also hypothesize that market and technological turbulence will demand a more service-centric business model, since the company will need to create a stable source of competitive advantage when product conditions are unstable.

We consider these general hypotheses in two different ways: first, by analysing the association of market and technological turbulence with the adopted level of service customization in product firms (namely Servitization focus) and, second, by considering the association of these environmental turbulence sources with three service business dimensions that support service-centric business model in product firms (Ayala et al., 2019): (i) *service offering*, i.e. the service-based conditions under which a product firm offers value to the customers; (ii) *service resource base*, i.e. the resources and capabilities needed to implement the transition to services; and (iii) *service activity system*, i.e. the internal organizational processes that product firms must conduct to implement Servitization. Our study is based on a quantitative cross-industry study of 104 servitized product firms. The empirical evidences support most of our hypotheses showing that product firms, in fact, tend to enhance service customization as a mechanism to increase customers' switching costs and to anticipate market and technological changes. Our findings also show that companies develop more service-centric business models when they face uncertain business conditions. Thus, we expand previous findings on industry conditions and servitization modes (Cusumano et al., 2015; Visnjic et al., 2019) by providing a detailed perspective of the uncertainties source effects and the mechanisms behind product firms' adoption of certain forms of services.

2 CAPABILITY-BASED SWITCHING COSTS AND SERVICE CUSTOMIZATION

Capability-based switching costs is a term coined by Brush et al (2012) to describe switching costs resulting from customers' investments and efforts to create new capabilities related to the solution offered by a product firm. This perspective is based on the switching costs theory, which in marketing refers to the costs that customers associate with the process of switching from one provider to another. Customers avoid switching providers when there are high costs associated to this decision. Switching cost can be due to procedural, financial or relational aspects. Capability-based switching costs builds on procedural and relational aspects, since it considers the investments made by the customer on learning about the solution (procedural costs) and the creation of emotional and psychological ties with the product firm (relational costs). In this sense, product firms may aim to exploit this kind of switching cost to gain competitive advantage.

Customers' capability-based switching costs can be strongly influenced by turbulent environments in two different ways. From one hand, environmental turbulence can be a result of low switching costs and easy substitution to competitors' products. From a capability-based perspective, this means that customers do not need to invest much time and effort to acquire product-related capabilities, i.e. it is intuitive for them to use any similar concurrent product. In this case, product firms will need to create mechanisms to reinforce customers' switching costs by intensifying product experience or by creating emotional relational ties between the customer and the solution provided (Burnham et al., 2003).

On the other hand, customers can develop high capability-based switching costs because of the turbulent environment. This means that time and effort invested to acquire the necessary capabilities can be proportionally too high regarding the fast pace of market and technological change, creating high uncertainties for product adoption and substitution. In this sense, product firms can exploit customers' switching costs as an opportunity, firstly by providing solutions that minimize these risks and uncertainties (Ambroise et al., 2018) and, then, by taking advantages of cross-selling of additional products that reduce the complementary search costs and reinforce the relationship of the customer with the product firm (Brush et al., 2012).

Both cases – customers facing low or high capability-based switching costs due to turbulent environment – create opportunities for the product firm to anticipate technological and market changes through the approximation to the customer and a faster learning process of his needs. This allows the company to exploit customers' searching costs for substitute products, which has synergies with the capability-based switching cost (Brush et al., 2012). Servitization literature has associated service offering with the potential creation of switching costs (Baines and Shi, 2015; Fang et al., 2008), but the type of services and switching costs involved have been treated in a generic manner. Some types of switching costs such as financial or procedural could be addressed either by standardized or customized services (Baines and Shi, 2015). However, only customized services may help to deepen the necessary customer-firm relationship that allows to create customers' capability-based switching costs, as we propose in our hypotheses, in Section 4.

3 SERVICE BUSINESS MODEL INNOVATION (BMI)

Prior research has shown that companies define first how they will deal with the business environment through their product strategy (e.g. service customization) followed by the operationalization of such strategy through the company's business model. Thus, a service BMI should integrate at least two levels: (i) the strategic positioning of the Servitization focus and (ii) the configuration of the service business model (Ghezzi et al., 2015). Regarding the strategic positioning or Servitization focus, product firms must decide the level of service customization – or standardization – to be offered, which can be applied either to product-oriented or customer-oriented services (Ayala et al., 2017). Regarding the configuration of the service business model, prior studies have proposed different dimensions that product firms should consider. Ayala et al. (2019) summarized them in three main service business model dimensions: service offering, service resource-base and service activity system.

"*Service offering*" business dimension is defined as the service-based conditions under which a product firm offers value to the customers (Ayala et al., 2019). This dimension deals with the definition of a service orientation of the company, reinforcing the role of services as a source of differentiation among other competitors (Ayala et al., 2019). The creation of additional value through services requires a greater knowledge about customer needs, business practices and value perception (Baines and Shi, 2015). Thus, it is necessary to develop a customer orientation regarding the development and delivery of tangible and intangible offerings (Ayala et al., 2019). In this sense, it is worth noticing that service offering is complementary to the Servitization focus (i.e. level of service customization or standardization). While the Servitization focus defines the type of service being offered, service offering defines the relevance of any kind of service in the company business model.

The second dimension, named "*resource base*", refers to the need of developing new resources (productive assets) and capabilities (what the firm can do) in order to be able to implement the transition to services (Ayala et al., 2019). It includes individual expertise as a source of competitive advantage, since employee engagement, knowledge and decentralized decision-making are essential to strengthen the service orientation. It also includes the company's internal capacity to adapt to market changes, which involves a flexible structure and resilience of the employees.

The last dimension is the "*activity system*" which involves the internal organizational processes and other operational aspects that product firms must conduct to implement Servitization (Ayala et al., 2019). The integration of product and service development processes is important for responding customers' needs with new products and services (Ayala et al., 2019). Another aspect is the integration of resources and functional processes, such as the involvement of the service functional area in strategic decisions about new products and markets, as well as the cross-integration and knowledge transfer among other functional areas and other business units. Lastly, this dimension also considers activities related to customer's feedback for service development, improvement and delivery processes.

These three service business dimensions can be less emphasized by the product firm when services are merely add-ons and the company remain product-centric or they can play a central role when product firms adopt a service-centric business model (Ayala et al., 2019). In general, product firms that adopt customized services tend to be more service-centric, which means that they give higher priority to the development of all service business dimensions.

4 HYPOTHESES DEVELOPMENT

Our hypotheses are based on some assumptions from prior findings of the Servitization literature. Firstly, there is empirical evidence that Servitization increases product firm value in turbulent environments (Fang et al., 2008; Gebauer et al., 2010). Therefore, we do not focus on whether product firms should servitize or not, but we go further to understand the type of service to be adopted (standardized vs. customized) in such environments. Secondly, Visnjic et al. (2019) have demonstrated the impact of industry turbulence on product-oriented and customer-oriented services. In this sense, our hypotheses divide turbulence into two specific types – market and technological – and focus on the relevance of the customization level as a way to deal with customers when facing these types of turbulence. We focus on market and technological turbulence because they are two of the most important sources of uncertainty affecting organizational design and performance (Akgün et al., 2012; Jaworski and Kohli, 1993) and, consequently, Servitization (Gebauer et al., 2010). Both are related, but distinct, since one of them can occur in period when the other is stable (Cusumano et al., 2008), being necessary to study both effects independently. Finally, we consider the relevance of a service-centric business model of product firms as a way to approach environmental turbulence and create capability-based switching costs. Thus, we propose the following hypotheses:

H1: Higher levels of market turbulence will be positively related to the level of service customization offered by a product firm, as opposed to service standardization.

H2: Higher levels of market turbulence will be positively related to a higher development of a service-centric business model of product firms, which is represented by:

(a) a higher development of a service offering business dimension (H2a),

(b) a higher development of a service resources base business dimension (H2b)

(c) a higher development of a service activity system business dimension (H2c)

H3: Higher levels of technological turbulence will be positively related to the degree of service customization offered by a product firm, as opposed to service standardization.

H4: Higher levels of technological turbulence will be positively related to a higher development of a service-centric business model of product firms, which is represented by:

(a) a higher development of a service offering business dimension (H4a),

(b) a higher development of a service resources base business dimension (H4b)

(c) a higher development of a service activity system business dimension (H4c)

The conceptual model shown in Figure 1 summarizes the proposed hypotheses. Environmental turbulence is subdivided into two independent variables: market and technological turbulence, which are associated with the service BMI of the product firm. On the other hand, service BMI is represented by two levels – the strategic and the operational levels. The first level is the Servitization focus, which is represented by the continuum between the level of standardization and the level of customization (i.e. the more customized, the less standardized). The second level considers the service business dimensions to support Servitization (Ayala et al., 2019): (a) the service offering, (b) service resource base and (c) service activity system.

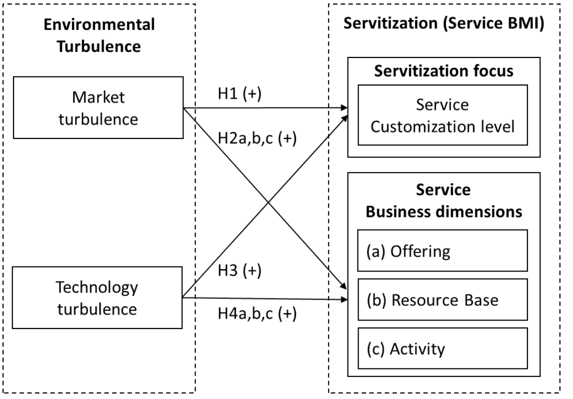

Figure 1 – Research model

5 RESEARCH METHOD

5.1 Data collection and sample

Following other studies that used multisamples, we performed a cross-sectional international survey in servitized product firms. Our sample is from two industrial networks of companies, one in Brazil and other in Italy. These two samples allow us to obtain evidences from environmental turbulence in both emerging and developed countries. Both industrial networks are coordinated by universities and aim to share knowledge on this topic by means of executive courses, seminars and conferences. The Brazilian sample is composed by 347 companies from the Southern region and the Italian sample is composed by 216 companies from the Northern region. The questionnaire was addressed to managers involved in the operations strategy of these companies and was administrated online, through the mailing list of the network. We obtained 104 useful responses for the variables considered in this paper (response rate of 18.47%). Table 1 shows the composition of the sample.

5.2 Variable operationalization and analysis

For the variable operationalization, we drew on prior constructs from the literature. For the assessment of the three service business dimensions for Servitization, we used the constructs proposed by Ayala et al. (2019). Following these authors, the strategic level of Servitization is operationalized in the *Service Offering* dimension [OFFERING], which is represented by 5 items (service as a competitive advantage, differentiation by services, value added by services, service to meet customers' needs and customer orientation). The *Resource Base* dimension [RESOURCE] is represented by four items (internal development of new competences, individual expertise for service offering, internal flexibility and internal knowledge related to services processes). The *Service Activity system* dimension [ACTIVITY] is represented by 5 items (joint development of products and services, involvement of service area in the NPD process, involvement of functional areas in solution development, involvement of customers in solution development, involvement of other business unites in the development of solutions). Ayala et al. (2018) developed these constructs with the support of both prior research and expert validation, since quantitative research is still limited in this field. For technological turbulence [TECH] and market turbulence [MARKET] constructs, we adapted the scales used in Akgün et al. (2007) and Lee et al. (2008) to our context, each of them composed by 3 items. Market turbulence consists of changes of customer´s preference over time, tendency of customer to look for new products and different needs of needs between new and current customers. Technological turbulence includes: rate of change of technology, new product launch due to technological breakthroughs and opportunities generated by technology change. Finally, service customization [CUSTOM] was assessed by a single item adapted from Cusumano et al. (2008) concept. For the data analysis, we used ordinary least square (OLS) regression, which was performed in the software Stata 13.0®. We performed four different OLS models, one for each dependent variable: CUSTOM, OFFERING, RESOURCE, ACTIVITY.

6 RESULTS

Our results of the OLS regression model are summarized in Table 3. In the first step of the model, we regressed the four dependent variables (OFFERING, RESOURCE, ACTIVITY and CUSTOM) on the control variables (Country, Size_large, Size_middle, Business and Portfolio) [1]. In the second step, we tested the environmental turbulence explanatory variables (MARKET and TECH) on the dependent variables. The final models for the direct effects of MARKET and TECH were statistically significant: a) the model for a) CUSTOM (F-value = 5.200, p-value < 0.01) explains 22.2% (adjusted R^2 = 0.222); b) the model for OFFERING (F-value = 6.162, p-value < 0.01) explains 26% of the variance of the dependent variable (adjusted R^2 = 0.260); c) RESOURCE (F-value = 3.494, p-value < 0.01) explains 14.5% (adjusted R^2 = 0.145); and d) ACTIVITY (F-value = 3.983, p-value < 0.01) explains 16.9% (adjusted R^2 = 0.169).
Regarding the independent variable 'market turbulence' [MARKET], our findings support H1, showing a slightly significant association (p<0.1) with the level of service customization [CUSTOM] (B = 0.189, p = 0.066), as shown in Table 3. In addition, we found statistical support for the association of MARKET with two of the three Servitization business dimensions analysed. In this sense, H2a was supported by showing a significant association of MARKET with OFFERING (B = 0.236, p = 0.019) and H2c was supported with a significant association of MARKET with ACTIVITY (B = 0.262, p = 0.015). H2b was not supported by our results because we did not find statistical significance for the regression of RESOURCE on MARKET.
Considering the second independent variable, 'technological turbulence' [TECH], the results of Table 3 support all the hypotheses proposed for this variable. Firstly, H3 was supported showing that the developing of more customized services [CUSTOM] is associated with higher levels of technological turbulence (B = 0.291, p = 0.005). Moreover, H4a, H4b and H4c were also supported showing that companies more emphasis to the internal business dimensions of Servitization when facing technological turbulence (OFFERING: B = 0.243, p = 0.015; RESOURCE: B = 0.310, p = 0.004; ACTIVITY: B = 0.209, p = 0.048).

Table 3 – Results of the regression analysis[(a)]

	CUSTOM	**OFFERING**	**RESOURCE**	**ACTIVITY**
Country (Italy= 0; Brazil= 1)	-0.065	-0.053	-0.086	0.149
Size_large	-0.175*	-0.139	0.012	0.038
Size_middle	-0.228**	0.044	0.103	0.011
Business (B2B= 0; B2C= 1)	-0.112	-0.191**	-0.090	-0.169*
Portfolio (Service level)	0.133	0.254***	0.071	0.066
MARKET	0.189*	0.236**	0.149	0.262**
TECH	0.291**	0.243**	0.310***	0.209**
F-value	5.200***	6.162***	3.494***	3.983***
R^2	0.275	0.310	0.203	0.225
Adj.R^2	0.222	0.260	0.145	0.169
Change in R^2	0.166***	0.163***	0.156***	0.158***

[(a)] Only the second stage and final of the hierarchical regression models are presented with standardized beta coefficients and significance range: *** p< 0.01; ** p <0.05; * p<0.1

[1] To simplify the presentation of our results, we only report the final stage of the model, with all independent and control variables.

7 DISCUSSION AND CONCLUSION

Our findings provide support for most of the hypotheses proposed, suggesting that, under market and technological turbulence conditions, servitized product firms will increase the level of service customization as a mechanism to develop or exploit customers' capability-based switching cost (besides other switching costs associated to both standardized and customized services). In such conditions, product firms will also emphasize a service-centric business model to be able to address effectively customers' capability-based switching cost through service customization. These results have implications for theory and practice as discussed next.

7.1 Theoretical implications

From a theoretical perspective, our paper extends the recent discussion on industry conditions that influence the strategic decision of servitizing in product firms (Visnjic et al. 2019). In this sense, we moved a step further by providing a detailed perspective of the effects of uncertainty sources, namely market and technological turbulence, and the mechanisms behind product firms' adoption of certain forms of services, i.e. customized services for the creation and exploitation of customers' capability-based switching costs. We did not consider the outcomes of service BMI, since prior literature has already proven that customized services increase companies' value in turbulent contexts (e.g. Fang et al., 2008) and that service-centric business models results in more long-term benefits for product firms (Ayala et al., 2019; Suarez et al., 2013; Visnjic et al., 2016). Instead, we focused our attention on the antecedents of service BMI decisions – i.e. the reasons why product firms tend to adopt service customization in turbulent environments – which we rooted on the capability-based switching costs theory (Brush et al., 2012).

Our findings on service customization in turbulent contexts congregate prior research findings, helping to obtain a more accurate vision of industrial conditions in Servitization. Visnjic´s et al. (2019) showed that, in turbulent environments, product firms tend to adopt product-oriented services (i.e. services focused on the product usage) to reinforce their capabilities in the existing technology, and Cusumano et al. (2008) suggested that, under uncertain market and technological conditions, product firms emphasize services that adapt the product to specific customer requirements. Thus, the addition of our findings to these prior studies, led us to conclude that, in high turbulent environments, product firms should enhance product-related services (Visnjic et al., 2019) and these services should have higher levels of customization (according to our results and as suggested before by Cusumano et al., 2008, 2015), which can help to exploit better customers' capability-based switching costs. These results support the conception that standardized product-related services (instead of customized services), such as standardized maintenance or installation, add little value to Servitization and are very limited to create customer loyalty and to anticipate market and technological change (Ambroise et al., 2018; Matthyssens and Vandenbempt, 2010)). Moreover, building on these previous findings, we also unpacked the type of turbulences involved in the process (i.e. market and technological), expanding the understanding of the external conditions that affects product firms' decisions on Servitization.

Our results show that product firms that face environmental turbulence not only focus more on customized services to create customers' switching costs mechanisms, but they also need to develop an internal service-centric business to address this strategic focus. In this sense, our findings show the relationship between the external environment and the internal strategic alignment of the product firm's business model to offer a servitized solution (Baines et al., 2017; Eloranta and Turunen, 2015). Prior research has shown that product firms can rely on external service suppliers instead of developing an internal service-centric business model (Ayala et al., 2017, 2019). Nonetheless, our findings show that developing internal conditions to support customized services can become a matter of survival in rapid changing environments (Ambroise et al., 2018; Turunen and Finne, 2014). Therefore, the business environment will have an important implication for such decision. Turbulent environment will lead to an increasing service-centric business model of the servitized product firm to be able to compete in the long-term.

7.2 Managerial implications

Practitioners can use our findings to support their decision on whether focus on more standardized or customized services, according to the level of market and technological turbulence observed in their industrial segment. Our findings suggest that managers should use more customized services when facing turbulent environment, as a way to maintain customer loyalty and their dependence to the product offered and to anticipate technological and market changes. Our findings also alert practitioners about the importance of environmental turbulence for the internal business model dimensions that should be operationalized for Servitization. Companies that face turbulent environments need to develop service-centric business model based on the three business dimensions considered in our work. This means that service cannot be treated just as an extension of product firms; they should be considered a strategical aspect while the service offering dimension should be highly developed to rapidly offer services that can meet customers' needs and create higher switching costs mechanisms – and, consequently, loyalty. This is very important from a practical perspective, because product firms can decide to delegate service development to external suppliers in order to accelerate the entrance in the servitization journey (Ayala et al., 2017; Wynstra et al., 2015). However, our results suggest that turbulent environments demand an internal service-centric business model of the product firm – i.e. companies need to develop jointly service offering, service resource-base and service activity system dimensions. Product firms can be supported by external partners, not for the outsourcing of the service innovation domain, but as a way to learn how to develop the internal conditions to create value in both product and services (Ayala et al. 2017).

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AUTHORS
Dr. Alejandro G. Frank
Department of Industrial Engineering,
Universidade Federal do Rio Grande do Sul, Brazil.
90.035-190
+55 51 3308 3491, frank@producao.ufrgs.br

Dr. Glauco H.S. Mendes
Department of Industrial Engineering,
Universidade Federal de São Carlos, Brazil
13565-905
+55 16 3351-8111, glaucohsmendes@gmail.com

Dr. Néstor F. Ayala
Department of Service Engineering, Universidade Federal do Rio Grande do Sul, Brazil.
90.035-190
+55 51 3308 3491, nestor.ayala@ufrgs.br

SERVITIZATION AS A GAMECHANGER IN THE OIL INDUSTRY

Scott Wagstaff, Jamie Burton & Judy Zolkiewski

ABSTRACT

Purpose: There is an abundance of literature supporting the position that organisations who cooperate achieve greater rewards than those that act in opposition or isolation. It is, therefore, puzzling why the oil industry remains resistant to the mutual benefits of servitization. Game theory was selected as a method to examine the types of business relationships in the oil industry and investigate if the development of servitization could influence the nature of these relationships.

Design/Methodology/Approach: Game theory was used in a mixed method study of 48 oil industry subjects to determine the nature of relationship between their respective organisations and the oil industry as a whole.

Findings: The statistical results and interviews find that all parties use adversarial strategies despite the publicised intent to work cooperatively. The interviews indicate that increasing servitization could increase cooperation and, in turn, value co-creation and vice versa.

Originality/Value: The use of game theory has indicated that a paradox exists between the oil industries intended and actual working relationships, resulting in the potential sacrifice of efficiency and value co-creation.

KEYWORDS: Servitization, Game Theory, Systematic Combining, Oil Industry

1. INTRODUCTION

Oil is a volatile global commodity and the primary export for many nations (Kesicki, 2010) which makes it a highly political product (Parra, 2004). In addition to this, the extraction, transportation and combustion of oil and its derivatives can have detrimental effects on the natural environment. Reducing the need to develop new oil reserves by increasing efficient use of existing reserves should, therefore, benefit the natural environment and economic and political stability of the nations who hold these reserves. With standard extraction practices only 20%–34% of the oil in a reservoir can be recovered with the remaining oil being permanently lost (Bentley, 2002; Zitha *et al.*, 2008). With pre-planning, advanced procedures and new technologies this can, in some instances, be increased to 35%–45% (Bentley, 2002; Zitha *et al.*, 2008). Cooperation between all stakeholders is needed to realise the associated political, environmental and financial gains achieved by increasing the recovery factor.

When questioned most organisations within the oil industry purport to have cooperative servitized relationships (*Schlumberger*, 2020) between the suppliers of equipment and technical services (SC) and the users of these services and equipment (OP). Game theory was selected as a method to examine these relationships *in practice* to determine if they are adversarial or cooperative in nature. By using a simple test based on a realistic business interaction between SC and OP game theory was used to uncover the actual conscious or unconscious strategies being used, rather than the intended or stated strategies.

The next phase of research quantified the level of servitization within each organisation using the scale created by Baines and Lightfoot (2013) during thirteen semi-structured interviews. These interview sessions where then developed to explore the possibility of servitization as a method to influence the adversarial or cooperative nature of the business relationships. The combined findings of this mixed methods process were examined using triangulation (Flick, 2009). Finally, the implications and future areas of investigation are presented.

2. LITERATURE REVIEW

The use of game theory as a tool to investigate the relationships between oil industry organisations and the role that servitization can have on the nature of these relationships remains sparse (Zhong, 2014). The following sections will explore these concepts further.

2.1 Game Theory

Game theory is used to explore, guide and interpret the strategic decision making of rational parties (Lima *et al.*, 2018). Game theory is used as a tool to maximise the payoff while minimising the risk of a negative outcome (Tadelis, 2013). There are two strategies in game theory which are known as cooperative and non-cooperative. In a non-cooperative strategy, each party attempts to get the best payoff for themselves by employing a strategy which includes the unknown strategies and counterstrategies of the other parties. In contrast to this, in a cooperative strategy the parties are free to make agreements and alliances to increase the likelihood of a fair outcome for each party (Peleg and Sudhölter, 2007).

Due to the recent introduction of modern mathematical tools game theory is now widely accessible (Ross, 2019) with the majority of applications employed in financial strategies (Chatterjee and Samuelson, 2014). However, there remains little literature where game theory is used in conjunction with servitization (Zhong, 2014). Several papers claim to be written on servitization and game theory (Süße and Wilkens, 2014; Lee, Yoo and Kim, 2016; Hezarkhani, 2017). However, it transpires that the papers are generally discussing gamification, which is a teaching and learning tool (Huotari and Hamari, 2012; Shi *et al.*, 2013; Andrews *et al.*, 2017), unlike game theory which is a method to understand and guide strategic decisions (Lima *et al.*, 2018).

2.2 Servitization

Servitization is a relatively new subject in the social sciences, with the first reference dating back only as far as 1988 (Vandermerwe and Rada, 1988). There are many definitions of the term servitization and the precise definition is often dependent on the focus of the author or topic being researched. Generally, one can regard servitization as the process a manufacturing organisation undergoes to increase their competitive advantage by developing the services they offer to their customers (Baines *et al.*, 2009; Kamp and Parry, 2017). For the purposes of this paper the definition provided by Baines et al. (2009, p. 555) shall be used, which states that "servitization is the innovation of an organisations capabilities and processes to better create mutual value through a shift from selling product to selling PSS".

Generally, the literature surrounding the topic of servitization within the oil industry is sparse. However, the available literature suggests that most organisations lack a definitive servitization strategy (Kumar and Markeset, 2007; Bandinelli and Gamberi, 2011). Scholars such as Shi et al. (2017) suggest that this is probably due to a general lack of understanding of their organisations current level of servitization, which in turn is related to their level of education in the process of servitization, rather than a failing of servitization itself. The literature also describes that the lack of a servitization strategy can lead to fragmentation of the organisation which may result in a reduced return on the investment in servitization, or in extreme circumstances complete de-servitization can result (Gebauer and Kowalkowski, 2012; Kowalkowski *et al.*, 2015).

2.3 Summary

Both game theory and servitization are relatively recent areas of study in the social sciences. Using the lens of game theory to examine the nature of the relationship between oil industry organisations provides a novel yet robust method with which to view these interactions. In order to investigate these relationships further, the following research questions were created:

1. Can the relationships within the oil industry be characterised as adversarial or cooperative in nature?
2. Can game theory be used to determine if the individuals are cognisant of their strategy?

3. Could increasing servitization cause an organisation to develop a cooperative relationship from an adversarial relationship?

Figure 1 below shows the theoretical framework for this paper. Starting from the left, one can see that if the servitization level between the operator and service company is at a base level (Baines and Lightfoot, 2013) their relationship is likely to be adversarial (Kemp and Stephen, 1999). Similarly, if the servitization relationship is advanced then their relationship is likely to be cooperative. This paper seeks to investigate if changing servitization level, indicated by the dashed arrows in Figure 1 below, can develop a relationship from adversarial to a cooperative and vice versa.

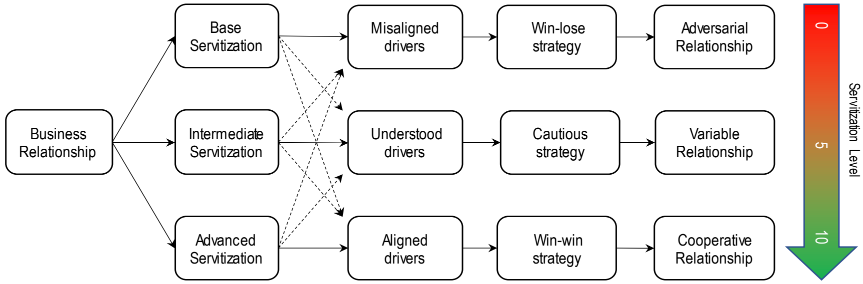

Figure 1: Theoretical Framework

3. METHODS AND METHODOLOGY

This a mixed method paper which will combine complimentary qualitative and quantitative methods, thereby benefiting from the relative strengths and reducing the individual weaknesses of each method (Brewer and Hunter, 1989). Using a mixed method will also allow triangulation of the findings (Denzin, 1978) whereby observations can be verified using more than one method, thereby "increase[ing] their scope, depth and consistency" (Flick, 2009, p. 445).

The research took part in three phases, the first phase used a representative sample size of 48 subjects in a quantitative test, see Table 1 below. The test is based on the classic game theory prisoners' dilemma. The second and third phases used a subset of 13 subjects where qualitative semi-structured interviews were used to determine their experience of servitization within their industry. Specifically, the subjects were asked to provide their expert opinion on the result of increasing or decreasing servitization levels and the influence this change could have on the relationship type.

	Qualitative	Quantitative	*n*
SC High $	3 Participants: HS1–HS3	9 Participants	12
SC Low $	4 Participants: LS1–LS4	8 Participants	12
OP High $	3 Participants: HO1–HO3	9 Participants	12
OP Low $	3 Participants: LO1–LO3	9 Participants	12
Totals (*n*)	13	35	**48**

Table 1: Research Group Classification and Distribution

3.1 Quantitative Analysis

A representative sample of 48 senior oilfield employees were selected, see Table 1 above, and provided with a test to determine if they elected to use a cooperative or adversarial strategy. The test consisted of a modified version of the established prisoners' dilemma (Dixit and Nalebuff, 2010) modified with a realistic oilfield scenario where the SC provided a new tool generating a saving for customer (OP). One version (High $) of the test produced a saving of $1,025,000 and the other version (Low $) a lesser saving of $350,000. The difference in values between the two tests was designed to determine if value was a factor in the strategy of either party, the tests were otherwise identical.

The subjects were then asked to allocate a percentage share of the saving to the SC, who were responsible for creating the saving. Each subject was asked to allocate the saving value based on what they thought they deserved. The same subject was then asked to reconsider the realistic saving value based upon their experience and expectation if the event occurred in their current organisation, both these values were recorded.

3.2 Qualitative Analysis

Thirteen semi-structured Interviews were carried out on a subset of the original forty-eight subjects using a process of systematic combining (Dubois and Gadde, 2002). Systematic combining was used which uses abductive reasoning and allowed the research to move between theory and the real-world refining the thematic analysis (King and Brooks, 2018) in the process, in essence allowing the data to drive the research direction within the parameters and scope of the stated research objectives (King, Horrocks and Brooks, 2010). Each interview was held in private and the duration was around 45–60 minutes. Each interview wad then transcribed and analysed using the Nvivo 12 software platform against the 17 original themes, which increased to 30 themes due to the systematic combining process. A calculation was performed to determine when thematic saturation was achieved (Lowe *et al.*, 2018), which occurred at the nineth interview (p=0.05). The five additional interviews were undertaken to balance the groups but were not required to improve thematic saturation.

The research subjects were first asked to identify the level of servitization of their current organisation based on the scale created by Baines and Lightfoot (2013) which has three levels; base, intermediate and advanced. There are many scales available such as Fang, Palmatier and Steenkamp (2008) who base their assessment on service revenue, or Homburg, Hoyer and Fassnacht (2002) who use the number of services as a measurement. Unlike the methods described above which tend to focus on a single parameter the Baines and Lightfoot (2013) scale uses a broad range of factors to identify servitization level and it was uncomplicated enough to explain and obtain results during the relatively short interview sessions.

After the servitization level of the subject's organisation was identified each subject was then interviewed on their experience of value co-creation and servitization levels in relation to cooperative and adversarial relationships. This part of the research process was designed to expand further on the initial results of the quantitative research, adding context and clarification. The subjects were also asked over several questions to refer to previous organisations where servitization levels were higher or lower and asked to comment if these relationships were adversarial or cooperative.

4. FINDINGS AND DISCUSSION

The following sections present the findings of this paper from the test and following interview sessions, the findings are then discussed before being summarised.

4.1 Quantitative Findings

The Shapley (1953) value is used in cooperative game theory to allocate a fair distribution of rewards and is used here to determine if a subject's strategy is cooperative or non-cooperative. If a reward distribution is fair, then the value of that award should approximate the Shapley value indicating that all parties are acting cooperatively. If the value differs from the Shapley value, this indicates that they are acting in a non-cooperative or adversarial way.

To determine if the subjects in the test were cognisant of their cooperation or non-cooperation the value of the two awards they were asked to provide, deserved and realistic, were compared. If the values were dissimilar, then each party was cognisant that the award they were offering was unfair and they were therefore knowingly acting in a non-cooperative way. If the values were similar, this indicates the intention to act fairly and cooperatively. However, if the values were appreciably different from the Shapley value, then they were not behaving cooperatively but were not cognisant of it, this is summarised in Table 2 below:

Award Finding		Conclusion	
Award ≈ Shapley value? (yes/no)	Deserved ≈ Realistic? (yes/no)	Fair award?	Cognisant of being unfair? (yes/no)
Yes	Yes	Fair	No
Yes	No	Fair	Yes
No	Yes	Unfair	No
No	No	Unfair	Yes

Table 2: Summary of Quantitative Analysis

The following charts show the award to the SC for making high and lower saving during the oilfield dilemma test. It is interesting to observe that in all cases the proposed reward is substantially lower than the Shapley value. In addition to this, and in all cases, there is a significant difference between the deserved award and the realistic award, signifying that both parties were aware that the award was not fair. Median values and Interquartile ranges (IQR) were used in the charts below based upon the recommendation of Murphy *et al.* (1998) to remove outliers and present a more robust data set.

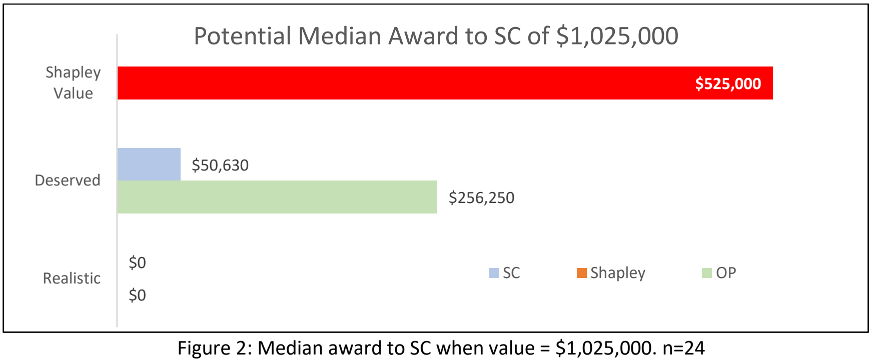

Figure 2: Median award to SC when value = $1,025,000. n=24

Figure 2 shows that there is a significant difference between all the proposed rewards and the Shapley value. In addition to the above findings a set of t-tests were carried out which show that the difference between SC deserved and realistic values were statistically significantly different ($p=0.004$). Similarly, the OP deserved, and realistic values were statistically significantly different ($p<0.001$). Referring to Table 2 we can determine that all parties were not working cooperatively and all parties were cognisant of this.

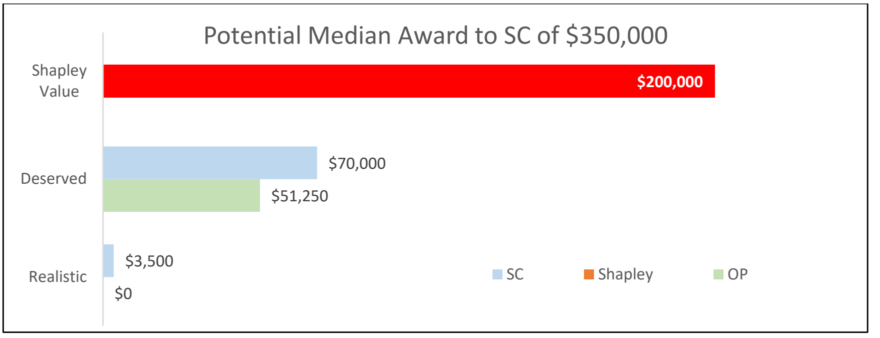

Figure 3: Median award to SC when value = $350,000. n=24

Figure 3 shows that there is a significant difference between all the proposed rewards and the Shapley value. In addition to the above findings a set of t-tests were carried out which show that the difference between SC deserved and realistic values were statistically significantly different ($p<0.001$). Similarly, the OP deserved, and realistic values were statistically significantly different ($p=0.008$). Referring to Table 2 we can determine that all parties were not working cooperatively and all parties were cognisant of this.

The servitization levels within each organisation were also collected and it was found that the median servitization level claimed by OP employees was 5.0, or intermediate, with an IQR of 1.5. However, the SC claimed a median servitization level of 6.5 which is slightly above intermediate, with an IQR of 5.0. Such a high IQR in SC would suggest that there is little consensus or uniformity in the SC results unlike the OP which are generally aligned with their servitization level.

4.2 Qualitative Findings

When questioned all interviewees agreed that increasing servitization level would create a more cooperative relationship. Subjects were asked to refer to previous organisation they had worked with who had different levels of servitization and compare the levels of cooperation or adversarial relationships. One senior SC manager from the US when asked if, in their experience, organisations with higher levels of servitization were more cooperative replied “absolutely”, another SC Regional Manager in the UAE responded “Definitely…I agree with that”. Similarly, an OP Lead Engineer in the UAE gave a similar response of “Of course…yeah”, and another OP Manager in Qatar stated that this was the case from their experience.

When asked the inverse of the above question, that reducing servitization wound, in their experience, lead to a more adversarial relationship all those interviewed agreed that this would be the case. As one SC manager in the UAE stated “It would certainly have a negative impact on our business. Yeah.”, another OP Contracts Manager stated, “I believe it would be more confrontational”.

Interestingly, many of those interviewed stated that relationships were becoming more adversarial, in an environment where a low oil price has led to a general downturn in the industry. As one SC Sales Manager in the US stated, “I would say pre downturn, it was more of a collaborative relationship post downturn or through the downturn, it has become a little bit more adversarial”. An OP Safety Manager in Qatar made the following observation “I would say that my particular company we see it moving more towards an adversarial relationship, rather than cooperative, in a bid to reduce costs, with a high focus on cost reduction at the moment”.

4.3 Discussion

The quantitative analysis has shown with a high degree of statistical significance that both the OP and SC are using an adversarial or non-cooperative strategy in their interactions. In addition to the quantitative results this finding was confirmed during the interview sessions. Furthermore, the interview sessions also reveal that the relationships appear to be becoming more adversarial in nature and suggest that a cost cutting environment brought about by a prolonged industry downturn may be responsible.

The use of game theory allowed the underlying nature of the relationship to be observed in the provided test and could, therefore, differentiate between intent and action. When comparing the proposed awards from the test, the findings show that the both parties were cognisant that their behavior was unfair and non-cooperative, or adversarial. One could therefore suggest that not only a base, but an intermediate level of servitization could create an environment where an adversarial relationship is prominent.

All parties were in firm agreement that they had experienced greater levels of cooperation in organisations with higher levels of servitization. Similarly, they also confirmed that they had experienced more adversarial behaviour when working for organisations with low levels of servitization within the oil industry. The group agreed that taking steps to increase or decrease servitization could therefore influence the development an adversarial relationship into a cooperative relationship.

5. MANAGEMENT AND PRACTICAL IMPLICATIONS

The transition to servitization is a difficult and prolonged process, requiring management commitment to change within an organisation (Ulaga and Reinartz, 2011; Raddats *et al.*, 2018) and provision of suitable resources (Baines and Lightfoot, 2013; Lenka *et al.*, 2018). It was believed that servitization was a linear process. However, this paper has shown that during economic downturns, such as the ongoing oil price crash of 2014 (England, 2020), it is not uncommon for servitization to stall or revert to an earlier incarnation, an observation also made by Andrews et al. (2018). This paper has shown that generally the oil industry acts in a non-cooperative way, but that continued support of servitization may, to some degree, increase the likelihood of developing a cooperative relationship. Therefore, if this is the true goal of an organisation, sustained investment, and development of servitization may enable this cooperation and realisation of the additional co-created value.

6. LIMITATIONS AND FUTURE RESEARCH

This paper was limited to the oil industry and therefore any findings are limited to this industry, but there is no reason to suspect that servitization may not promote cooperative relationships in other industries and are therefore worthy of further research in this area. The test taken by the subjects was realistic and factored in elements such as the size of award, however, there is a possibility that the subjects could have responded differently to a different scenario or group of scenarios. Therefore, it would be prudent to confirm these findings with a greater range of tests.

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CONFIGURATIONAL APPROACH TO DIGITAL SERVITIZATION BUSINESS MODELS

Marko Kohtamäki, Vinit Parida, David Sjödin, Stephan Henneberg & Rodrigo Rabetino

ABSTRACT

Purpose: The present study intends to extend the discussion about digital servitization business model configurations and the journey towards digital servitization business model. Technology companies are moving towards the digital servitization, e.g., business models that bundle products, services, and software systems in ways we have not seen before. New business models transform the existing ones by adding technologies related to blockchain, artificial intelligence, and IoT.

Design/Methodology/Approach: Systematic review

Findings: The study describes five business model configurations in digital servitization.

Originality/Value: The study uses a configurational approach to understand digital servitization business models, and to provide suggestions for future research on digital servitization.

KEYWORDS: Digital servitization, business model configurations, Ecosystems and networks, Product-Service Systems (PSS), Business model innovation, Platforms, and Sustainability

1. Introduction

In his famous column, "Why software is eating the world", the investor Marc Andreessen argued how the software continues disrupting new industries and companies. Indeed, during the last decades, we have witnessed the march of the digitalization, and 'the digital' transforming activities, companies, ecosystems, and entire industries. The icons of the digital age, such as google, amazon, or Spotify, have demonstrated how software can entirely disrupt competitive logic within industries. In industrial companies, e.g., technology companies producing product-service-software systems, similar things have been taking place, although perhaps slower. Already the digitalization has enabled industrial companies such as Rolls-Royce, Wärtsilä, or KONE, to explore and develop new types of servitization business models. The interplay between products, services, and software drives the invention of new types of models for value creation and capture. The who, how and what of smart solutions is under disruption, when technology companies are moving towards the future we coin as the digital servitization. Amongst many others, we use the concept of digital servitization to denote the interplay between digitalization (e.g., Internet-of-things) and servitization, as servitization (e.g., product-service systems, PSS) enables profit generation from digital technologies (Kohtamäki, Parida, Patel, & Gebauer, 2020; Naik, Schroeder, Kapoor, Bigdeli & Baines, 2020). In the present study, we review the existing literature on digital servitization to outline the concept and develop the configurations or related business models. Thus, in definition, we utilize configurational theory to describe the various ideal types of digital servitization business models.

At the very core of the configuration theory is the concept of equifinality – an idea according to which many configurations may provide equally successful outcomes, and there is no one and only right solution (Doty, Glick, & Huber, 1993). For strategizing and business model innovation in a servitizing manufacturing company, this circumstance sets a challenge. Derivation of value from various business model configurations is far from easy – potential configurations are many (Forkmann, Henneberg, Witell, & Kindström, 2017). The literature does provide some answers to these questions but yet rather insufficient. Kohtamäki, Henneberg, Martinez, Kimita, and Gebauer (2019) conducted a review on strategic configurations in the servitization literature, building on the environment-strategy-structure framework.

As such, during the past 20 years, we have witnessed a rapid expansion of servitization literature (Kowalkowski, Gebauer, & Oliva, 2017; Rabetino, Harmsen, Kohtamäki, & Sihvonen, 2018; Raddats, Kowalkowski, Benedittini, Burton, & Gebauer, 2019). Servitization research has provided valuable empirical evidence regarding antecedents, processes and outcomes of servitization, including a variety of mediators and moderators ranging from the business environment, through firm strategies until micro-foundations (Lenka, Parida, Sjödin, & Wincent, 2017) and micro-practices (Kohtamäki, Baines, Rabetino, & Bigdeli, 2018). Studies have also provided some evidence regarding servitization business models, identifying business models from products and add-on services, to maintenance agreement models, operational service business models, and outcome-based business models (Visnjic, Jovanovic, Neely, & Engwall, 2017; Sjödin, Parida, Jovanovic & Visjnic, 2020). While the identification of these business model types has been significant, the previous servitization research has been criticized for neglecting the role of digital transition (Coreynen, Matthyssens, & Van Bockhaven, 2017; Kohtamäki, Parida, Oghazi, Gebauer, & Baines, 2019).

Digitalization in smart product-service solutions is here defined as a transition from remote monitoring to optimization, control, and ultimately towards autonomous systems (Porter & Heppelmann, 2015). The autonomous system can refer to autonomous vehicles, machinery, industrial production lines, or factories, depending on the smart products. As such, the emerging research on digital servitization put increasing emphasis on the role of “digital” and software, acknowledging the interplay between digitalization and servitization when technology companies are seeking novel business models (Kohtamäki et al., 2020). Beginning from remote diagnostics (Brax & Jonsson, 2009; Grubic, 2018), servitization and Product-Service Systems studies have been developing the literature on the interplay between digitalization and servitization. Yet, the servitization literature has been criticized for neglecting the role of digitalization in servitization (Coreynen et al., 2017). The role is to be defined (Grubic, 2018), as the interplay between digitalization and servitization is somewhat emergent, taking multiple different forms and configurations in various companies. The configurational approach is needed to capture the complexity and dynamics of digital servitization in context, or so-called, product-service-software systems, which have to continually adapt to the changes in the business environment, customer, competitor, and resource markets.

The present study concentrates on scrutinizing the digital servitization literature, including relevant papers from the earlier servitization, and product-service systems literature, intending to answer the following research question: What are the business model configurations in digital servitization, and what is the role of business model innovation in moving forward towards autonomous solutions? Building on the previous literature, we intend to understand configurations related to five specific business models which we coin as 1) product provider, 2) industrializer, 3) customized integrated solution provider, 4) outcome provider, and 5) platform provider (Kohtamäki, Parida, et al., 2019). We search and review the digital servitization literature, to scrutinize the concept of digital servitization, and discuss the interplay between the two constructs. We review the business model concepts in digital servitization to define a typology and unfold the various business model configurations. We take a critical perspective on the existing knowledge base and present suggestions for future research. Finally, we introduce the articles in our special issue.

2. REVIEW METHODOLOGY AND DESCRIPTION OF DATA

For the study, we conducted a systematic search of articles based on two search strings, servitization, and digitalization. We used the following keywords 1. Servitization: "service infusion*", "servitization*", "servitisation*", "service transition*", "service transformation*", and 2. Digitalization: "digital", "internet-of-things", "internet of things", "IOT", "remote", "industry 4.0", "smart solution", "smart product". The search produced 134 hits, from which we selected 95 papers for further analysis, as these papers put significant attention to digitalization. We complement the discussion about the digital servitization studies by adding some seminal papers on servitization, as the classic servitization and Product-Service Systems can provide significant depth to the discussion about business models and the transformation process. In the analysis, we utilized Vosviewer and Leximancer 4.5 to decipher and visualize complex relationships between concepts.

3. The concept of digital servitization

The concept of digital servitization has been evolving in an interplay between digitalization and servitization. It is the interaction between digital technology and servitization that enables an increase in sales and profits. While digitalization provides a critical technological enabler for new types of smart solutions, services provide the means of capturing the value from digital technologies.

As suggested in previous studies, conceptual richness is vast. There are many concepts in this conceptual sphere known as digital servitization, which denote product technologies, software and data, and servitization and services. The roots of the digital servitization discussion are in servitization research, where the studies have previously approached the role of software through the concepts of remote monitoring technology, and remote diagnostics (Brax and Jonsson, 2009; Grubic, 2018). Porter and Heppelmann (2015) used the concept of smart products, and some have suggested the concept of smart solutions, to integrate better the product-service-software system (Kohtamäki et al., 2019c). Table 1 offers definitions of related concepts.

Table 1: Defining digital servitization and related concepts.

Researchers	Definition
Kohtamäki, Parida, et al., (2019)	<u>Digital servitization</u> *"We define digital servitization as the transition toward smart product-service-software systems that enable value creation and capture through monitoring, control, optimization, and autonomous function. To gain value from digital servitization, firms must capitalize on three dimensions of digital offerings (i.e., products, services, and software), which should work together."* (p. 383)
Porter & Heppelman (2015)	<u>Smart product</u> *"smart, connected products, from home appliances to industrial equipment, share three core elements: physical components (such as mechanical and electrical parts); smart components (sensors, microprocessors, data storage, controls, software, an embedded operating system, and a digital user interface); and connectivity components (ports, antennae, protocols, and networks that enable communication between the product and the product cloud, which runs on remote servers and contains the product's external operating system)."* (p. 4)
Gartner Glossary (2020)	<u>Digitalization</u> *Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business.* (p. 1)
Coreynen et al. (2017)	<u>Digitization</u> *"Digitization refers to the increasing use of digital technologies for connecting people, systems, companies, products and services (Hsu, 2007), a trend which offers a number of opportunities for manufacturers."* (p. 3)
Grubic & Peppard (2016)	<u>Remote Monitoring Technology (RMT)</u> *"Remote monitoring technology is a combination of principle software and hardware technologies which enable remote collection of data about the performance and usage of a product in the field to determine its current and predicted condition and health"* (p. 157)
Sjödin, Parida, Kohtamäki and Wincent, 2020	<u>Digital servitization</u> *"the transformation in processes, capabilities, and offerings within industrial firms and their associate ecosystems to progressively create, deliver, and capture increased service value arising from a broad range of enabling digital technologies such as the Internet of things (IoT), big data, artificial intelligence (AI), and cloud computing"* (p. 478)

To understand how digital servitization articles conceptualize the digital servitization field, we ran some conceptual analysis by the Leximancer software, which identifies the central concepts and clusters the papers concentrate. Conceptual clusters involve main concepts of data, servitization and service, and maintenance. Based on the software analysis, we can identify two clusters of concepts of Service, PSS, digital, and data, which are clearly related on digital servitization (e.g. Services and PSS), two related more on digitalization such as digital and data (Figure 1). Thus, the figure tells that both servitization and digitalization discussions within digital servitization literature splits into two sub-discussions, servitization into services and PSS (Lightfoot et al., 2013; Rabetino et al., 2018), and the digital into digitalization and remote diagnostics (or installed-base data). Servitization-based literature has been seen as splitting to multiple sub-discussions, or sub-communities, of which servitization and PSS are the largest (Rabetino et al., 2018). The digital splits into a specific discussion about installed base data, remote diagnostics and control, so-called smart products or solutions. At the same time, the digitalization reflects the broader debate about transformation towards the digital business model. Together, these streams generate the literature on digital servitization, where the value is created and captured in an interplay between the digitalization and servitization. Services enable value capture from new digital innovations (Kohtamäki et al., 2020). We define digital servitization as a transition towards smart, sustainable product-service systems that enable value creation and capture through monitoring, control, optimization, or autonomous function.

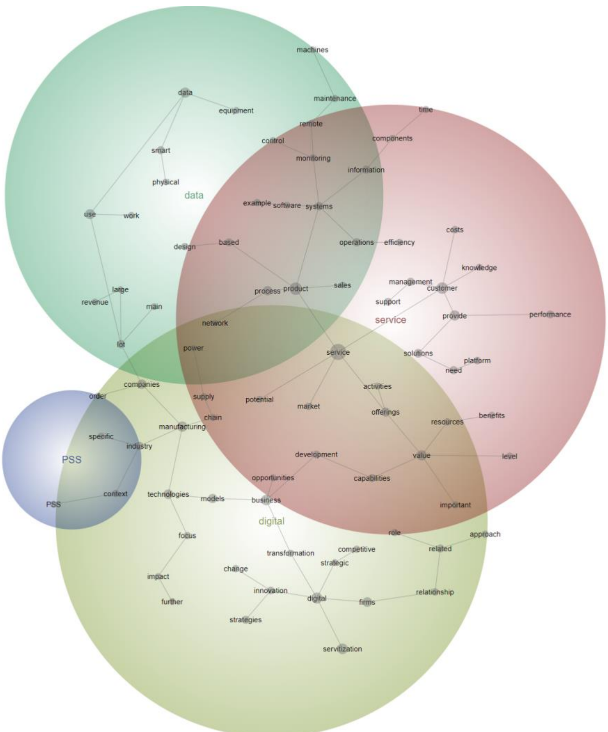

Figure 1: Conceptualizing digital servitization literature.

4. Scrutinizing the content digital servitization business models

4.1 Understanding the digital servitization strategy content

The servitization literature business model typologies, from which we selected a few examples. Business model typologies in previous digital servitization research.

Table 2: Business model typologies from servitization to digital servitization research.

Study	Business model dimensions	Ideal typical business models	Findings
Helander & Möller, (2007)	1) Activities 2) Resources & capabilities	1) equipment supplier, 2) solution provider, 3)	Changing activities enable achievement of the role of the solution provider

	3) Network resources 4) Coordination mechanisms	performance provider	
Gebauer, Edvardsson, Gustafsson, & Witell (2010)	1) Organizational design factors 2) Human resource management 3) Organizational structures	1) after sales service provider, 2) customer support service provider, 3) customer service strategy, 4) development partner, 5) outsourcing partner	Strategy-structure configuration enables succession
Kowalkowski, Windahl, Kindström, & Gebauer, (2015)	1) Business growth, customer loyalty, stable revenues 2) Customer demand, differentiation, partnership potential, customer lock-in 3) Scale economies, in-house resources, potential to address larger customer base	1) availability provider, 2) performance provider 3) industrializer	Firms need to balance growth and standardization Firms should also manage the co-existence of different roles
(Kujala et al., 2010)	1) customers, 2) value proposition, 3) competitive strategy, 4) position in the value network, 5) Internal organization and capabilities, 6) logic of revenue generation	1) Basic installed base services, 2) customer support services, 3) Operations and maintenance outsourcing, 4) Life-cycle solutions (4a delivery, and 4b development solutions)	Study creates a business model typology for project-based firms.
Forkmann, Ramos, Henneberg, & Naudé, (2017)	1) Service offering, 2) Delivery structure, 3) Governance	1) Service infusion, 2) Service defusion, 3) , 4)	The study depicts service business models as the interplay between service offering and delivery structures
Huikkola & Kohtamäki (2018)	1) Process ownership 2) Product vs. process 3) Primary customer segments 4) Examples of services 5) customer value proposition 6) Profit formula 7) Key resources 8) Rationale 9) Examples of solutions 10) Time frame for deals	1) product business model, 2) service-agreement business model, 3) process-oriented business model, 4) performance-oriented business model	Paper depicts 4 ideal typical business models and describes their basic characteristics. Paper uses solution providers as illustrative case examples.
Kohtamäki, Parida, et al., (2019)	1) Digitalization 2) Pricing logic 3) Level of solution customization	1) Product provider, 2) Industrializer, 3) Customized integrated solution provider, 4) Outcome provider, 5) Platform provider	Paper depicts how digital servitization business models within ecosystems vary regarding strategic positioning, strategic identity, strategic capabilities, and transaction costs.
Paiola and Gebauer (2020)	1) Services type 2) Service orientation towards technology	1) Product, 2) Process, 3) Outcome	Paper identifies opportunities and challenges of process and outcome-oriented business models in digital servitization
Frank et al., (2019)	1) Servitization levels 2) Digitalization levels	1) Customer-oriented, 2) Process-oriented	The paper identifies nine service offering types and provides illustrative examples
Parida, Sjödin and Reim (2019)	1) Value creation, 2) value delivery and 3) value capture	1) Add on services, 2) optimization service, 3) digital platforms 4) outcome based services	The paper identifies current knowledge and future research directions for digitalization enabled business model innovation

Based on previous research, the ideal types identified by the previous studies exist in the empirical world and are hence viable. This situation suggests that the equifinality assumption holds in servitization as well as in digital servitization, that is various configurations can lead to optimal outcomes – there is no one path or trajectory to success (Fiss, 2007; Forkmann et al., 2017; Sjödin et al., 2016), or failure, suggesting that a company can succeed or fail in so many ways. Thus, when building a business model, a company should not only fit the customer need, strategy, and structure, but also the business environment (Kohtamäki et al., 2019b). One of the challenges of the existing business model theorizing has been, that it tends to neglect the business environment.

Based on the literature, we can identify five business model configurations, which we coin, aligned with Kohtamäki et al. (2019) as 1) product provider, 2) industrializer, 3) customized integrated solution provider, 4) outcome provider, and 5) platform provider (Table 3). Product provider references to a typical product business model (+ add-on services), where a company offers relatively standardized products and only add-on basic services. Industrializer refers to a business model, where the manufacturer has standardized its customized offerings. Customized integrated solutions provider refers to a manufacturer providing large, customized solutions combined with maintenance agreement and some availability offering (e.g., performance guarantees). Outcome provider sells performance instead of products, offering the performance or outcome produced by the machinery, e.g., Power-by-the-hour. Platform provider refers to an Über-type of business model, where a manufacturer takes a platform operator role, starting to offer a multisided exchange platform instead of only products and services, e.g., Alibaba in industrial goods.

Table 3: Crafting business model configurations in digital servitization.

	Product provider	**Industrializer**	**Solution provider business model**	**Outcome business model**	**Platform business model**
Description of the business model	Provision of standardized products and add-on services	Modular product offerings and service agreements	Customized /modular product-service systems with some performance guarantees or operational services. Provision of availability.	Customized /modular product-service systems owned by the manufacturer, performance pricing predominantly	Services-dominant business model, where the platform provider enables provider-customer interactions, and sharing services
Integrating concepts / models from the literature	Products + Add-on services, Equipment supplier	System supplier	Availability provider System integrator	Performance provider, Outcome business model (OBM)	Platform business model
The role of digital	Some smart features based on remote diagnostics	Efficient use of some remote diagnostics features, typically related to monitoring, diagnostics and proactive maintenance.	Remote diagnostics enable provision of availability requiring effective monitoring, control and optimization. Use of new data sources.	Remote diagnostics enable monitor, control, optimization and autonomous operation	Digital platform enables effective interactions. Operator may monitor, control, optimize, and provide ecosystem enabling autonomous products (e.g. vehicles) Intention to utilize autonomous solutions
Who is the customer?	Traditional product customer, who wants to own a product, and maintain the products.	Conventional product customer, who needs a service agreement with the manufacturer. Buys relatively standard product(s) and maintenance.	Customer that appreciates extensive customization of the solution. May buy availability as part of the maintenance agreement.	Customer that buys purely availability, not the product. Appreciate fully operational fleet, and pays for performance, outcome, and availability.	A customer who buys outcome instead of product and maintenance. Perhaps a customer who does not care who delivers the outcome, as long as the value meets the expectation.
What is the value proposition?	Manufacturer offers products + add-on services.	Manufacturer offers products and maintenance agreements.	Manufacturer provides customized products supported by maintenance agreements and some availability offering (e.g. performance guarantees).	Manufacturer provides outcome or performance instead of a product.	Provider operates a platform which suppliers and customer can use to engage in transactions. E.g., instead of offering product and maintenance the provider offer a platform for transportation.
How is the value proposition delivered?	Manufacturer needs competitive product value chain, sales, product engineering, manufacturing and delivery	In addition to capable value chain, particular emphasis required on the mass-customization solutions. Remote diagnostics, analytics and preventive maintenance.	Capable customization and delivery of integrated solutions. Also digital / analytics capacity to provide availability.	Strategic capability to offer outcomes, manage risk through remote monitoring technologies. Capability to keep up-to-speed of technological development.	Requires different capabilities from manufacturing, e.g. platform creation, operation and management, network capabilities for managing the ecosystem. Software capabilities and branding.

Why the model enables profits?	Profits are based on product features and differentiation, and/or low product costs. Spare parts can add to margins.	Service agreements support higher margins, and protect spare parts exchanges. Mass-customization lowers production costs.	Solutions customization differentiates, but also generates high project costs (incl. transaction costs). Effective project management enables margins.	By reducing the risk of the customer, provider can charge premium. Provides growth opportunities for the customer	Profits are based on the large volumes in the platform. Platform should generate the scale and scope needed to generate profits.
Challenges of the business model	Product commoditization, increasing competition and lowering margins in standard products.	Difficult to mass-customize, and enforce customers to use standard components. Many managerial challenges when trying to standardize.	Difficult to evaluate the costs of customization / project, when project vary significantly. Difficult to standardize anything. Few risky projects may destroy profits.	Product ownership increases capital costs and transfers risk to the manufacturer Customers do not want outcome, but product	Challenge to change buyer behaviour, and achieve market position with a new business model. Expensive and risky platform development / launch.
Studies	(Helander and Möller, 2007; Kohtamäki et al., 2019a)	(Kohtamäki et al., 2019c; Kowalkowski et al., 2015)	(Helander and Möller, 2007; Kohtamäki et al., 2019c; Kowalkowski et al., 2015)	(Helander and Möller, 2007; Kohtamäki et al., 2019c; Kowalkowski et al., 2015)	(Kohtamäki et al., 2019c; Zhu and Iansiti, 2019)

5.RESEARCH DIRECTIONS

Based on the review on the digital servitization literature, some shortcomings in the literature can be identified, to suggest future research. The literature on digital servitization may have continued advancing the servitization and PSS literature, but more work is needed to provide insight for the renewal of manufacturing technology companies. Advance of productivity, an increase of revenues, and growth of market value requires companies not only to exploit the existing capabilities but specifically to explore new ones. While this may not be easy for conservative manufacturing sectors, it is inevitable.

> **Research direction 1.** We need to continue exploring new business models from other sectors than only manufacturing.

Very little empirical research exists on the platform business models in manufacturing industries (Cenamor et al., 2017). However, the platform business models may be approaching, for instance, Alibaba already provides quite a variety of industrial goods and services in their platform. Yet, the current digital servitization literature is missing research on digital platform models.

> **Research direction 2.** Further theory development is needed regarding the platform business models.

A business model should find an optimal fit not between strategy and strategy and structure, but also between business environment and strategy, and business environment and structure. While the business model literature seems to neglect the business environment in times, it should not be acknowledged by the digital servitization literature. The interplay between the macro and micro-dimensions of business can be approached from either perspective. The institutional theory approaches the interplay from macro –perspective, the macro environment affecting to micro-behaviors, whereas the practice theory approaches the interplay from the micro-perspective, the micro shaping the macro. When advancing the digital servitization literature, both angles deserve attention. For example, what are the challenges, resistances, and how does firms, business units, and individuals cope with these (Lenka, Parida, Sjödin and Wincent, 2018).

> **Research direction 3.** Macro-level understanding is needed about the institutional challenges faced by the manufacturers when moving towards autonomous systems.

Empirical research is needed on models on advanced digital offerings, to depict and analyze the digital offerings in-use, as well as innovative business models (Kohtamäki et al., 2019). Perhaps, multiple case studies could be used for this purpose.

> **Research direction 4.** Future research is needed on the digital offerings used by the advanced service business models.

Future digital servitization research should tap into process research to unfold the activities and processes related to digital servitization. In its core, digital servitization is a transformation process for provider and customers (Kamalaldin et al., 2020) and it may require a radically different innovation process ensuring agility and customer co-reation while stimulating internal capability development (Sjödin et al., 2020).

> **Research direction 5.** Process research is needed to understand the evolvement of digital servitization in manufacturing companies.

6. Discussion and conclusions

Theoretical conclusions

This paper was set out to become an introduction to the special issue on autonomous solutions. Hence, the paper will continue evolve during the coming year to a full paper, intending to shed light on the business model configurations from servitization to digital servitization, with emphasis on digitalization of servitization business models. Our perspective is configurational highlighting the equifinality of various business models – there is more than one potential configuration that can lead to optimal outcomes. As argued by the configurational literature, this perspective enables researchers to appreciate the complexity of empirical business world.

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AUTHORS

Marko Kohtamäki, Professor, School of Management, University of Vaasa, Finland
marko.kohtamaki@uva.fi.

David Sjödin, Associate Professor, Entrepreneurship and Innovation, Luleå University of Technology, Sweden
david.sjodin@ltu.se

Rodrigo Rabetino, Associate Professor, School of Management, University of Vaasa, Finland
rodrigo.rabetino@uva.fi

Vinit Parida, Professor, Entrepreneurship and Innovation, Luleå University of Technology, Sweden
vinit.parida@ltu.se.

Stephan Henneberg, Professor, Queen Mary University of London, School of Business and Management, Mile End, London E14NS, United Kingdom
s.henneberg@qmul.ac.uk.

PROPOSAL OF A COMPREHENSIVE PRODUCT-SERVICE SYSTEM EVALUATION METHOD TO SUPPORT THE DECISION-MAKING PROCESS THROUGHOUT THE PSS LIFE CYCLE

Mar'atus Sholihah, Takehiko Nakada, Yuya Mitake & Yoshiki Shimomura

ABSTRACT

Purpose: Continuous and consistent evaluations are essential throughout the PSS life cycle. The motivation to evaluate PSS in a life cycle phase differs from one another as the necessity of PSS evaluation is a unique case-by-case. However, the previous studies reveal a deficiency in the comprehensive evaluation method, which fully supports a structured assessment for PSS from diverse motivations and life cycle phases. Therefore, this research aims to develop a comprehensive evaluation method to support diverse decision-making processes throughout the PSS life cycle.

Design/Methodology/Approach: The research method comprises four main research activities involving systematic literature review, identification of pertinent elements of PSS evaluations, development of a conceptual framework and indicator database, and introduction of the evaluation procedure.

Findings: The necessity to evaluate PSS resides in the requirement to evaluate PSS design alternatives in the planning and development phases and to monitor performance during the implementation phase. The proposed conceptual framework provides an evident illustration that a different purpose of evaluation requires a different evaluation scheme involving the scope, perspective, and criteria of evaluation. An indicator database comprising 146 evaluation indicators characterize evaluation criteria. Finally, an evaluation procedure facilitates the implementation of the propose evaluation to support divers decision-making throughout the PSS life cycle.

Originality/Value: This research fosters the maturity of the evaluation topic in the PSS research field. It theoretically contributes to the literature by systematically identifying the substantial aspects of PSS evaluations. This research introduces the comprehensive PSS evaluation to support PSS providers in performing an appropriate evaluation throughout the PSS life cycle.

KEYWORDS: Evaluation Method, Product-Service System (PSS), Decision-making Support, Life Cycle.

1. INTRODUCTION

Evaluation is a valuable aspect of PSS management. Evaluation is a means to increase the successful likelihood of PSS development and it likewise to foster the improvement of the implemented PSS (Kim et al. 2016). An evaluation in the development phase is highly desirable to respond to what extent and in what manner products and services need best be bundled (Xing et al. 2013). This evaluation serves as a decision-making support that affords a selection of the best PSS design alternatives (Zhang et al. 2019). The urgency of evaluation resides also in the later phases of the PSS life cycle. Since the premise of a PSS value proposition is to continuously satisfy customer requirements, thus analysing customer satisfaction, monitoring the progress of the PSS implementation and identifying improvement opportunities are great importance for the PSS provider (Geng and Chu 2012). It becomes apparent that evaluation plays a pivotal role in multi phases of the PSS life cycle with the objective varies from one life cycle phase to another. It makes the necessity of PSS evaluation a unique case-by-case base (Kim et al. 2016). However, continuous and consistent evaluation is essential throughout the PSS life cycle (Mourtzis et al. 2018c). PSS is not a guarantee of environmentally, economically and socially benign, therefore a comprehensive, consistent and continuous evaluation is important for planning, developing and implementing PSS (Zhang et al. 2018).

The importance of PSS evaluation has been widely emphasized by PSS academic community, however continuous evaluation throughout PSS life cycle phases has not been fully explored in the current PSS studies. There is a deficiency of comprehensive evaluation proposals (including the conceptual frameworks, guidelines, procedures or tools) that can fully support the structured assessments of PSS from diverse motivations and across different life cycle phases. The existing PSS evaluations were developed based on specific purposes and serve a partial life cycle phase. For instance, (Lee et al. 2015a) proposed an evaluation method for a new PSS design following the estimation of customer value. The application of the proposal in other life cycle phases would be inappropriate, such as to evaluate the performance of the implemented PSS. Similarly, the performance evaluation proposed by (Pan and Nguyen 2015), which utilized the four perspectives of the balanced scorecard, cannot be applied to the development phase since it can only be performed based on the results obtained following PSS implementation. Consequently, it is challenging for PSS providers to choose and perform evaluation schemes based on their specific purposes consistently and appropriately. Whereas inappropriate evaluation schemes may lead to evaluation failure and inaccurate decision-making.

This research intends to fill in this research gap by proposing a comprehensive evaluation method that supports decision-making throughout the PSS life cycle. To this end, systematic literature was conducted to obtain an adequate foundation of the extant studies in PSS evaluation. This review affords the identification of the necessary evaluations and their pertinent elements to be addressed throughout the life cycle phases. Based on this result, a PSS evaluation framework is developed as well as the evaluation indicator database. An evaluation guideline is also introduced for the practical implementation in the real case. Additionally, a case study was performed to illustrate the applicability of the proposal.

2. THEORITICAL FOUNDATION

The academic community has been long aware of the importance of evaluation in the PSS development phase (Mourtzis et al. 2018a). The evaluation in the development phase generally serves as a feasibility analysis in which a new PSS design is objectively and rationally assessed based on several criteria considering provider and market perspectives (Yoon et al. 2012). In the PSS provider point of view, this evaluation aims to ascertain a new PSS design complies with the requirements of environmental, economic, technological and political-legal feasibilities (Yoon et al. 2012). Meanwhile, a systematic evaluation based on customer perspective is pivotal, not only to assess market acceptance (Kimita et al. 2009) but more importantly also to ensure the new design provides the value perceived by customers (Sakao and Lindahl 2012). The prolong responsibility, the system complexity, the involvement of multi-stakeholders and the constant requirement to satisfy the customer are among unique attributes of the PSS concept (Geng and Chu 2012, Mourtzis et al. 2018c) that entail continuous monitoring. Evaluating PSS performance in the implementation phase is a crucial task for PSS provider considering its influences on the company's competitiveness and business performance (Mourtzis et al. 2018a).

The PSS evaluation scholars introduce their evaluation proposal through several styles comprised of a conceptual framework, procedure, evaluation criteria, indicators, index or application-based supporting tool. This research utilizes the term evaluation proposal to describe these PSS evaluation-related proposals. The majority of PSS evaluation proposals focus on introducing the evaluation criteria to examine the sustainability benefits from PSS provider point of view (Xing et al. 2013, Chiu et al. 2015, Mourtzis et al. 2017) as well as value and satisfaction assessment from customers perspective (Sakao and Lindahl 2012, Geng and Chu 2012, Zhang et al. 2019). Several other proposals have emphasized the balance evaluation between the two perspectives (Chirumalla et al. 2013, Kim et al. 2016).

To summarize, the relevance and importance of evaluation reside not only in the development phase but also in the later phases of the PSS life cycle. The purpose of PSS evaluation differs from one life cycle phase to another. But the continuous and consistent evaluation is substantial to foster PSS provider sustainability. Different circumstances lead to distinct needs of decision-making, careful selection of the best-suited evaluation scheme therefore is pivotal in enabling a reliable PSS evaluation to support the decision-making. On this basis, the extant studies have emphasized the need for a comprehensive evaluation proposal. The comprehensiveness itself is characterized by two aspects of efficacy, namely effectivity and efficiency. An effective evaluation proposal affords the selection of the best-suited evaluation criteria to the company's conditions. Simultaneously, it is capable be efficiently implemented.

3. RESEARCH METHODOLOGY

The research was conducted through four main phases. The first phase comprised the identification of the evaluation needs throughout the PSS life cycle. It was continued by the identification and systematization of evaluation indicators. These two phases were conducted based on a systematic literature review. The literature search was undertaken in the Scopus database in September 2019. The keyword search was the combination of 14 synonyms of the product-service system (such as servitization, industrial product-service system and integrated product-service offering) and 6 synonyms of evaluation (such as performance, measurement and assessment). Several restrictions were applied to ensure the selection of high-quality papers. Only English-written journal articles and reviews were selected. This initial search resulted in 833 papers. These initial results were subsequently refined based on the fulfilment of the two following criteria: (1) present the proposition, application or review of evaluation in PSS; (2) present framework, method, procedure, tool or indicators to evaluate PSS. These inclusion criteria were applied by reading the title, abstract and keywords of the papers and this process yielded to 32 articles for further analysis.

The focus of the analysis was to scrutinize the PSS evaluation propositions based on the following aspects: purpose, rationale, target phase in the PSS life cycle, perspective, method, procedure and tool. This investigation leads to the identification of the relevant and important evaluations throughout the PSS life cycle and the pertinent elements of such evaluations. Based on this knowledge, a comprehensive PSS evaluation framework was developed. In the second phase, 538 evaluation indicators were identified from the review process. These indicators were consolidated to eliminate similarities and overlaps. This process resulted in 146 evaluation indicators which classified according to particular evaluations identified in the first phase. This systematization constructs an indicator database.

An implementation guide was developed in research phase 3 to facilitate the practical implementation of the evaluation proposition. Since the evaluation proposal utilizes indicator-based evaluation, the guide was developed in a logical step-by-step approach following the selection of performance indicators in the performance measurement system (Neely et al. 2000). This approach is deemed suitable considering previous adoptions in similar studies including eco-design performance measurement (Issa et al. 2015).

The last research phase comprised the illustration and initial evaluation of the proposal through a case study. The case study involved a Japanese heavy industry manufacturer. The case study was conducted through a workshop where the participants use the proposal. The participants' satisfaction toward the proposal, in which the proposal is perceived as successful by the participants, was measured using a questionnaire. This success refers to the value attributed by the company and its variable ranged from "unsatisfactory" to "very satisfactory" (Issa et al. 2015) covering the usefulness and easy-to-use of the evaluation proposal, the usefulness and completeness of indicators, and the time-efficiency of evaluation. Although this single case study is not sufficient to validate the evaluation proposal, the inclusion of this case study plays a critical role as a means of theory-testing of the proposal and to define the improvement opportunities.

4. A COMPREHENSIVE PSS EVALUATION METHOD

4.1 Literature Review Findings

This research defined the life cycle phases of PSS as planning, development and implementation following the reference model of integrated PSS life cycle proposed by (Hepperle et al. 2012). As an early design stage, the planning phase is pivotal in overall PSS development by consuming up to 70% of the total development cost (Chen et al. 2015). An evaluation in this phase is greatly important to mitigate damage that is hardly compensated in the later life cycle phases such as design medication or redesign (Chen et al. 2014, 2015). The evaluation proposals from previous studies in this phase are centered to assess PSS concepts and select the best alternative under complex and vague environments (Shen et al. 2017, Zhang et al. 2019). Particularly customer-based evaluation is highly advocated to examine customers' acceptance or to estimate their satisfaction based on the perceived value of PSS offerings (Lee et al. 2015a, Zhang et al. 2019, Bertoni 2019). From the provider perspective, three aspects of sustainability including economic, environment and social are used as assessment criteria (Chen et al. 2015, Shen et al. 2017, Mourtzis et al. 2018a).

Similar to the planning phase, assessment and selection of design alternatives is again the main motivation of evaluation in the development phase (Latora et al. 2018, Zhang et al. 2018, Chen et al. 2019). Other studies emphasized the feasibility assessment of a single PSS design. Since the selected PSS concept has been technically developed into detail PSS design, the focus of evaluation in the development phase is shifted to ensure that PSS design meets the expected value of the customers (Yoon et al. 2012, Li et al. 2016, Mourtzis et al. 2018b). Economic, environmental and social (sustainability) assessments from the providers' perspective have become major evaluation criteria (Chiu et al. 2015, Latora et al. 2018, Chen et al. 2019). The combination of sustainability assessment and customer satisfaction are the most common criteria in the providers and customers-based evaluation proposals (Li et al. 2016, Mourtzis et al. 2018b, Zhang et al. 2018). Only (Sakao and Lindahl 2012) relied upon its evaluation merely based on an assessment of customer value.

The motivation to evaluate the implementation phase is highly triggered by the need to monitor the progress (Geng and Chu 2012, Pan and Nguyen 2015, Tseng et al. 2019) and identify improvement opportunities (Chirumalla et al. 2013, Wang and Ming 2018, Kjaer et al. 2018). Interestingly, most of the current studies perform the evaluation based on the providers' perspective. The evaluation criteria vary from four perspectives of BSC (Pan and Nguyen 2015, Ziaee Bigdeli et al. 2018), the combination of the triple bottom line (TBL) of sustainability (Hu et al. 2012, Lee et al. 2015b, Kjaer et al. 2018) or management and innovation capabilities (Sun et al. 2012, Tseng et al. 2019). While customer acceptance (Geng and Chu 2012) and satisfaction (Wang and Ming 2018) again the main evaluation criteria from the customer perspective. Similar to evolution in previous phases, the combination of TBL and customer satisfaction become the most adopted criteria for integrated provider-customer-based evaluation (Chirumalla et al. 2013).

There are very limited studies that specifically propose an evaluation scheme for the overall PSS life cycle (Lee et al. 2012, Chou et al. 2015, Kim et al. 2016, Mourtzis et al. 2017, 2018c). The proposed evaluation is designed to continuously facilitate decision-making throughout the PSS life cycle. These studies proposed a comprehensive evaluation covering both evaluations of design alternative and performance assessment. As a comprehensive evaluation, provider and customer perspectives are treated equally in these proposals with main evaluation criteria comprising the integration of TBL and customer value (Kim et al. 2016, Mourtzis et al. 2018c). While the rest two studies solely utilize TBL from the provider perspective as the center of assessment (Lee et al. 2012, Mourtzis et al. 2017).

Another pertinent element of the evaluation proposals is the scope of evaluation covering to what extent or what aspect of PSS is evaluated. It is found that the evaluation scope differs among the proposals ranging from PSS offering, PSS business model and PSS company. The smallest unit analysis is PSS offering defined as a provider's value proposition in which products, services and systems are integrated and optimized to create value for customers (Sakao and Lindahl 2012). PSS business models describe the logic in how the PSS offerings are developed and delivered to customers (Adrodegari et al. 2017). While the company covers the overall entities in the organization that may consist of multiple business units/models including a non-PSS business model. Generally, the evaluation proposals in the planning and development phases centre their assessment in PSS offering. It is triggered by the need to systematically and closely examine the PSS concepts that comply with the value perceived by customers (Sakao and Lindahl 2012, Xing et al. 2013). As the concept of PSS is further developed into detailed design specifications, thoroughly understanding the structure of the PSS business model and its capability of value generation for multi-stakeholders is the goal of evaluation in the development phase (Yoon et al. 2012, Li et al. 2016). Whereas monitoring functional performance in the implementation phase is targeted either in the PSS business model (Wang and Ming 2018, Kjaer et al. 2018, Tseng et al. 2019) or overall company (Chirumalla et al. 2013, Pan and Nguyen 2015, Ziaee Bigdeli et al. 2018). Measuring the functional performance of the PSS business model and overall company not only affords the identification of potential improvements (Lee et al. 2015b), but also the appraisal of the organization's transformation progress towards becoming a PSS provider (Ziaee Bigdeli et al. 2018). Among other proposals, only (Kim et al. 2016) specifically addressed the need for evaluation in all types of evaluation scope throughout the life cycle phases by proposing an indicator-based evaluation where the PSS providers have high flexibility to select and perform an evaluation based on their specific context. Based on this fact, (Kim et al. 2016) has introduced the most comprehensive evaluation PSS proposal by addressing a wide range of evaluation scope throughout PSS life cycle phases.

Many evaluation propositions are developed based on several well-established approaches. Several scholars have adopted multi-criteria decision-making (MCDM) analysis such as the analytical hierarchy process (AHP), sustainability analysis like LCA or strategic management tools such as balanced scorecard (BSC) and key performance indicator (KPI). Several evaluation proposals in the planning and development phases are developed based on the combination of several MCDM analysis (Wang and Ming 2018, Bertoni 2019, Chen et al. 2019). It is aligned with the evaluation purpose in these phases to examine and select the best alternative among multiple criteria. MCDM analysis remains widely used in the implementation phase, but it is incorporated with sustainability assessment and indicator-based evaluation. The evaluation proposals for the overall life cycle have extensively used indicator-based evaluation with sustainability assessment (Chou et al. 2015, Kim et al. 2016, Mourtzis et al. 2018c). This approach is selected based on its flexibility to change its evaluation scheme recommendation following the need of the user. Considering this fact, indicator-based evaluation is the most reliable approach to propose a comprehensive evaluation of PSS. By presenting evaluation criteria throughout the set of indicators associated with specific evaluation elements, the PSS providers can select and implement continuous evaluation consistently and appropriately. The review of the current literature reveals several important elements of PSS evaluations.

4.2 Comprehensive PSS Evaluation Method

By structuring the pertinent elements, a conceptual framework of PSS evaluation is developed (Figure 1). This conceptual framework provides an evident illustration that a different purpose of evaluation requires a different evaluation scheme involving the scope, perspective, and criteria of evaluation. There are two relevant needs for PSS providers to evaluate PSS. A design alternatives evaluation is needed during the planning and development phases, whereas a performance evaluation is pivotal during the implementation phase. These motivations contribute to the urgency to continuously evaluate the PSS throughout its life cycle

This research defines the scope of evaluation ranging from PSS offering, business model to the whole company following predefined purposes. This conceptual framework promotes a balanced assessment between provider and customer perspectives as value is co-created between providers and customers in the PSS concept (Wang and Ming 2018). The selection of the evaluation's perspective describes the evaluation criteria and finally identifies the detailed evaluation indicators. This research adopts the TBL of sustainability as evaluation criteria from the provider perspective. Customer acceptance and satisfaction are the evaluation criteria for the customer-based evaluation. These criteria are highly emphasized and widely used by PSS scholars to comprehensively represent the success of PSS (Kim et al. 2016, Mourtzis et al. 2018c).

The indicator-based evaluation approach is preferred to facilitate the consistent and continuous evaluation throughout the life cycle. It allows the PSS providers to select the best-suited indicators based on their specific conditions without compensating for the comprehensiveness of the evaluation. Based on conceptualization of evaluation criteria (Figure 2), corresponding evaluation indicators are identified. An indicator database collects and stores these evaluation indicators. Figure 3 presents an exemplary indicator its classification.

Figure 4 provides an implementation guideline to support the practicability of the evaluation proposal. It presents a detailed procedure to perform a PSS evaluation. The first step consists of an identification of the intended motivation of a PSS provider to perform an evaluation. Once the PSS provider identifies its purpose of evaluation, the PSS provider can pre-select the evaluation indicators by connecting its evaluation purpose with the phases of the life cycle, scopes of evaluation, perspectives of evaluation and the evaluation criteria. The classification criteria (life cycle phase, scope, perspective and evaluation criteria) serve as filters to obtain subsets of evaluation indicators from the database.

The PSS provider can decide the selected indicators (Step 3) based on the previous step. The indicator database only provides a recommendation for evaluation indicators. To achieve a successful evaluation, the PSS provider requires considering several practical criteria when applying and measuring the indicators, for instance, time efficiency, data, and resource availability. Step 2 and 3 are iterative, thus this research suggests the PSS provider iteratively apply the filter in the indicator database and review the pre-selected indicators as many as necessary. The PSS provider also needs to consider the number of selected indicators. Selecting a manageable number of indicators, between ten and twenty is recommendable (Issa et al. 2015).

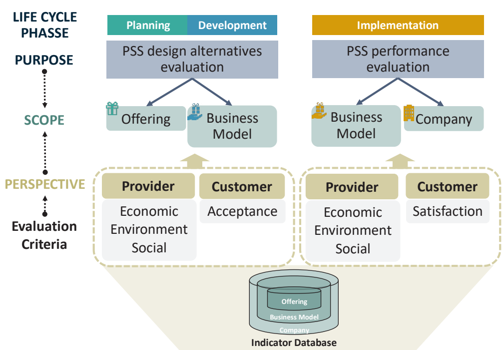

Figure 1: A conceptual framework of PSS evaluation

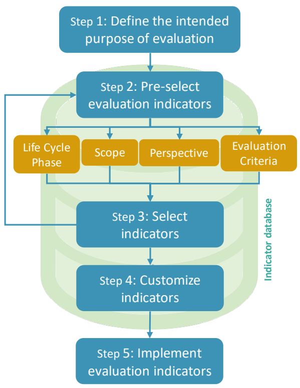

Figure 4: The evaluation procedure

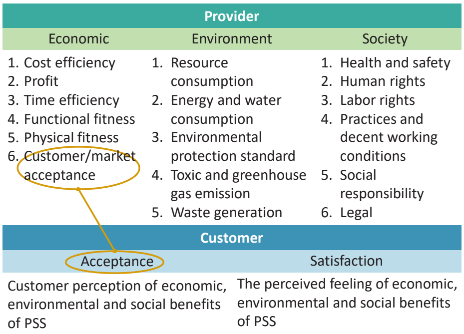

Figure 2: The conceptualization of evaluation criteria

Purpose: Design alternatives evaluation
Life cycle phase: Development
Scope: Business model
Perspective: Provider
Evaluation criteria: Social

Conceptualization	Indicator	General description	Evaluation score
Practices and decent working conditions	Readiness in employees' capabilities	The level of readiness of employees (related to capabilities/skills) to provide PSS	Employees' capabilities readiness = 1 (Not capable at all)~5 (Highly capable)

Likert Scale	Evaluation Score				
	1	2	3	4	5
Capabilities readiness	Not compatible at all	Less capable	Neutral	Capable	Highly capable

Figure 3: An example of evaluation indicator and its categories

The PSS providers can customize the selected evaluation indicators (Step 4) from the database to meet their specific conditions. Finally, the PSS provider evaluates the selected evaluation scope by applying and measuring the selected indicators (Step 5). The measurement of indicators uses relative scales (Likert Scale) from 1 to 5. This research utilizes the relative type of measure to achieve a simple and understandable operation and presentation of PSS evaluation (Chou et al. 2015). This understandable PSS evaluation advocates an efficient evaluation implementation. Finally, the proposed conceptual framework, the indicator database and the evaluation procedure constitute a comprehensive PSS evaluation method to support the decision-making process throughout the PSS life cycle.

5. CASE STUDY FOR THEORY TESTING

This case study was conducted to assess the usability of the evaluation proposal to support the decision-making process throughout the PSS life cycle. Company A is a Japanese public multinational company known as one of the three biggest heavy industry manufacturers in Japan. Company A has actively provided basic services related to its heavy equipment. It has a high intention to expand its business towards the PSS provision. As one of its endeavours, Company A has a PSS development project in which is the object collaboration of this research. The participants of the case study workshop included the company’s employees from multiple departments involving in the development project.

In this case, Company A aimed to comprehensively evaluate its PSS business model alternatives and obtain the best-suited PSS business model. To this end, the company A set the classification criteria as follows: the life cycle phase was the development phase, the scope of evaluation was business model, the perspective of the evaluation was provider, the evaluation criteria were economic, environmental and social. By relating the evaluation purpose with the classification criteria as filters, Company A obtained 31 evaluation indicators. Company A adopted these indicators directly from the database due to its suitability with the company’s context. Finally, the participants applied the indicators to assess the PSS business model alternatives.

Upon the completion of the workshop, the participants provided feedback through the questionnaire. The participants perceived the proposed evaluation method were satisfactory in respect of time-efficiently, easy-to-use and usefulness of the evaluation. Company A expressed that the proposal was simple and easy to comprehend while maintaining the balance of sustainability evaluation. However, the participants found the usefulness and completeness of selected indicators were moderately satisfactory. Company A showed that the recommended indicators in evaluation criteria “Society” were insufficient. The relative type of measurement by using Likert Scale advocated simple qualitative evaluation, but Company A articulated the need to use absolute type of evaluation to facilitate more detail evaluation expressed in absolute numbers. These feedback were valuable foundations for the improvement of this research.

6. CONCLUSION

This research presented a systematic literature review on PSS evaluation, identified and analysed the requirement to evaluate PSS throughout its life cycle. Two possible motivations to evaluate PSS were to evaluate design alternatives in the planning and development phases or to evaluate the PSS performance during the implementation phase. This research proposed a comprehensive PSS evaluation method to support appropriate PSS evaluation in the whole PSS life cycle, comprising the conceptual framework, indicator database, and evaluation procedure. The conceptual framework provided apparent insight of different pertinent elements to conduct these evaluations, namely the scope (offering, business model or company), perspective (provider or customer), and evaluation criteria (economic, environment, social, customer acceptance and customer satisfaction). In total, 146 evaluation indicators were systematized in an indicator database to support the implementation of the evaluation procedure. Additionally, a conducted case study illustrated the implementation of the proposal.

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AUTHORS

Mar'atus Sholihah
Department of System Design, Tokyo Metropolitan University, 191-0065
+81-42-585-8636, sholihah-mar'atus@ed.tmu.ac.jp

Takehiko Nakada
Department of System Design, Tokyo Metropolitan University, 191-0065
+81-42-585-8636, nakada-takehiko@ed.tmu.ac.jp

Yuya Mitake
Department of System Design, Tokyo Metropolitan University, 191-0065
+81-42-585-8636, mitake-yuya@ed.tmu.ac.jp

Prof. Yoshiki Shimomura
Department of System Design, Tokyo Metropolitan University, 191-0065
+81-42-585-8636, yoshiki-shimomura@tmu.ac.jp

BUSINESS MODEL PATTERNS OF IOT PLATFORMS IN THE B2B CONTEXT

Lino Markfort, Philipp Koegler, Alexander Arzt & Heiko Gebauer

ABSTRACT

The Internet of Things (IoT) enables new business opportunities for industrial companies in the Business-to-Business (B2B) context. Many companies invest into the development of data-driven business models around IoT platforms. However, there is still little systematic research on the characteristics of these business models. Based on a quantitative study, this paper explores patterns and elements of business models in the IoT platform context. Furthermore, based on a qualitative study, it describes and compares IoT platform business models from different industries and emphasizes similarities and differences.

Keywords: business model patterns, IoT platforms, business ecosystem, digital services, manufacturing companies

1. INTRODUCTION

In accordance with the Service-Dominant Logic (Vargo & Lusch 2004), manufacturing companies shift from selling traditional products to offering diversified product-service systems as solutions. To serve customers with a well-suited solution it is essential to know about customer's needs and wants. Recently, IoT is gaining a lot of momentum as a technology and new ways to do business seem to arise. The number of connected devices has been doubling since 2015 from 15 to 30 billion (IHS 2016). This phenomenon has also changed the manufacturing companies generate data of their machines in use. In order to make data accessible quickly, at any time and for different users, they are usually stored in a cloud. In a further step, data can then be used to create digital services that focus on analyzing the status of a specific machine in order to predict downtimes and failures. This opens up new value creation opportunities. In that context, digital platforms serve as a technical and organizational basis for the transaction of data and for the distribution of digital services. Consequently, the question arises how companies adapt and innovate their business models in order to successfully establish such platform-based businesses. The goal of our research was to gain insights about the nature of business models of IoT platforms used in mechanical companies. Using a mixed methods research approach, this paper identifies and analyzes 3 business model patterns of IoT platforms. In addition, the structures of 3 major IoT platforms are then examined by comparing them across industries.

2. THEORETICAL BACKGROUND

Digitalization changes the business logic in many industries. Companies like Amazon, Alphabet, Facebook etc. are among the most valuable companies on the stock markets (Feng & Furr 2016). What these companies have in common is a business model based on a platform approach. Literature differentiates two platform concepts:

On the one hand, the technological concept, defined by Wheelwright & Clark (1992), describes platforms as a modular system for realizing economies of scale and scope. This concept was mainly applied in economics and engineering literature.

On the other hand, the transactional concept perceives platforms as means to mediate supply and demand in order to facilitate transactions between different market participants. Thus, this concept relates to an imaginary marketplace (Evans & Gawer 2016; Gawer 2014), which is particularly associated with offers such as matchmaking (Ardolino et al. 2016; Evans & Gawer 2016) or retailing (Kenney & Zysman 2016). In this context, technologies, products or services serve as a basis for external actors to interact with each other, to conduct transactions, to create complementary innovations and to commercialize them (Frattini et al. 2014; Gawer & Cusumano 2014; McIntyre & Srinivasan 2017). Rochet & Tirole (2003), Eisenmann et al. (2006) and Evans & Schmalensee (2007) refer to a platform-mediating network. It consists of users whose transactions may be subject to both direct and indirect network effects. This concept applies to platform companies such as Amazon, Alibaba, Facebook etc. So far, platforms have been investigated primarily in the Business-to-Consumer (B2C) context. Many researchers assume that essential characteristics can be transferred to the B2B context (de Reuver et al. 2018; Saarikko et al. 2016).

Digital platforms have in common that they use the acquired data from machines to increase the customer value. The data obtained can thus be used as a starting point for adapting products and services to fulfil customer needs.

The integration of physical products into a digital network is also known as IoT (Internal Telecommunication Union 2005). The connection between the physical and digital world is becoming increasingly important in order to minimize frictional losses. A company's products and services can be adapted even more to customer needs with the help of data on usage and capacity utilization. IoT technology is thus a key concept for the further servitization (Vandermerwe & Rada 1988) of digital offerings.

IoT platforms leverage IoT technology. They are characterized by the fact that they support the development of intelligent products and services in IoT with the help of software systems and make data usable on an underlying technological infrastructure (own formulation based on Krause et al (2017), p. 6). This definition suggests that the networking of physical devices is a basic prerequisite for an IoT platform.

As IoT platforms are primarily used to carry out transactions of data, they have a special technological infrastructure. A cloud is used to ensure parallel data generation, storage, preparation and processing. Porter & Heppelmann (2015) proposed an illustration of basic IoT platform infrastructure for smart, connected products [see Figure 1].

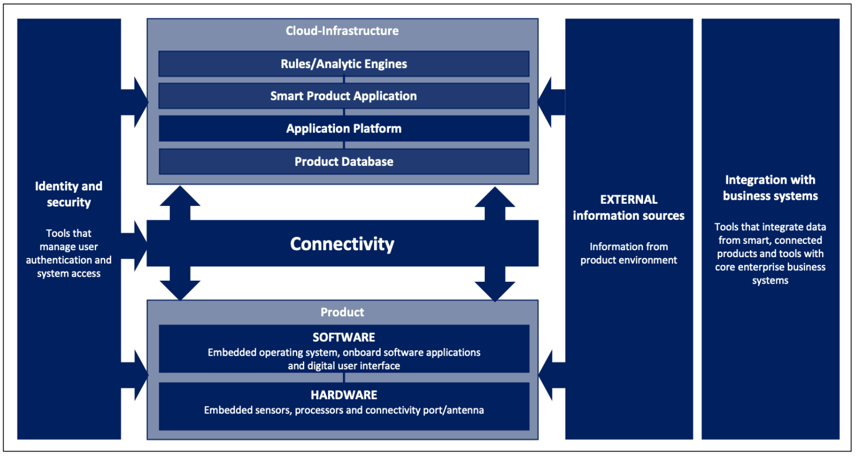

Figure 1: Necessary infrastructure for building platform-based smart, connected products and services (Own presentation, based on: Porter & Heppelmann, 2015, p. 7)

Another important element of platforms is an ecosystem. In contrast to the traditional value chain, platforms involve a value network. This network includes various actors, such as IoT infrastructure providers, software developers, manufacturers, and service partners that co-create value. Parker et al. (2016) and Rauen et al. (2018) conceptualize four different platform actors [see Table 1].

Ecosystem Role	Profile and fields of activity
Provider	Offers infrastructure, interfaces, for platforms and cloud-services
Owner	Controller of platform IP and arbiter of who may participate and in what way
Producer	Creator and developer of the platform offerings (Hardware, Software, Services etc.)
Consumer	Buyers or users of the offering

Table 1: Own representation, based on: Parker et al (2016); Rauen et al (2018), p. 12.

Due to the above-mentioned developments, the question arises how companies can create business models around IoT platforms and integrate them into their existing value creation concepts. According to the definition of Teece (2010), business models are primarily about understanding the organizational and financial architecture of a business. Gassmann et al. (2016) propose a classification into specific subject areas with the St. Galler Business Model Navigator. In the sense of the model, there are 4 questions to be answered: 1) What is the offering to the customer? (value proposition), 2) How is the value proposition created? (value creation), 3) Who is the target customer? 4) How is revenue created? (profit equation).

With regard to the platform concept, companies must also rethink their approach away from value chains and towards value networks (Gawer & Cusumano 2014; McIntyre & Srinivasan 2017). Such a value network, in turn, requires companies to involve various partners in the value creation process. The ecosystem thus becomes relevant in the course of these new business model concepts. Ecosystems consist of various interconnected actors categorized as supplier, owner, producer and customer (Parker et al. 2016). Within the platform ecosystem, companies can take one or more roles and simultaneously create different sources of revenue, which is associated with the term value creation network. According to Chesbrough & Bogers (2014), Dahlander & Gann (2010) and Parker et al. (2017) the possibilities to establish novel business models and create new competitive conditions are no longer limited.

3. RESEARCH METHODOLOGY

Throughout this paper, the authors opted for a mixed methods research approach. Due to the mix of qualitative and quantitative methods, the research process is divided into 2 studies.

For Study I, a survey of 81 companies from different branches of the manufacturing industry was conducted. The companies were selected at random from the IoT ONE database (www.iotone.com), which contains information on around 1,550 companies. The selected manufacturing companies mainly from Germany and the USA include the following industries: mechanical and plant engineering (44.4%), mobile and transport equipment (30.8%), energy equipment (4.9%), technology providers (4.9%), software specialists (3.7%), and others (11.1%). About 50% of the companies have a turnover of <5 billion euros, 20% between 5 and 15 billion euros and the remaining 30% have a turnover of more than 15 billion euros. The questionnaire sent to the selected companies included 57 questions that were based on the 3 business model elements according to Teece (2010) and Gassmann et al. (2016): value proposition, value creation, profit equation. Through a cluster analysis (Ketchen & Shook 1996), 3 business model patterns were identified.

Study II comprises a cross-industry comparison analyzing the structures behind the business model patterns in detail. 3 companies were selected, based on high product values and a pioneer position in their industry according to their digital strategy. The companies that we analyzed included Lufthansa (platform: AVIATAR), John Deere (platform: MyJohnDeere) and CLAAS (platform: 365FarmNet). The data corpus for the comparison included both primary and secondary data. In addition to 11 expert interviews, company websites, annual reports, balance sheets, strategic plans, organization charts and benchmarking documents were analyzed. In the semi-structured expert interviews, questions were asked on the following areas: Technological infrastructure of the IoT platform; participants of the platform; involvement of external partners; organizational location and platform activities; degree of openness of the platform. Furthermore, previous changes in business models, and management decisions and practices were addressed. We took care to ask unbiased and unobtrusive questions to achieve objective results (McCracken 1988). Participants were also asked to back up their statements with concrete examples (Mishler 1986). After the formal part of the interview there was an exchange of views on the strengths, weaknesses, risks, opportunities and obstacles of digital business models in terms of an IoT platform.

4. FINDINGS

Study I revealed 3 business model patterns [as shown in Table 2].

	Pattern 1: “The Skimmer”	**Pattern 2: “The Creator”**	**Pattern 3: “The Networker”**
Capabilities	Collection and analysis	Creation and collaboration	Networking, cooperation and collaboration
Experience with platforms	Beginner	Advanced	Professional
Experience in the role	Advanced	Professional	Beginner
Target	Cost transparency	Cost reduction and first revenues	Increase turnover

Table 2: Business Model patterns for an IoT platform (Own representation, 2020).

Pattern 1 is denoted as “The Networker” due to position as a platform operator. Companies in this pattern offer their customers a platform to interact and transact on. Companies use the platform as a “matchmaker” between different actors, and to offer apps or software. With the help of existing, but also newly created cooperation, the network effects and economies of scale and scope of the platform can be exploited. Using models for cost and revenue sharing between the participants of the platform, the "networker" tries to create benefit for the entire ecosystem surrounding him.

Pattern 2 is denoted as “The Creator”. Companies in this pattern operate as app and software developers. They mainly offer apps and software that enable their customers to achieve cost savings in the use of their machines. In order to generate revenue, they sell software (through business models like “subscription” or “leasing models”) or applications (through business models like “free to fee”). In addition, connectivity solutions are often integrated into the actual price of the product, so that connectivity of devices can be used as a unique selling point in comparison to competitors.

Pattern 3 is denoted as “The Networker” and differs significantly from the other two patterns. Companies in this pattern are more concerned with cost savings than with increasing sales in the IoT sector. Most of these companies have comparatively little experience with IoT technologies and platform business models. Initially companies focus on establishing connectivity. In a further step, they create first digital offerings, which, for example, create transparency in customer processes. Nevertheless, the company uses IoT data primarily to optimize machines or to adapt them to customer needs.

In summary, cost reduction and process optimization have been identified as key motivators for companies that use IoT platforms. Moreover, it was apparent that platform operators and producers of applications and software in particular aim at offering their customers data-driven services. Many phenomena of platforms from the B2C context (e.g. network effects and economies of scale) also occurred on the observed IoT platforms from the B2B context.

Study II shows that the examined business model patterns depend on several factors. In particular, the experience with digital technologies and platform business concepts, the potential participants of a platform ecosystem as well as the market shares in the respective industry play an important role in the choice of a business model pattern. Another decisive factor in this context is how open an IoT platform is for partners and external providers. This also depends on the industry and ecosystem in which the company operates. We observed different levels of strategic willingness to interact with complementors and external partners. Although we identified similar elements of platforms in both industries, we also discovered differences, such as different approaches to platform ownership (e.g. direct ownership and shareholder relationship). An excerpt of similarities and differences of the analyzed companies is displayed in table 3.

Elements	AVIATAR	365FarmNet (by CLAAS)	MyJohnDeere
Launch	2017 as brand of Lufthansa Technik	2013 as stand-alone business	2013 as brand of John Deere & Company
Type	**Pattern 3 – „The Skimmer“**	**Pattern 1 + 2 – „The Networker“ and „The Creator“**	**Pattern 1 – „The Networker“**
Value proposition	Comprehensive operations management software		
Connectivity components	No offering	Own offering	
Data infrastructure	Cloud computing by connectivity	Cloud computing by connectivity, telematics and mobile network (Cooperation by connecting own clouds with each other: Cloud-to-Cloud)	
Data owner	Consumer		
Value capture	Licenses; Pay-per-use	Freemium; Premium	Freemium; Licenses
Role in platform ecosystem	Owner & partly producer of own applications		
Platform access	Owner of brand-independent devices		Owner of John Deere machines (brand-depending)
Cooperation / partnerships	Cooperation with external (physical/digital) service/software suppliers		Cooperation with external software suppliers to offer own range of services

Table 3: Comparison of 3 major IoT platforms (Own representation, 2020).

5. THEORETICAL AND PRACTICAL CONTRIBUTION

From a theoretical perspective, this work has shown that IoT is a key concept for companies to build new platform-based businesses. With the help of a cloud infrastructure, companies are now able to offer digital services to customers that focus on the needs of the customer. Besides providing new digital solutions for customer problems (Vargo & Lusch 2004) the generated data can as well be used to improve physical product-service offerings. In addition, our study revealed challenges that companies face in connection with IoT platforms, such as the sharing of revenues and costs among ecosystem participants or the distribution of ownership rights and protection of know-how.

For practitioners the results offer a new perspective on how manufacturing companies can expand their service offerings or improve existing ones. With the help of the 3 identified business model patterns, companies are able to better understand their own position and can adapt their future actions. The detailed analysis of the individual components (Study II) of a platform supports managers in assessing the advantages and disadvantages of a business model pattern in comparison to other industries. Thus, the integration process for an IoT platform can be carried out faster and typical errors during transformation processes can be avoided.

Nonetheless, many questions remain unanswered at the end of this work. Future research should investigate if these patterns remain the same or if they evolve over time. It will also be of major interest to outline how costs and revenue in IoT platform ecosystems are shared between actors.

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AUTHORS
Lino Markfort
University of Leipzig, Chair of Innovation Management and Innovation Economics, Grimmaische Straße 12, 04109 Leipzig, Germany, +49 341 231039-280, lino.markfort@uni-leipzig.de

Philipp Koegler
Fraunhofer Center for International Management and Knowledge Economy IMW, Data Mining and Value Creation, Neumarkt 9-19, 04109 Leipzig, Germany, philipp.koegler@imw.fraunhofer.de

Alexander Arzt
Fraunhofer Center for International Management and Knowledge Economy IMW, Data Mining and Value Creation, Neumarkt 9-19, 04109 Leipzig, Germany, alexander.arzt@imw.fraunhofer.de

Prof. Dr. Heiko Gebauer
Fraunhofer Center for International Management and Knowledge Economy IMW, Data Mining and Value Creation, Neumarkt 9-19, 04109 Leipzig, Germany, heiko.gebauer@imw.fraunhofer.de; Linköping University, Sweden; University of St. Gallen, Switzerland

DIGITALLY SUPPORTING THE CO-CREATION OF FUTURE ADVANCED SERVICES FOR 'HEAT AS A SERVICE'

Sara Mountney, Tracy Ross, Andrew May, Sheng-Feng Qin, Xiaojing Niu, Melanie King, Kawaljeet Kapoor, Vicky Story and Jamie Burton

ABSTRACT
Purpose: This paper is a preliminary exploration of how a digital prototype might be developed to support co-creation in developing future advanced services for 'Heat as a Service' (HaaS).
Design/Methodology/Approach: A user-centred design approach was undertaken with two customer segments to establish potential requirements for HaaS. A systems thinking approach was then used for the preliminary development of a digital tool to support new advanced services.
Findings: Further definitions of HaaS from the perspective of two different customer segments are presented, with emerging proposals on (i) how they can be managed in a system setting and (ii) suitable supporting digital tools.
Originality/Value: A user-centred approach to new advanced services development is presented to take into consideration current and future engineering and digital capabilities, moving beyond a conventional product-centric service development approach.

KEYWORDS: Advanced services, user-centred design, digital twin

1. INTRODUCTION
Advanced services are the provision of outcome-based solutions, creating a risk and value sharing partnership between the customer and the supplier. Advances in digitalized technology create an opportunity to increase the scope of such advanced services, whether this be through the addition of smart technology into the service itself, or the use of digital techniques to model and explore new advanced service concepts. An example of an advanced service is the move towards providing heat in the home as 'Heat as a Service' (HaaS), based on the provision of thermal comfort, rather than the payment of physical products and units of energy. For a manufacturing organisation looking to move into the provision of advanced services in this area, there are challenges in translating the HaaS concept into a range of flexible solutions to suit wide ranging customer needs and expectations. Digitalized methods to support and create opportunities for novel advanced services through co-creation therefore require further investigation.

This work is part of a larger multi-disciplinary project that takes a customer-focused perspective to develop a better understanding of the HaaS concept. This understanding will then be used to design a digital prototype to digitally map the future services, providing an environment for service co-creation to occur. This paper specifically reports on the preliminary findings of the user-centred design approach with customer preferences reflecting potential advanced service opportunities. A systems thinking approach is then taken to explore the digital resources available to support the prototyping of new advanced services to meet these preferences. The concept for a digital prototype to support this is then presented.

2. BACKGROUND
Advanced Services are a type of servitization that deliver customer value based on outcome rather than ownership; sharing risk, revenue and value (Musson et al. 2019). Such business models are being adopted by manufacturing organisations to widen the scope of their customer offerings to offer a mix of products and services (Kowalkowski, Gebauer and Oliva, 2017). Advances in digitalized technologies offer significant opportunities to such organisations, in that they can be exploited to increase the scope of potential services offered both within the existing product in use (i.e. condition monitoring),

and those not embodied in the product definition and / or of higher value (Coreynen et al. 2017, Chowdhury et al. 2018).

HaaS is an example of a potential advanced service. Rather than paying for units of energy delivered (i.e. KWH), customers pay for units of experience, in this case, the provision of 'warm hours' or 'smart thermal comfort', often delivered via smart systems (Energy Systems Catapult 2019). The drivers for HaaS lie in the decarbonisation of UK home heating, more efficient energy provision and providers seeking more consistent revenue streams. However, delivering HaaS presents a series of challenges both to the energy provider and the network of organisations that provide various parts of the infrastructure for delivering such a service. Examples are: the range of property types and ages, and their varying efficiencies, particularly for existing housing stock; and the range of users of such HaaS systems and their own individual circumstances, requirements, and behaviours towards the system (Energy Systems Catapult 2019). The Energy Systems Catapult highlights '3Cs' (Comfort, Control and Convenience)' as key customer requirements for an acceptable alternative to their current (often gas-fired) systems (2019). Delta-EE have highlighted five risks normally borne by the customer that would need to be transferred to the supplier in order to deliver HaaS. They are financial, technical, performance-related, behavioural and energy price fluctuations (Delta-EE 2019). Organisations operating in this environment, therefore, need to know how and where they will contribute to the new HaaS value chain, and develop capabilities to ensure they can deliver value (Bustinza et al., 2015). Essentially the customer is defining the value to be added but flexibility is needed to both understand what this value might look like and understand how, as a network of providers in a value chain, these organisations respond. Thus, in defining what a new advanced services to deliver HaaS might be, a method that involves customer co-creation activities is clearly advantageous.

It is worthwhile examining current digital approaches that could be used in the development of advanced services. Digital modelling approaches, particularly digital twins, are being increasingly developed to support the introduction of new products and services into the marketplace. Kritzinger et al. (2018) distinguish between three stages of digital modelling (digital models, digital shadows and digital twins), depending on the level of interaction between the physical model and the virtual model. With a digital twin, there is a real-time connection between both spaces with updating in both directions (Kritzinger et al., 2018). However, this real-time, two-way interaction is most developed through product in-use or operation data and represents a challenge for the early stages of concept product design due to the availability and uniformity of the data (Jones et al 2019). Ströer et al. (2018) discuss how most service-related data is generated during use and fed back for product design. In the absence of such data, simulation and machine learning can be used to predict the data required and inform the design progression.

In terms of design methods utilising digital modelling, the dominant approach is an extension of product lifecycle management, so that new developments are primarily product-centric, and services support the existing product in use. The emphasis is on the efficient integration of data across each stage of the product lifecycle. As an example, Tao et al. (2018) considered a product-centric digital twin approach that spanned across all stages of product lifecycle management, with the primary aim of improving the efficiency of data integration across each stage. The purpose of adding value through services (servitization) was not acknowledged, only services related to maintaining the product in use. However, the integration of customer data was acknowledged as a requirement during the concept stage of design and the digital twin presented as a suitable means of integrating this. Zheng et al. (2018) also presented the potential of a digital twin as an enabler for smart service innovations due to its linking of physical and digital spaces. They demonstrated this with a smart product service system, using wearable technology (a respirator) as an example. An opportunity for designing new service opportunities around the data generated from its use was highlighted. Hence, there was an opportunity for the value in services to transcend those directly related to the product and the scope of the digital twin was increased. Furthermore, Rambow-Hoeschele et al. (2018) extended the scope of a digital twin beyond the scope of the physical product to business models, creating a digital model builder, which encompassed elements of product, service and value offering modelling from a business modelling perspective. This was defined as a digital twin due to the real time exchange of data between the physical and virtual spaces.

An opportunity, therefore, exists to consider in detail, the generation and use of customer user data for the co-creation of digitally enhanced advanced services, focusing on a HaaS solution. A digital approach is required that enables an organisation to explore potential advanced services and capabilities to respond, but without tying this to a conventional product-centric design approach.

To investigate this further, a two-stage study design approach was adopted. Study 1 was a user-centred design approach to understand the end user perspective and uncover future potential service opportunities for HaaS. These were then used to inform study 2, which used a systems thinking approach to explore potential digital prototyping opportunities. These studies are reported in the next two sections respectively.

3. STUDY 1: THE DESIRED USER EXPERIENCE FROM TWO PERSPECTIVES

3.1 Approach and Study

In the context of everyday tasks, user-centred design can be considered to offer both a philosophy and a process (Haines and Mitchell, 2013). The philosophy is that design should focus on the needs of the user as a central tenet, seeking to ensure that the needs and wants of users are considered throughout the process (Norman, 1998). The process is characterised by an early focus on users and tasks (Gould and Lewis, 1985) and stresses the importance of user goals, behaviours, contexts, characteristics and decision-making (Sharp et al. 2007). User-centred design is widely accepted as leading to the design of useful, usable and desirable products, services and systems.

The user-centric design approach was taken to uncover future opportunities and requirements for the heat as a service concept. Two key end-user groups were identified in collaboration with the focal manufacturer: householders and social housing landlords. These groups were selected in order to explore two diverse scenarios of use to take forward into the next phases of research.

The first group comprised 15 householders with the following characteristics: a mix of owner-occupier and rental with 1-5 occupants; 6 male and 9 female; predominantly gas boilers plus a range of additional heating or log burners; some with smart meters or intelligent thermostats; and a range of attitudes to technology. A participatory design approach was used to take the householders through 3 stages of a semi-structured interview: (i) sensitisation to the context (describing their current heating situation and experiences); (ii) a design fiction ("your heating is stripped out and you have your own 'thermal comfort PA' what would they need to know and what could they do for you?"); and (iii) idea-generation, based on (ii) and exploring three main phases of the personalised thermal comfort 'system' - planning, using, and leaving (e.g. moving house). All sessions were audio recorded, transcribed and subjected to a thematic analysis to extract the key functional and experiential needs.

The second group comprised social housing landlords. These are an interesting use case since they act as an intermediary between equipment and service suppliers and the end consumer. Social landlords provide rented housing to selected community groups (including vulnerable sectors) and are responsible for providing a tenancy service that enables good value, comfortable and healthy living (legal requirement) environments. Two large social landlord organisations based in the UK took part in the study – large organisations were chosen as they have a wide range of staff with various roles and technical expertise, and can provide a multi-disciplinary contribution to service-related insights centred around heating. A total of eight staff took part in two semi-structured discussion groups, each lasting about one and half hours. The specialisms of the staff within these organisations were as follows: new technology and innovation, technology and process transformation, operations management, customer service, and external and internal communications. The discussions followed the approximate format of: research background, consent and ethics, introductions, key measures of success, problems they face, needs they have, new ideas to meet needs and capitalize on opportunities, paths and barriers relating to implementation. A range of user and service focussed tools were used including stakeholder and customer journey mapping, as preferred by the participants.

3.2 Results

The results from the householder interviews elicited some key high-level insights. Firstly, there was a wide variation in needs and wants, influenced by factors such as personal comfort preferences, occupants (e.g. babies, visitors), schedules (daily, weekly, annual) and attitudes to technology and data usage. In addition, participants varied in their prioritising of what we have identified as the '5Cs' – comfort, control, convenience, cost and carbon-reduction (with the latter two factors adding to the three identified previously (Energy Systems Catapult, 2019). Results based on the three main phases of the personalised thermal comfort 'system' (planning, using, and leaving) indicated what knowledge/data the 'thermal comfort PA' would need to access and are presented in Table 1.

Table 1. Knowledge and actions required for the 'thermal comfort PA'

Planning	**Using**	**Leaving**
Occupants Personal temperature preferences (un)known Household routines (or lack of) & exceptions Room usage level and activity/function Priorities ('5Cs': comfort, convenience, control, cost and carbon-reduction) House structure, insulation, decoration, sun location Aesthetic	Moving in and out of house Moving around house Instantaneous heat when enter (room/house) Room-by-room variation Privacy of schedule/activity data (wide variety of opinions) Automation? But with user control, awareness, assurances Learning then stabilising + user intervention Reports, hints & tips, to 'help the grid'	Take my profile with me Adjust to new home/schedule/occupants Need to re-coup my investment What data do I leave behind? 'take the brain!' How would it work re the 'supplier'? Chance for complete transformation e.g. Passive House Reduce the stress!

The results from the social housing landlords focused on generating some specific service concepts that would meet their needs in relation to 'heat as a service' provision to tenants. Table 2 gives an outline of the ten service concepts (SC1-SC10) generated with the Social Landlords, together with the key features for service interaction. They are shown in a temporal order that relates to key touchpoints and processes on the customer journey from SC1 to SC10 of a social housing tenant, and include some specific, and other more general, and future focussed concepts.

Table 2. Service Concepts and Key Features for Social Housing Landlords

Service concept	**Key features**
SC1 -Getting the gas and heating up and running for the customer	An advisory/intelligent system/liaison type service that guides the tenant through this process
SC2 -Managing access around the annual gas safety check	Opening up communication channels with the tenant and scheduling inspection visits based on engineer locations and availability
SC3 -Diagnosis/resolution of heating problems	A single, manufacturer agnostic, diagnostic dashboard that can be used by the customer service team in conjunction with the engineering team, it sends back fault data from the boiler to enable remote fault finding and diagnosis.

Table 2. Continued

Service concept	Key features
SC4 -Predictive boiler performance and preventative maintenance	A predictive tool that enables the landlord to identify when a boiler is starting to work non-optimally, and flags this up to the landlord for maintenance
SC5 -Optimising the thermal performance of the housing stock	A service that does an audit on each landlord property, and recommends to the landlords a variety of retrofit options with alternative costs and benefits profiles.
SC6 -Using data to 'look after' the customer	A tool that enables a landlord to identify tenant behaviours which are contrary to good wellbeing, centred around heating, but could extend to broader safety and wellbeing.
SC7 -The (healthy, enabling) connected home (link with above)	Service solutions around the 'connected home' using a portal and heat and other sensor data.
SC8 -Managing the transition away from gas boilers (the future limits on installing gas-fired boilers into new properties)	An educational service, aimed at enabling social landlords, customers and heating manufacturers to understand and develop future heating solutions
SC9 -Provision of 'warm hours'	Centralised heat provision, tailored service plans, hot-swappable provision
SC10 -Maximising organisational operational efficiency	A service that maximise operational efficiency for the social landlords based on optimising trade-offs between: customer (internal and external) satisfaction; operational efficiency; compliance; future proofing; environment concerns.

4. STUDY 2: PRELIMINARY STUDY OF SUPPORTING DIGITAL TOOLS

In terms of the method by which new advanced services developments could be investigated, and requirements understood, a Systems thinking perspective was adopted. In this context, systems thinking can be defined as a '*framework for seeing wholes and interrelationships*' (Arnold and Wade, 2015). Systems thinking involves looking entirely at the bigger picture while understanding the relationships between all the separate parts and how they work together. Systems thinking can be applied by understanding the system of interest, its inherent and emergent behaviour while trying to reduce complexity through modelling (Kossiakoff et al. 2011). Systems thinking is important in this context, as the HaaS solution will necessitate a multi-stakeholder collaboration in order to deliver a variety of systems and services and, therefore, it is important to consider the socio-technical capabilities that each organisation will need to deliver, and to whom, as the beneficiary of the service or system. In other words, the 'end-user' or customer of one system, may well be the service provider to the end-user of the HaaS experience, i.e. the occupant. Additionally, this creates an environment where potential solutions can be explored without them being tied specifically to an existing or new product proposal. Therefore, the full scope of advanced services – and the capabilities required to deliver them – can be investigated.

From the end-user insights indicated in Table 1 and Table 2, a preliminary exploration was conducted using the systems thinking approach. The system key elements were first identified from six dimensions including human players, machine (equipment), services (already identified in the user perceptions data), data, service tools and the system structure. The human players include householders, landlords with their tenants, and service providers (in/outside of the manufacturer). The machine includes all individual heating equipment, each with a unique product ID and embedded sensors for receiving instructions or sending product running data/information to the system via IoT for SC3-5. Data includes user-generated data, machine-generated data and service generated data. Examples of user-generated data include occupants' profiles and behaviour data for SC1 and 6, the machine-generated data includes machine-specific faults and performance data to support SC3 and 5, and the service generated data includes third-party service providers' generated data, such as problem diagnostic data and gas inspection data for SC2 and 3. The service tools include service advisory tools for SC1 and 5, communication tools in SC2, predictive tools in SC4 and 6, and educational tools in SC 8.

A digital twinning platform is now being explored as the system backbone, with a front-end as a web app and the back-end as a web service, to integrate all system key elements together and through incrementally digital twinning processing, eventually make it an ecosystem. The system structure is illustrated in Figure 1, outlining the key interactions and enabling tools that will be required.

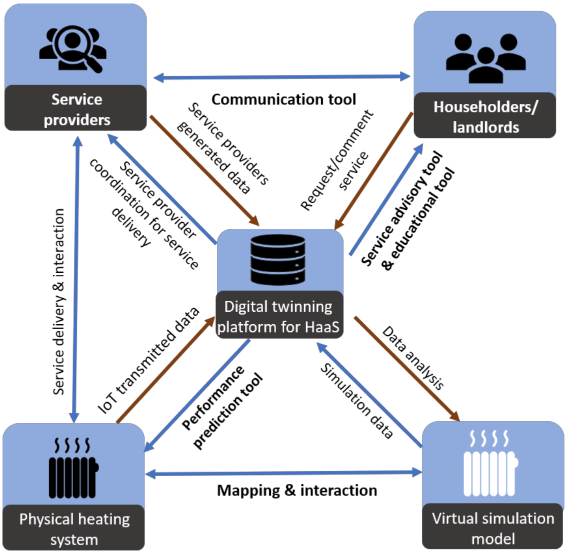

Figure 1: Key interactions and enabling tools on HaaS digital twinning platform.

The key to developing a digital twinning platform is to connect heating devices and key system players to the platform and to implement platform enabling tools, providing householders, and social landlords and their tenants, an easy way to get their requested services delivered in a timely way, thus, bringing them a better user experience. In turn, with more data (the red arrows in Fig. 1) adding to the platform, the simulation model gets more accurate over time, making the platform more reliable in delivering high-quality digital heating services and in providing data to help shape/upgrade heating devices and services in the future.

An early stage demonstrator for the platform, with simulation, is now being considered. A small selection of the key service concepts from those identified in table 2 will be selected and used to design and prototype the supporting tools in the demonstrator. The aim of this work will be to demonstrate and evaluate the principle of digital twinning technology for advanced services.

5. CONCLUSIONS

In this work, we have investigated how digitalization can support the development of new advanced services within the HaaS environment by capturing customer requirements and feedback. Potential opportunities for Haas developments were explored with two customer segments to generate a deeper understanding of the desired user experience. Following on from this, a digital twin platform approach, using simulation, is being used to prototype a demonstrator for evaluation on two accounts. The first is to evaluate how desired user experiences can be used to explore future advanced services opportunities. The second is to evaluate the digital twin platform to explore opportunities in advanced services development beyond the product-centric approach, and the suitability of its application at the concept stage.

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AUTHORS

Dr Sara Mountney
Department of Engineering and Mathematics, Sheffield Hallam University, Sheffield, UK, S1 1WB
0114 225 6895, s.mountney@shu.ac.uk

Dr Tracy Ross
Design School, Loughborough University, Loughborough, UK, LE11 3TU
01509 226913, t.ross@lboro.ac.uk

Dr Andrew May
Design School, Loughborough University, Loughborough, UK, LE11 3TU
01509 226906, A.J.May@lboro.ac.uk

Prof. Sheng-Feng Qin
School of Design, Northumbria University, Newcastle, UK, NE1 8ST
0191 243 7829, Sheng-feng.qin@northumbria.ac.uk

Xiaojing Niu
School of Design, Northumbria University, Newcastle, UK, NE1 8ST
0191 243 7829, Xiaojing.Niu@northumbria.ac.uk

Dr Melanie King
Wolfson School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough, UK, LE11 3TU
01509 227198, m.r.n.king@lboro.ac.uk

Dr Kawaljeet Kapoor
Aston Business School, Aston University, Birmingham, UK, B4 7ET
07578511057, k.kapoor@aston.ac.uk

Prof. Vicky Story
School of Business and Economics, Loughborough University, Loughborough, UK, LE11 3TU
01509 228301, v.m.story@lboro.ac.uk

Prof. Jamie Burton
Alliance Manchester Business School, University of Manchester, Manchester, UK, M15 6PB
0161 275 6508, Jamie.Burton@manchester.ac.uk

A SERVITIZATION ROADMAP FOR BASQUE MANUFACTURING SMEs

Eduardo Castellano-Fernández and Urko Lopez-Odriozola

ABSTRACT
Purpose: Design a servitization roadmap for manufacturing SMEs that need/want to extend their incomes through industrial services.
Design/Methodology/Approach: The servitization roadmap designed is an instantiation of a servitization transformation process defined for the strategic, tactical and operational perspectives. This servitization transformation process has been developed based on a literature research as well as case studies with +30 Basque manufacturing SMEs. Meanwhile, the servitization roadmap has been designed through a Community of Practice with 11 manufacturing SMEs of the MONDRAGON Corporation.
Findings: Once defined the new industrial service catalogue, its launching to the market should be sequenced starting with the base services, then the intermediate and finally the advanced ones in order to; (1) demonstrate to the product-driven manufacturing SME the value of the services (e.g. extended incomes with high margins…), its scalability and economic self-sustainability, (2) progressively introduce the new service processes and roles without disturbing significantly the product-driven culture of the manufacturing firm, and (3) enrich the data base of how the machines are being used by the clients and their condition during their life cycle (e.g. reliability, availability, maintainability, energy consumption, performance over time…) for RAM-LCC and TCO more accurate estimates.
Originality/Value: Many manufacturing SMEs that compete in mature sectors (e.g. capital goods), have the need to differentiate themselves through the introduction of industrial services in order to extend their incomes, make their turnover figures more resilient to the economic cycle and foster customer loyalty. In practice, the cultural and organizational change from a product-driven manufacturing SME towards a service-driven manufacturing SME is usually very challenging; this research presents a validated route to tackle this transformation.

KEYWORDS: Servitization, Roadmap, Transformation Process, Case Studies

1. INTRODUCTION

Servitization is especially linked to promoting the proximity strategy with the customers, knowing their needs, going from transactional relationships to continuous and close relationships (Baines & Lightfoot, 2013; Rabetino et. al, 2017). This kind of relationships are developed through different industrial services; base services (oriented to the provision of the product), intermediate services (oriented to guarantee the condition of the product) and advanced services (oriented to assist the functionality or result of the client's activity, being the product a medium-platform for the provision of services) (Baines & Lightfoot, 2013).

Moving from offering base, intermediate and advanced services involves a transfer of previously internal activities for the client. The provision, or not, of said base, intermediate and advanced services will depend on whether (Baines & Lightfoot, 2013: 64): [1] the client wants to do it by himself, [2] the client wants "us" to do it together, or, [3] the client wants "us" to do it.

2. THEORETICAL BACKGROUND

A fundamental motivation for an industrial manufacturer to decide to undertake a servitization strategy is the greater profit margin of services compared to the one that comes from sales of new equipment, and that the collection/monetization of these can be recurring throughout the life of the product (Gebauer & Friedli, 2005; Baines & Lightfoot, 2013). As pointed out by Lexutt

(2020); *"Servitization is driven financially by the desire to realize higher profit margins and more stable revenue flows through service offerings"*.

In addition to the profit margins, from a loyalty point of view, it has been found that customers satisfied with the service are between 3 and 5 times less sensitive to price variations than those who only buy the product. This is complemented by studies that show that the acquisition cost of a new customer is 5 times higher than the retention cost of a customer satisfied with the service (Chylinski, 2016). In fact, customer loyalty or loyalty and the attraction of new customers through the prescription of existing customers are reasons that encourage companies to develop services (Brax, 2005; Grönroos & Helle, 2010).

In turn, customers who buy services also benefit because they: [1] Focus their energy-resources on key activities of their business, leaving vendor manufacturers to optimize the availability and performance of their non-strategic assets; [2] Transfer fixed costs (purchase of equipment) to variable costs (use of equipment), improving the financial visibility of the business, and; [3] Reduce the risk of buying equipment with new, less mature technologies.

Lay (2014) emphasizes the need to take care of the installed machine base, since, if not, customers can go to the competition. This would lead competitors to establish relationships of trust with customers. As Cusumano et. al (2015) state, many customers are increasingly aware that they do not necessarily want to own a product; that the products serve to carry out operations or functions forward. Therefore, the support that a supplier can give after the delivery of a good is equally important or more for the selection of the supplier.

In any case, the design and implementation of services by companies are not exempt from incidents and inhibitory factors like: [1] Lack of confidence in the products/processes on the part of the manufacturers, who prefer to play safe (Gebauer et al., 2005); [2] Clients prefer to own an asset for fear of leaking valuable and strategic information from the company (Gebauer et al., 2005); [3] Lack of willingness to apply new business models for preferring to enter a high sum of input instead of having a regular cash flow dosed in time (Vargo & Lusch, 2008), and/or; [4] The secondary importance of services, offering basic services (maintenance, repair and replacement) and / or free services (Vargo & Lusch, 2008).

There are different ways of implementing servitization in industrial manufacturers. These routes depend fundamentally on the starting point where these companies are located. The development of servitization has a direct reflection on the business model of a company. In this sense, Adrodegari et al. (2015) define five levels of progressive maturity; from the business model focused on the product (level 1) towards the business model focused on the performance of the solution (level 5). These levels are related to the sales of base, intermediate and advanced services. In this sense, Adrodegari et al. (2015), through a study based on the answers offered by 95 European industrial companies undertaking the servitization process (50% SMEs and 50% large), show the following conclusions and generic challenges for component manufacturers, OEMs and marketers of industrial products:

- The offer of services in manufacturers of Components and OEMs are mainly based on basic services, while advanced services is incipient in some OEMs and broad in Dealers.
- European manufacturers have not yet formalized the service strategy, development activities, responsibilities, budget, formal processes and operational methods.
- The servitization process is not complex but must be progressive; from the proactive management of spare parts throughout the useful life of the asset to, finally, payment contracts for use and performance (with financial partner).
- The calculation of Total Cost of Ownership (TCO) and cost for lack of reliability (RAM-LCC) are key to moving from base services (transactional and price-based relationships) to intermediate and advanced services (customer relations throughout the life cycle).
- Best-in-class companies are significantly increasing their service offer towards business models based on use.

3. RESEARCH METHODOLOGY

The research approach is based on two stages. The first is devoted to the design of a Servitization Transformation Process based on a literature research performed at three levels; strategic, tactical and operational. And its contrast with +30 manufacturing SMEs, case studies (Yin, 2002), involved in related transformations. The second stage, developed through an action research approach (Whyte, 1991), is devoted to the definition of an instantiation Roadmap of the servitization transformation process based on a Community of Practice (CoP) with 11 of them (e.g. machine tools, forklifts, electric engines, foundries, automatisms, components for heating equipment, packaging machines…) The following main issues were prioritised to drive the CoP reflection: How to create value to our customers through servitizing the offer?; How to transform our business model towards servitization?; Which practices and technologies to use to develop the new industrial services?; Which service engineering processes to deploy for serving the new service catalogue?

All the manufacturing SMEs involved in the research belong to MONDRAGON Corporation. And due to the Data Protection Act, we cannot offer the names of these firms. MONDRAGON group, located in the Basque Autonomous Community in Spain, constitutes a group of 98 firms and 143 subsidiaries with a total turnover of 12.215 million euros, employing 81.837 people. About the 78 percent of those employed in industrial cooperatives are worker members who are highly involved in their companies, participating in management, in capital and in the profits generated (MONDRAGON, 2019). Many of these manufacturing firms are SMEs that compete in mature sectors (e.g. capital goods), thus having the need to differentiate themselves through the introduction of product-services systems in order to extend their incomes, make their turnover figures more resilient to the economic cycle and foster customer loyalty.

Numerous authors have researched this experience from an economic approach (the benefits and singularities of cooperative labour and social economy), while other authors have highlighted the effects of will-power and a people-based business model as well as the utopia of subordinating capital to labour, from a sociological and organizational point of view (Lopez et al., 2009; Errasti et. al., 2017). But little has been written about the role of servitization in MONDRAGON's manufacturing SMEs.

4. THE SERVITIZATION TRANSFORMATION PROCESS

The Servitization Transformation Process developed covers the strategic, tactical and operational levels. The servitization strategic perspective is specially focused on the competitive strategy of the manufacturing SME, the analysis of internal factors (enablers and inhibitors to develop service offerings – strengths and weakness), the analysis of clients and sectorial factors (opportunities and threads) (Baines & Lightfoot, 2013; Rabetino et al. 2017; Weigel & Hadwich, 2018), in order transform transactional relationships to continuous and closer relationships. The tactical perspective is devoted to the design of the service catalogue and the service business model. This has been approached through a twofold market-pull (i.e. design thinking tools) and technology-push ideation processes in order to define and rank potential new services, as well as their corresponding service business models (Adrodegari et al. 2015). Finally, operational drivers for the services development have been identified for the calculation of the services' costs, i.e. critical reliability-cost matrix, reliability vs. availability models, resources sizing and location, RAM-LCC (Castellano, et al. 2016, Erguido et al. 2017), as well as service engineering operational drivers, i.e. KPI metrics, facilities, ICT resources/platforms, professional profiles and financial partner (Baines & Lightfoot, 2013).

Due to extension issues, and as the strategic perspective has already been very well described by other authors (Baines & Lightfoot, 2013; Rabetino et al. 2017; Weigel & Hadwich, 2018), the following sections will just focus on the tactical perspective and operational drivers, i.e. innovation of the industrial services catalogue, practices and technologies for the development of industrial services, key resources for the deployment of industrial services and the financing of advanced services. Each section is enriched with a real case study description.

4.1 The Innovation of the Industrial Services Catalogue

This axis has been approached from twofold perspective; driven from the insights of customers (market-pull) and powered from the product functional model (product/technology-push).

The point of view of the customer's insights proposed a framework based on design thinking. In this sense, the knowledge of the client-user, as well as the techniques and tools to carry out this activity, is a field widely worked from the discipline of Service Design Thinking (Stickdorn, et. al., 2016). This activity is framed in the exploration phase, which is complemented by subsequent phases aimed at the ideation of solutions and their development (MONDRAGON, 2013) under a type scheme of methodologies agile to the development of new services, e.g. Lean Service Creation (Sarvas et. al., 2016).

The point of view of the functional model follows an approach consisting of four stages: (1) Functional modeling of the value proposition and description of the current products-services offer; (2) Ideation of new product-service systems (PSS, hereafter) and forms of monetization for the segments; (3) Integration of the new PSS in order to make coherent SPS groupings with value propositions oriented to specific segments, and, finally; (4) Selection of the new PSS that will make up the new catalog through criteria related to the probability of its commercial success as well as its probability of technical development and associated costs (Berasategi, 2017).

Case #1: Reconditioning and re-manufacturing company of electric engines
The company has generated a platform for the sale of electric engines and spare parts with several options: (1) Repair + sale of a second-hand engine; (2) Sale of the engine and depending on the terms in which the customer wants the price can be set; (3) It is only charged when you want to carry out (buyer or seller) the reconditioning; (4) Pioneers in energy efficiency reports, so that the customer can see if the engine is worth repairing or not, or is interested in putting a new one, and (5) WIN-WIN relationship with ABB. Repair and maintenance constitute the core of this firm. The routes chosen to generate value for its customers are the reconditioning of a product, and the re-manufacturing, if necessary. The reconditioning includes an in-depth inspection that ensures its correct operation, with guarantee on the entire product, but without having new product status. Re-manufacturing covers aspects of reconditioning and aspects of modernization and improvement of the product. Thus, the aforementioned offer of services has allowed this company to enter the concept of circular economy from an industrial perspective. The concept consists on manufacturing a product thinking not only on its use, but also of its repair. Thus, value is generated for users in two ways; reconditioning the product or re-manufacturing, and offering also a predictive maintenance (once the engine is analyzed, they give all the data to the client so that they can observe where the engine fails).

4.2 Practices and Technologies for Service Development

The hierarchy of the systems, subsystems and components of an industrial product, depending on its criticality, is key to determine the resources that will be necessary to market different services (base, intermediate, advanced) associated with it. Or more specifically, to size the cost of such services. This criticality is usually quantified based on the reliability in use of the product, as well as the consequences derived from the lack of the same (e.g. cost of unavailability in the client's processes, corrective costs, safety and environmental costs, etc.). Once the criticality of the systems, subsystems and components of an industrial product in operation has been mapped, it can be determined the type of maintenance to be performed to each of them; corrective, preventive, Condition-Based Maintenance (CBM) or predictive. From the reliability distribution functions of the components, the frequency of the interventions to be performed will be determined, according to the level of availability desired by the client, defining the master plan (customizable) of preventive maintenance operations (Castellano et al., 2016).

Case #2: Blow molding machines and plastic containers and resin materials producer
The company has implemented a CBM system. This monitoring has been carried out through the installation of a machine that stores and issues machine use and performance data, this data being accessible through computers and mobile devices such as a smartphone and tablets. The availability of data allows the development of customer service systems. The monitoring has a series of gaps that should be resolved: • The machines should be connected to the network, in order to have real-time data on the operation and performance of the machines. • In case that the machines are connected, the customer owns the data and who, consequently, must give permission to this company to access them. There are three important points about the development of services and servitization activities: 1. It is about opening a catalogue of services using current and short-term available capabilities. 2. Servitization performed must be based on the cost of the service, and not on the cost of the machine 3. Three novelties of servitization mix: (a) Performance - Collection on production results, losses, costs, quality, etc.; (b) Monitoring 4.0 - Charge for results, and; (c) Data analytics 4.0 - Customer affiliation to cooperate and co-create, through a Knowledge contract. From the point of view of business, it is about connecting the new ranges of service, developed or to be developed, with critical moments such as the design and development of the packaging, the acceptance of the offer at source, the assembly of the machine and after sales service.

In this sense, a customized plan affects guaranteeing functionality and availability, as well as procedures and resources necessary to execute them. These resources (tools, critical spare parts, technical personnel ...), in the words of Castellano et. al. (2016), condition the logistics of the interventions to be carried out, thus it is important to have simulators-optimizers (service time vs. cost) that identify different scenarios for their optimal location. Based on the information from the interventions carried out on each asset, there are applications to calculate the cost due to lack of reliability of the industrial product in use, i.e. RAM-LCC (Erguido, et. Al., 2017). By joining the RAM-LCC with a monitoring of the consumption of the machine, it is possible to determine the Total Cost of Ownership (TCO). RAM-LCC is essential to set the price range for intermediate services, just as the TCO is essential for the prices of advanced services.

In the same way, it is necessary to take into account that the Information and Communication Technologies (ICT) characteristics of companies focused on the manufacture of products are mainly focused on the planning and control of production processes and operations, e.g. ERP. But ICT can be used also, for example, to capture machines' data through sensors (PLC, smart sensors), communicate data (IoT, IIoT…), store and analyze the data or act remotely. Taking into account that the volume of data and its storage capabilities increases exponentially, it is possible to identify algorithms and behavioral models, under operating conditions, with greater predictive potential. All this allows to offer personalized services based on the operation data generated by the user and to make a micro-segmentation models and personalized dynamic prices based on specific customer preferences, as well as in the context of use and performance of advanced services (i.e. pay-per-use and pay-per-performance).

Case #3: Automation, control and digitization company
This company works for different sectors and performs turnkey automation projects. The company performs different types of activity: (1) Turnkey projects; (2) Complete electrical engineering, both basic and detailed, of the set of cabinets and field elements, control, motors, etc.; (3) Equipment supplies - manufacture of cabinets and equipment supply for MT transformation centers, BT distribution centers, CCMs, PLC's, control desks, synoptics, field elements, etc.; (4) Programming control solutions (PLC, SCADA) of new projects such as upgrades of obsolete versions, and; (5) Process analysis – big data is used for different activities such as reducing energy consumption, improving productivity or predictive maintenance activities. Given the work approach of this company, its business lines respond to different sectors of activity, such as: (1) Water treatment plants, (2) Metallurgical sector, and (3) Automotive sector.

This company offers 4 levels of service, as a consequence of the two concepts previously commented:

1. Services related to the scorecard, in which it transforms the data into information, which goes directly to the client and they make the interpretation.
2. Automation consulting - The company performs the interpretation of the data, but adds proposals for improvements, and gives the option to the client to make them.
3. Online surveillance - Modeling and detection of outliers and predictive activities.
4. Process consulting activities – Through advanced controls and simulations.

4.3. Service Engineering

The typical KPI metrics of an industrial manufacturer usually focus especially on the cost, quality and delivery time of the product. On the other hand, the metrics of the Service reflect the results of the clients and the operations of the service. To do this, three levels of metrics and a series of practices are usually used to help demonstrate the value provided to customers (Baines & Lightfoot, 2013):

- Business indicators of customer processes.
- Indicators of industrial product behavior.
- Service delivery management indicators.

Finally, in the words of Baines & Lightfoot (2013), it is important to evidence/demonstrate the value provided by the service team, since, if the service is managed correctly, the client can get the feeling that nothing significant is being done so that everything works correctly, e.g. through visits to the operations room, training installations or regular reports.

In addition, it is necessary to take into account the operations of the service and its location (Baines & Lightfoot, 2013; Sklyar et. al, 2019). The successful delivery of advanced services is possible when the service provider is integrated into activities previously performed by the client; repair and maintenance of assets, and management of non-core operations for the client. This requires a front-office that implements these activities, and a back-office that provides technical support through workshops or mini-factories with certain design / re-engineering and manufacturing / re-manufacturing capabilities throughout life.

Case #4: Appliance maintenance and repair
This is an after-sales network firm with national coverage. The contact center is structured in two areas. The “front office” once contact is established for an incident, and the "back office" focused on providing coverage to the end user. This coverage is offered in three different areas: (1) Product information, marketing and services; (2) Coordination of visits to carry out a pre-diagnosis and / or to be able to offer a telephone solution without the need for future travel and; (3) Claims management. The contact center has a Special Customer Service (SCS) area, aimed at customers, not users. In this SCS it has two lines: (1) Monitoring of clients and incidents, and (2) Troubleshooting when the claim is tracked and closed once the endpoint of the problem has been reached. The firm has stepped forward from having a little capacity for personalization of the service, and the consequent management of customer expectations, to control the service from the system itself and to personalize for each client, all through the use of smartphones-tablets. Through an application the technician is provided with info about the type of repair to be made, whether or not the product is under warranty, the user's/customer's contact number, a detailed description of the provision of the service and the instructions for the technician. In turn, it also allows the management of spare parts and the repair or commissioning budget through an electronic invoice. This level of personalization of the service entails a “tailored” monetization.

The successful delivery of advanced services is enabled through smaller facilities (own, shared or third-party) located near the client's operations, e.g. through joint-ventures, network of distributors-marketers or local industrial services companies. In order to avoid problems arising from the multilocalization of facilities, Baines & Lightfoot (2013) highlight that it is advisable to have an important capacity and stock, as well as an adequate ICT infrastructure and the possibility of modular product designs, which make possible the personnel replace defective modules without performing on-site repair work. According to the authors, the staff can be differentiated into two profiles, the frontline (project managers, account managers and field engineers) directly interface with the client, and the support staff, who assist to frontline personnel and who have competences related to the back-office.

4.4 Financing of Advanced Services

There are cases in which the manufacturer keeps for itself the product's ownership, being also responsible of its maintenance, repair and control. This means that the customer gets the product's availability through different monetization mechanisms, e.g. renting, leasing, sharing or pooling (Ambroise et. al., 2018). But, producers who are at the same time providers must be aware of certain financial risks. According to Annarelli et. al. (2019: 161) *"expanding product and service offerings means exposing oneself to a great financial risk, which must be faced with adequate resources or by tightening closer relations with financial partners".*

Advanced services, in which the final customer does not buy the industrial product to be used, is a land normally unknown to industrial manufacturers. The figure of financial partner covers a very important space in this regard. Through models like leasing, in words of Annarelli et al. (2019: 75), *"*the offer becomes *more servitized: the customer pays for the use (…) and the ownership is maintained by the company, and there can be a shift of product ownership to the customer if (…) is fully payed, like for every leasing contract. This model usually involves a financial partner".*

The role of the financial partner is exemplified by Baines & Lightfoot (2013) in which there are 3 main roles: a manufacturer, a customer and a financial partner. In this case the financial partner is who buys the product and its real owner, hiring it to the customer, who pays a periodical fee. The manufacturer offers services linked to the maintenance and management of the product/equipment, for which the customer makes a periodic payment.

Case #5. Forklifts dealer
This firm supplies forklifts for warehouses and heavy-duty installation surfaces. The company considers itself as a solutions/services company and not a product company. As a result of the 2008 crisis, given the general problems of financing sourcing for their clients, the company designed a financial solution with DLL Group (Rabobank). Thus, through leasing activities, it offers its customers the possibility of having forklifts, both new and reconditioned. The key to this service lies in the flexibility regarding each type of client. In this sense, within the renting formula, the company offers different modalities. Their Fleet Manager Platform is based on sensors integrated in the trucks and IoT connectivity that allows receiving real-time data about the presence of a driver in the truck, the cooling temperature, the impacts received by the machine, the machine speed, battery status, transmission temperature, hydraulic temperature and pressure… Knowing all the time, for all their machine installed base, each machines' operational conditions and performance attributes. This service has a direct impact on the management of the workloads of people in the technical service. In this way, the company focuses on those issues that add value to the customer through SAT Online, Technicians located by GPS and Planning of the activities of technicians based on geographical proximity and customer needs. In this sense, it has moved from having negative margins in the Technical Assistance Service, to obtain margins close to 10%.

5. SERVITIZATION ROADMAP

Through the MONDRAGON Servitization CoP, the different drivers of the Servitization Transformation Process were further debated, using an action research approach, in order to identify and effective and efficient route for its deployment in manufacturing SMEs.

The servitization roadmap formulated covers, in phase 1, the strategic perspective, in phase 2, the tactical, and in phase 3 and 4 the operational ones.

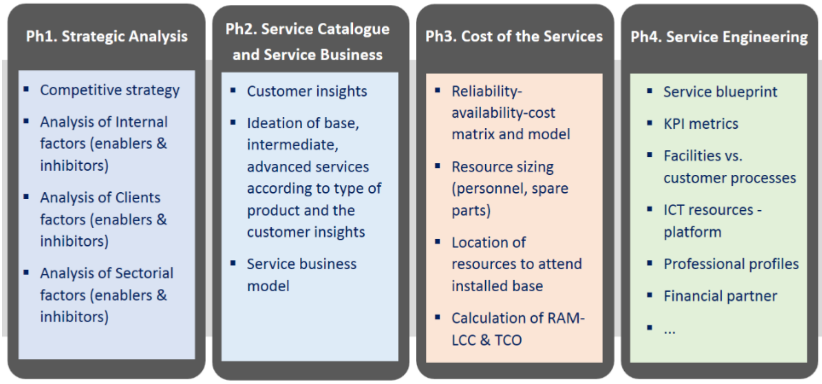

Figure 1. Servitization roadmap for manufacturing SMEs

Once the strategic decision to go forward is taken (i.e. Phase 1), the potential new service catalogue is defined, according to market-pull and technology-push criteria, as well as the corresponding business model(s) (i.e. Phase 2).

The launching of the new service catalogue to the market is sequenced starting with the base services (e.g. proactive selling of spare parts to the installed base), then the intermediate and finally the advanced ones. First calculating their corresponding costs (i.e. Phase 3), and later deploying the needed processes for serving them to the market (i.e. Phase 4).

The reasons identified for sequencing the launch of the services progressively are threefold:

1. Demonstrate to the product-driven manufacturing SME the value of the services (e.g. extended incomes with high margins…), its scalability and economic self-sustainability;
2. Progressively introduce the new service processes and roles without disturbing significantly the product-driven culture of the manufacturing firm, and;
3. Enrich the data base of how the machines are being used by the clients and their condition during their life cycle (e.g. reliability, availability, maintainability, energy consumption, performance over time…)

6. CONCLUSIONS

The manufacturing SMEs that have participated in this study compete in mature sectors (e.g. capital goods), thus having the need to differentiate themselves through the introduction of product-services systems in order to extend their incomes, make their turnover figures more resilient to the economic cycle and foster customer loyalty. Related to the theoretical implications, it is interesting to note that the customer's loyalty and the possibility to attract new customers, have motivated this SMEs to begin the service design and deployment processes (Brax, 2005; Grönroos & Helle, 2010), but the carried out strategies vary for each company.

Regarding practical implications, there is not a unique servitization pattern, neither situation, in MONDRAGON's manufacturing SMEs, but through the +30 case studies analysed and the 11 manufacturing firms involved in the Servitization CoP, it has been possible to identify common issues and drivers that have allowed the design of a generic Servitization Transformation Process and a widely accepted route for its deployment, i.e. Servitization Roadmap. Also, following the Servitization CoP, different projects have been activated in order to walk the way throughout the roadmap phases and activities. The SMEs involved manufacture different type of industrial products and are at different servitization maturity levels, thus looking ahead, there could be an interesting field of research devoted to the potential customization of the servitization roadmap according to such different backgrounds and products' typologies.

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AUTHORS

Dr. Eduardo Castellano Fernández
MIK Research Center
Oñati (20560). Spain
ecastellano@mondragon.edu

Prof. Urko Lopez Odriozola
Mondragon University Faculty of Business
Oñati (20560). Spain
ulopez@mondragon.edu

DIGITAL SERVITIZATION OF SMES: THE ROLE OF KNOWLEDGE-INTENSIVE BUSINESS SERVICES (KIBS)

Mario Rapaccini, Federico Adrodegari, Nicola Saccani, Cosimo Barbieri & Riccardo Giannetti

ABSTRACT
Purpose: The aim of the paper is to investigate the role played by KIBS firms in the digital servitization of SMEs.
Design/Methodology/Approach: The paper is based on a retrospective case-study of an Italian small manufacturing SME that undertook digital servitization, with the facilitation of a KIBS firm.
Findings: The paper shows how the firm developed a multi-stage approach and the knowledge stocks that were created by the interplay between the SME and the KIBS in the initial stage of their partnership.
Originality/Value: This study contributes to fill a gap in the literature, providing evidence on how small and medium-sized manufacturers can develop both digitization and servitization, and innovate their business model, fulfilling the knowledge gaps that previous literature had pointed out.

KEYWORDS: digital servitization, SME, KIBS, digitalization, industrial internet platform.

1. INTRODUCTION
The term servitization defines a strategy of a manufacturing firm that "*deliberately or in an emergent fashion introduces service elements in its business model*" (Brax & Visintin 2017). Previous research agrees that this move can bring remarkable benefits to any business (Baines et al. 2009). More recently, the focus of research has shifted on exploring the impact of digital breakthroughs- such as cloud computing, industrial internet, and predictive analytics (Ardolino et al. 2017), on servitization. Exploration of the interdependency between servitization and digitalisation has rapidly streamed out new research, namely "digital servitization", which is now of paramount importance for any business (Paschou et al. 2019). Thus, this paper focuses on digital servitization. This move can be especially crucial in the case of small and medium-sized firms (hereafter, SMEs), that are usually more vulnerable to competitive pressures (Man et al. 2002), although they play an important role in the world economy (Brunswicker & Vanhaverbeke 2015). It is said that the topic of servitization in SMEs is rather under-explored (Uden & Naaranoja 2009). Thus, this paper focuses on digital servitization in small and medium-sized firms. Due to their limited size and resources, SMEs recourse frequently to external partners to complement their knowledge and innovate their offerings (Rajala, Westerlund, & Rajala 2008; Franco & Haase 2015). It has been pointed out that Knowledge-Intensive Business Services (KIBS) firms (hereafter, simply KIBS) can have in this regard a notable role (Das & Teng 2000). KIBS are private organizations that provide services in the form of professional knowledge, consultancy, and technology, to professional and industrial customers (Miles 2005; den Hertog, Gallouj, & Segers 2011), and have been recognized as one of the most important carriers of change towards SMEs (Zhou et al. 2016). Despite this relevance, the literature on the interplay between KIBS firms and SMEs in the enablement of servitization and digital servitization is relatively scant. Thus, this paper aims at filling this gap. Specifically, this research presents findings from a retrospective case study, of a small manufacturer pursuing a digital servitization project.

The rest of the paper is organized as follows. Section 2 presents a short review of previous studies dealing with servitization, digital servitization of SMEs, and the role of KIBS firms. Section 3 illustrates the research methodology. Section 4 points out the findings from the case study, while Section 5 draws some considerations that contribute to the debate on the digital servitization of SMEs. The paper ends discussing in Section 6 the implications and limits of this study, as well as the avenues of future research.

2. BACKGROUND

2.1. Servitization and digital servitization of SMEs

Previous literature agrees on the fact that also small and medium-sized firms can successfully benefit from the competition based on services (Kowalkowski et al. 2013). This move can be stimulated by the erosion of product margins, the intensification of competition and the search for new ways of creating value (Michalik et al. 2019). However, numerous challenges have to be faced (Confente et al. 2015). In this paper, we focus in particular on challenges induced by knowledge gaps. It is said that SMEs lack the necessary knowledge for implementing a service business (Hsieh & Chou 2018). Service innovation and service management capabilities cannot be improvised or developed from scratch (Hernandez-Pardo et al. 2013). Designing, promoting, and selling services is different than with products (Coreynen et al. 2017). In other words, servitization requires capabilities that are not usually in the DNA of a small product-centric firm (Chalal et al. 2015; Teso & Walters 2016). It is said that to cope with these challenges, SMEs can adopt digital technologies (Coreynen et al. 2017; Hernández Pardo et al. 2012; Prindible & Petrick 2015). However, the research on the interdependency between servitization and digitalization is still scant, and particular – not linear – relationships could exist (Kohtamäki et al. 2020). In addition, digitalization could increase the knowledge gaps of SMEs. In fact, it is claimed that SMEs may lack managerial and technical competences, as well as resources that can manage digitalisation projects (Paschou et al., 2020). Digital servitization is mostly based on making the installed based smart and connected (Porter & Heppelman 2014). This may require expertise in informatics and electronics, that are not easily available in a product-centric SME (Peillon & Dubruc 2019). Other problems can derive from the lack of knowledge in designing the digital experiences of customers (Coreynen et al. 2017). As said, KIBS can play a crucial role in supporting the generation of new knowledge in SME, thus favouring the transformations connected to digital servitization. In the next section, we illustrate this concept.

2.2 How KIBS can facilitate servitization and digital servitization in SMEs

KIBS are private organizations that sell and deliver professional services to business customers, in the form of applied knowledge (Miles 2005; den Hertog, Gallouj, & Segers 2011). The definition is sufficiently broad to include different kinds of companies such as hardware and software vendors, consultancy and professional firms (e.g. lawyers, accountants, engineers) (Zhou et al. 2016). The literature discriminates two major classes, namely P-KIBS and T-KIBS (Miles et al. 1995). The first includes firms providing professional services such as management consulting, communication, legal and tax accounting, market research, quality certification. The second category includes firms that deliver outcomes in the form of technical expertise as well as proprietary or third-party technologies (e.g. software houses, R&D and product design firms). It is claimed that P-KIBS delivers more personalised solutions, and tailored to address customer's specific needs. Conversely, T-KIBS generates value through prearranged service packages (Consoli & Hortelano 2010). Irrespective of their kind, it is recognized that KIBS firms have remarkable impacts on SMEs' innovation (Doloreux & Shearmur 2012). In fact, KIBS facilitate the generation of new knowledge (Wagner, Hoisl, & Thoma 2014), in the form of explicit or tacit knowledge (den Hertog 2000). It is then of paramount importance to explore the mechanisms of knowledge generation in the intercourse between SMEs and KIBS, that are partnered to pursue digital servitization. This paper addresses this issue with a retrospective single case research.

3. RESEARCH METHODOLOGY

Theory building in its early stage can greatly benefit from case study research (Voss, Tsikriktsis & Frohlich 2002). We defined the following criteria to select the case study company: 1) the case should consist in a small manufacturer in the course of digital servitization; 2) the knowledge gaps of this manufacturer should have been accelerated by the collaboration with a KIBS firm; 3) any attempts to cope with the challenges induced by the service transformation should have been observable concerning the mentioned partnership; 4) the relationship between the SME and the KIBS should have been established since a given amount of time, to allow for retrospective investigation; and 5) data and information should be easily disclosed to the researchers. We selected purposively a manufacturing company that complies with the mentioned criteria. This company was fully committed to pursuing digital servitization based on an industrial internet platform provided by a software company that was playing the role of KIBS in this project. For confidentiality reasons, in the rest of the paper, the manufacturer is named ALPHA, and with BETA we refer to the software company.

4. CASE FINDINGS

ALFA is a small-size Italian manufacturing company (around 6 millions of Euros of revenues and 30 employees), producing technical gas (e.g. hydrogen, nitrogen and zero/dry air) generators. It is a relatively recent company, founded 30 years ago, whose business has reached a relatively steady state, showing less than yearly 2% of revenue growth in the last three fiscal years. ALFA products are sold to customers operating in the food and beverage industry, in laser cutting and analytical applications (e.g. gas chromatography). Over the years, the company has built a good reputation: irrespective of its small size, it counts +20,000 installations in 30 different countries worldwide. Competitors are large multinational companies such as Atlascopco (+34,000 employees), Hitachi (+335,000 employees), and Parker (+57,000 employees), in addition to a few smaller German and Italian companies. There are also indirect competitors that produce and sell not the generators but the technical gases in cylinders, such as the giant Air Liquide (+66,000 employees).

The company had already in place typical pre and post-sales service offerings such as commissioning, maintenance contracts, warranty extensions, and quality certifications, but recently they started an ambitious project, concerning the company's size, to connect the installed base of generators to a digital platform, to collect data and sell digital services such as condition monitoring and remote assistance, remote control and optimization, etc. As said, we studied the interplay between ALFA and BETA in the course of the digital servitization and found that this initiative can be structured in different stages that spread over a multi-year roadmap. These stages are described in Figure 1 and shortly presented below.

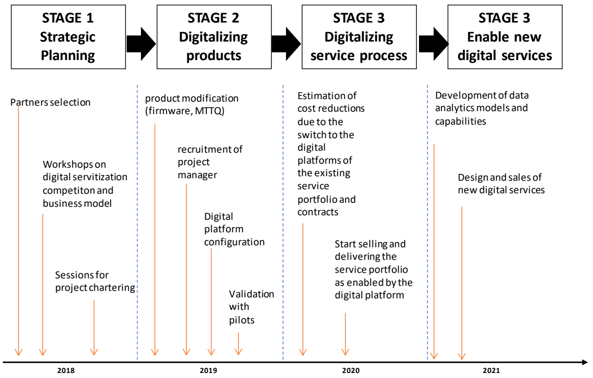

Figure 1 - Digital servitization approach

4.1. Stage 1. Strategic planning

This stage was finalized by identifying the partner. The case study pointed out how the commitment of the company leader was key to this stage. He envisioned great opportunities from digital servitization. Being aware that the company did not have adequate resources internally, the need arose to select external partners that, at reasonable costs, could facilitate this transformation. The encounter between ALFA and BETA resulted from a workshop organized by the local digital innovation hub for SMEs, in which BETA had the opportunity of presenting its industrial internet platform and approach to digital servitization. This was considered consistent with the objectives of ALPHA. The alignment of strategic objectives between the two parties at this stage was considered crucial and was obtained through the organization of some brainstorming sessions. The purpose of these sessions was twofold. First, the concept of a new business model was jointly elaborated by the managers of ALFA and BETA. It was recognized that there could have been remarkable opportunities to generate new revenue streams from the sale of advanced services. Second, previous experience of the KIBS was used to illustrate that a digital servitization pathway could have shown some pitfalls. Therefore, it was agreed that the digital platform should have been initially leveraged to improve the delivery of the actual portfolio of services, and then to enable the new ones.

4.2. Stage 2. Digitalizing products

This stage was purposed to adapt the electronics and control systems of new generators, to connect them to the ALFA4YOU platform and enable data exchange. Standard protocols (e.g. MQTT) were used to communicate data to external gateways and then to the industrial internet platform. Finally, some anchor clients with whom the subsequent pilot testing could have been carried out were selected.

4.3. Stage 3. Digitalizing the service process

After the commercial launch of the platform, a campaign to promote this solution was started. At the same time, an analysis to understand the impact on the actual costs of the digital service delivery process was elaborated. For example, it was estimated the potential savings that could have been achieved due to the notification about the equipment status coming from connected machines. Given the estimated savings, some commercial proposals were launched to the products' owners, such as extending the warranty coverage or the duration of full-service contracts. These experiments were are purposed to shed light on the sustainability of the digital business.

4.4. Stage 4. Enable new digital services

The objective of this last stage is clearly to extend the product-service portfolio with new advanced services, totally enabled by the digital platform. Although an early exercise, the development of equipment-as-a-service and outcome-based contracts is under consideration. But before advancing to this stage, the company manager wants to accurately assess all the implications in terms of financial and operational risks, costs and benefits.

5. CONSIDERATIONS

Partnering with a KIBS can be notably crucial for a SME undergoing digital servitization. In particular, the partner should provide the SME with both the technologies (i.e. the industrial internet platform) as well as with consultancy, advice, customer support and training. Having the capabilities of jointly acting as a T-KIBS and a P-KIBS could then make a difference. These projects require long term orientation, strategic vision, and strategic planning. The KIBS firms, with its experience, can play a crucial role also in this respect. The knowledge gaps that typically affect the SMEs can be better-fulfilled thanks to the interplay between the SMEs and the KIBS. In particular, the interviews showed that BETA has contributed to generate new knowledge, which has remarkably complemented the knowledge of ALFA. We believe that this new knowledge was generated in combination (i.e. complementary knowledge), from the interplay between ALFA and BETA. In particular, in the initial stage, ALFA provided knowledge about market opportunities, customers' needs, and competitors' moves. This was combined with the knowledge provided by BETA, which regarded the approach to digital servitization. At the very beginning of the project, this knowledge was presumably available tacitly. As far as the project advanced to the second stage, other needs emerged. In particular, ALFA was requested to upgrade the generators and make them compatible with the communication protocols required by the digital platform. Lacking the corresponding skills of design and development of electronics and embedded software, ALFA was helped by the KIBS. In this case. however, the knowledge was mostly provided by BETA, based on technical documents, standards, and specifications, i.e. in the form of explicit knowledge.

6.CONCLUSIONS

This study sheds light on the interplay between a KIBS and a SME pursuing digital servitization. The retrospective case study investigated how new knowledge stocks and insights were generated. We also discriminate between tacit and explicit knowledge, and on the knowledge stocks that are complemented by the interplay, rather than supplemented by the KIBS to overcome the SMEs knowledge gaps. This research focuses in particular on the first stages of this intercourse. The main contribution regards the multi-stage approaches, that we think can be valid in general. Limitations are related to the information that comes from a single case study. Our findings should be thus complemented and confronted with other studies. This is an avenue for future research.

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AUTHORS

Mario Rapaccini and Cosimo Barbieri
Department of Industrial Engineering
University of Florence, Firenze, Italy
+mario.rapaccini@unifi.it

Riccardo Giannetti
Department of Economics and Management
University of Pisa, Pisa, Italy
riccardo.giannetti@unipi.it

Nicola Saccani and Federico Adrodegari
Dept. of Mechanical and Industrial Engineering
University of Brescia, Brescia, Italy
federico.adrodegari@unibs.it

SMART SERVICE PATTERNS FOR SMALL MANUFACTURING ENTERPRISES

Jürg Meierhofer, Martin Dobler, Klaus Frick & Lukas Schweiger

ABSTRACT

Purpose:

This paper provides patterns for developing smart services for SMEs which are at an early stage of their development towards data-driven servitization.

Design/Methodology/Approach:

Based on a field study analysing the hurdles of SMEs regarding the introduction of smart services as a start of the transformation towards servitization, viable and desirable approaches were elaborated in a multiple case study including rapid prototyping.

Findings:

These patterns are well suited to demonstrate the business benefit of smart services while providing evidence that the underlying complexity is sufficiently low for the implementation by SMEs with adequate effort.

Originality/Value:

The study described in this paper provides a set of patterns that complements the existing theory in terms of delivering viable servitization procedures for manufacturing SMEs. They serve as blueprints for small enterprises to overcome the entry hurdle for servitization. SMEs are equipped with blueprints and tools to help them enter the field of smart services and create value for themselves and their customers.

KEYWORDS: Servitization, Smart Services, SMEs, Rapid Service Prototyping, Data Science.

1. INTRODUCTION: SMART SERVICES IN MANUFACTURING

1.1 The Relevance of Data for Providing Industrial Services

The transition from products to services is considered essential in general and specifically for small and medium-sized enterprises (SMEs). On the transition from products to services, the focus moves from the concept of “Goods-Dominant Logic” (GDL) to “Service-Dominant Logic” (SDL). In SDL, service is considered the fundamental purpose of economic exchange (Vargo & Lusch, 2008). It is provided in networks of actors, which are called “manufacturing service ecosystems” (Opresnik & Taisch, 2015). The concept of industrial companies as service providers has emerged (Lay, 2014). The value creation is moved from the manufacturer processes to the co-creation between the manufacturer and the customer (Vargo & Lusch, 2008).

The literature provides a classification of industrial services based on the value provided to the customer, who is guaranteed either an input or some output performance ((Kowalkowski & Ulaga, 2017; Ulaga & Reinartz, 2011)). Examples for input-oriented services are the installation of new equipment, maintenance, repair or spare parts delivery. When the provider moves to new service models around his products, these services are complemented or replaced by output-oriented ones, such as, for example, condition monitoring, predictive maintenance, or performance optimisation. New service models that focus on output performance are also referred to as “advanced services” (Lightfoot et al., 2013). For advanced services, assessing and quantifying the fluctuations and risks inherent to the output performance as well as to the production costs for achieving this performance becomes a key capability for a provider. Managing and analysing data for the development and the provision of services becomes a critical challenge with the increasing degree of servitization of manufacturing and the move to advanced services.

It is challenging for SMEs to successfully adopt the concepts of servitization of manufacturing. This is because many of the concepts and approaches of servitization have been designed for larger companies (Hewitt-Dundas, 2006). It is considerably more demanding for SMEs to develop the necessary resources in the area of data capabilities for services (Neely, 2008). According to (Meierhofer et al., 2019), SMEs lag behind corporates in particular with respect to the so-called “soft factors” such as lack of knowledge and feeling of urgency, or an unclear vision how to use data for their services. The study shows that more than half of the SMEs use data for improving their cost efficiency and not for new customer value propositions. Additionally, when data science tools are applied by SMEs, these are mainly business intelligence (BI) instead of advanced analytics tools. However, it is reported in this study that the SMEs expect that they need to significantly leverage data for new services within the next five years and that they need to find ways to enter this domain. The lack of consideration of servitization research in the SME area is discussed in (Kowalkowski et al., 2015).

Related to this lack of knowledge and skills, there are specific hurdles that SMEs need to overcome, in particular (Meierhofer et al., 2019): 1) technical skills and tools for acquiring and managing data and its analysis for the development and the provision of advanced services and 2) mastering service design-oriented processes and methodologies for the customer-centred development of data-driven services. These hurdles are further intensified by the fact that the literature provides methods for customer-centred service design primarily in the B2C (business to consumer) segment, which cannot be directly transferred and applied to the manufacturing B2B (business to business) segment.

The key question of this paper is: how can SMEs overcome the chicken-and-egg situation in which they do not want to invest in the new capabilities until the benefit of the data-driven services can be estimated, which is usually not quantifiable before implementing them.

1.2 Value Creation by Smart Services in Manufacturing SMEs

The literature refers to the concepts of “smart services” or “smart products”, where value is created for a specific external or internal user or customer (i.e., an actor). In the concept of service design and service dominant logic, value may not only be functional or financial, but also emotional or social, for instance (Sheth et al., 1991). In the concepts around the term of “smart factory” increasing efficiency or quality is of primary relevance. However, if there is a factory-internal human beneficiary of the data-driven service, we can interpret this as an internal smart service in the context of the smart factory. In (Thoben et al., 2017) the terms “smart manufacturing” and “smart factory” are defined and references for analytics in smart manufacturing are provided. In (Weimer et al., 2016) analytics algorithms that can be used in smart manufacturing are discussed.

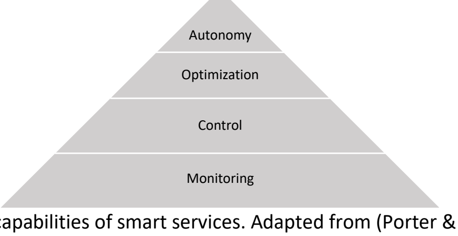

Figure 1: Hierarchy of capabilities of smart services. Adapted from (Porter & Heppelmann, 2014).

(Porter & Heppelmann, 2014) introduce a hierarchy of capabilities with smart services, which helps to discuss value creation in relation to SDL (Figure 1). By implementing these steps, value is created with intelligent services and products by: 1) Monitoring 2) Control 3) Optimization and 4) Autonomy. An example of 1) is the condition monitoring of machines. The service provider can remotely observe the condition of the machine running at the customer's site ("remote monitoring"). On level 2), feedback is established to control the machine based on the results of the monitoring. This can lead, for example, to operating parameters being adjusted to improve the

condition of the machine. The optimization used at level 3) pursues a goal such as, e.g., energy consumption or number of units produced per time. Autonomous systems at level 4) would be completely self-organized factories, which is still rare today.
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2. RESEARCH METHODOLOGY

The empirical part of this study was underpinned by a preceding literature review about the specific situation and needs of SMEs related to implementing data-driven services as summarized in section 1. In particular, based on the insights of the previous study reported in (Meierhofer et al., 2019), this analysis revealed a specific challenge of SMEs in creating a need for action to develop data-driven services and – related to this – in estimating what a potential benefit could be related to the investment hurdle for solving the chicken-and-egg problem mentioned before.

Therefore, for this study, a multiple case study approach with in-depth assessments of a sample of five manufacturing SMEs and additionally three SME-like departments of mid to large size enterprises was chosen. To address the SME specific hurdles, the study started with identifying the relevant actors. This was typically the factory manager, who is responsible for creating the customer value with the production facilities. The jobs to be done and pains of these actors were then analysed by service design approaches, in particular by contextual in-depth interviews or observations of the job being conducted by the actors. This resulted in typical profiles of the actors – so-called actor personas. Additionally, typical patterns of data of the installed base or of individual machines were assessed.

Given this, sketches for value propositions were elaborated in the form of rapid prototypes in the form of mock-ups. These were presented to the actors and evaluated whether they could help getting the jobs done and overcoming the pains. Based on the feedback from the actors, the rapid prototypes were refined or adapted. In the service design approach, these iterations should be repeated until saturation is reached, i.e., the value propositions sufficiently supports the jobs. However, the optimization of these design research cycles is not in the core interest of this study. It rather intends to demonstrate the feasibility of data-driven support for providing these value propositions.

Therefore, the rapid prototypes which resulted in sufficient value creation for the actors were further enhanced by integrating data and analytics – depending on the case based on real or synthetic data or on simplified evaluation schemes. The resulting rapid service prototypes were examined for characteristic patterns in the following dimensions: 1) Which job does the service support? 2) Which pain of the actor is relieved? 3) Which level of the hierarchy of capabilities (Figure 1) is reached? Typical dashboards or user interfaces were developed.

Additionally, a focus was put on achieving the data analytics tasks by simple off-the-shelve tools – in the case of the prototypes building on open source code. This was considering that SMEs in this early adoption phase of smart services do not strive for achieving analytics results that are close to the theoretical optimum, but rather intend to make first steps at reasonable costs.

3. FINDINGS: NEW SERVICE PATTERNS

3.1 Typical Jobs and Pains in Manufacturing SME Environments

Based on the design-oriented analysis of the jobs and pains of the actors in the manufacturing SMEs, their typical profile could be described as shown in Figure 2 in the form of a so-called actor persona description. The typical profile of the factory manager, whose job is to keep the machines up and running in order to provide and improve the service for the customers of the SME, features pains like unplanned machine break downs and insufficient information for maintaining the machines.

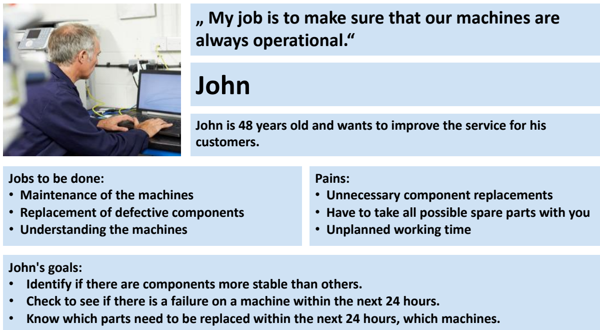

Figure 2: Profile of the SME factory manager related to the service needs.

A typical statement was: “When I come to the factory in the morning, all I want to know is whether the machines were ok overnight, how they are doing right now and how they will do in the coming hours”.

3.2 Use cases and Patterns of Smart Services in SME practice

In the course of the project, the possibilities of developing solution approaches were discussed in exchange with the SMEs. In co-creation mode, user jobs and pains as well as customer journeys were analysed and possible service concepts were developed, which in some cases went as far as the development of small concept prototypes with real or synthetic data, which was occasionally used if the available real data was not sufficient in terms of quality or quantity for prototypical model creation. This resulted in the four types of service concepts described below. Example dashboards for these four service concept types are shown in Figure 3.

<u>Service concept type 1: Retrospective visualization and monitoring of the operating status of the shop floor</u>

1) The aim of this type of service is to make the performance and condition of shop floor transparent for the factory manager and thus to foster the operational competencies.
2) Typical pains of factory managers such as "Not having an overview of important production metrics without much effort" or "Too complicated to know what is going on the shop floor" can be covered.
3) In the hierarchy shown in Figure 1, this service is at the "Monitoring" level.

Testing with the actors has shown that the simplest possible dashboards have proven their worth, where users can immediately see the status of the various machines at a glance – even in sometimes suboptimal environment conditions in the shop floor, like, e.g., diffuse light, noise, wearing gloves etc. (Figure 3).

<u>Service concept type 2: Improvement of production output through insight into machine behaviour metrics</u>

1) Service type 2 is about enabling an operator to better understand and adjust his machines so that better performance is achieved, e.g., depending on the resources used. It is primarily about improving performance by changing the settings on the machines, which can lead to optimisation in the final configuration.
2) Typical pains of production managers such as "Not being able to observe and improve effort, time, resource requirements and performance in production" or "Not knowing how to derive better planning values" are covered by this service.
3) In the hierarchy shown in Figure 1, this service is located between the "Control" or "Optimization" levels.

The practical testing has shown that also here dashboards that are as simple as possible have proven their worth in this respect, allowing users to observe the performance of their machine in relation to the settings. In this way, they develop an understanding of the dependence of production performance on the settings and can improve this over time (Figure 3).

<u>Service Concept Type 3: Predictive Condition Monitoring</u>

1) Service type 3 is about predicting whether the condition of individual machines will deteriorate with a lead time appropriate to the available data at controllable complexity. This puts the operator in a position to prepare for potential failures, e.g., by making resources available for maintenance as a precaution or by dealing with the fault. Note that this can be considered a first step towards approaching predictive maintenance services.
2) Typical needs of production managers such as "Increasing business continuity by reducing downtime or downtime reduction", "Avoiding operational hectic and stress situations”, or “Becoming less reactive and therefore proactive" can be covered.
3) In the hierarchy shown in Figure 1, this service is located between the "Control" or "Optimization" levels.

Again, dashboards that are as simple as possible have proven their worth, in which the users can see from a simple traffic light system whether a machine is likely to fail ("red") or not ("green") in the next few hours (Figure 3).

<u>Service concept type 4: Process instruction / decision support for manual activities</u>

1) Service type 4 is concerned with supporting employees in the execution of manual activities, especially at decision points in machine operation, by means of instructions. This makes it possible to standardize manual processes or to balance out a heterogeneous level of knowledge among employees, thus improving machine operation as a whole.
2) Typical needs of production managers such as "Increase of operational excellence through standardization of process sequences" or "Reduction of dependency on the know-how of individual employees" can be covered by this service.
3) In the hierarchy shown in Figure 1, this service is located at the "Control" or "Optimization" levels.

The practical survey has shown that the simplest possible dashboards have proven to be extremely valuable, in which users receive simple work instructions depending on the current status and context of a machine (Figure 3).

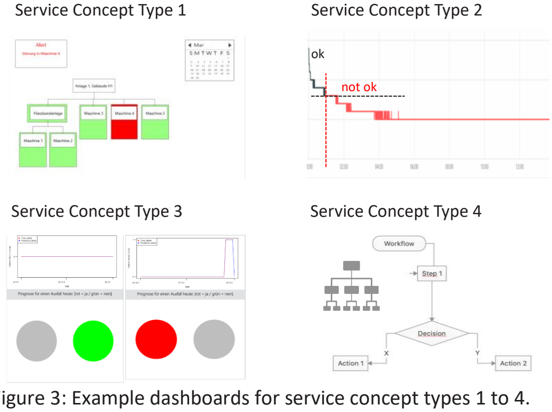

Figure 3: Example dashboards for service concept types 1 to 4.

4. PROCEDURES FOR SMES TO START WITH SMART SERVICES

SMEs that decide to take the step towards novel smart services should base their development on a clear understanding of customer needs. According to the detailed approach described in the procedure, the following steps should be taken:

1. Who should potentially benefit from the service? In particular: for which individuals should the service be of use? These can be individuals in the own company (e.g. own service technicians or operators) or corresponding roles at the customer.
2. Which service needs does this person have and can these needs be met? In practice, the methods of value proposition design have proven to be very useful for this purpose, in which the needs are described using the terms jobs (customer tasks) and pains (customer problem points while completing this task). A possible value proposition is described accordingly.
3. On this basis, the possibility is examined whether the service can be realized with the help of data and analytics. A prerequisite for this is the availability of data, e.g. measurement data from machines or processes. For an initial pilot, this data can also be collected manually. If this pilot phase shows that the service will provide a clear benefit for the actor, then systematic data acquisition can be planned and implemented, which usually leads to a project specifically designed for this purpose.
4. For a first development of a specific service providing a tangible benefit to the actor, it is recommended to look at the four types of service concepts described in this paper. This may give rise to ideas for initial value propositions, which can of course be adapted to the specific situation and further developed.

5. PROVEN TECHNOLOGICAL PROTOTYPING APPROACHES

Low complexity but full functioning prototypes combine preliminary algorithms and data pipelining in the backend and a rudimentary graphical interface in the frontend. This gives rise to the following requirements for the development platforms:

1. The prototypes for the service patterns are built on standard tools that are available off-the-shelve, have good community support and whenever possible are distributed as open source.
2. IIoT protocols such as TCP/IP, MQTT, REST or OPC-UA are implemented such that a data bypass or retrofits (“brownfield machinery”) can be realized on the shop floor.
3. The platform can manage automated pipelines to clean and pre-process data.
4. There exists a rich collection of boiler-plate code for data visualization (bar-, box- and pie plots, time series, scatterplots, etc).
5. Standard modelling capabilities (linear or logistic regression, k-nearest neighbors, PCA, etc.) are available.

Well known candidates for suitable platforms are the R and Python programming languages. Aside to satisfying the above requirements that guarantee the backend capabilities, these languages provide simple yet powerful extensions for creating graphical interfaces. Above all the web-based solutions Shiny (for R) and Django (Python) should be mentioned.

For the infrastructure of service provision, cloud-based development tools can be used to deploy prototypes and systems which are considered as release candidates. Well-tested and widely adopted (open-source) tools for a range of settings exist, namely graphical representation of (optimised) data sets, real-time manufacturing data, optimisation and handling of said data sets and the provision of exchange formats. Among the most well-known tools for the provision of data science prototypes are Jupyter or Apache Zeppelin notebooks, mostly in combination with data driven programming languages such as Python or R. Commercial alternatives are also available, most notably RStudio IDE and IBM Watson Studio. Solutions for providing dashboards include Seal Report, Freeboard or Dashbuilder. Among cloud-based commercial offerings, solutions like Google’s Data Studio can provide quick results and local technical start-ups provide specialised dashboards (e.g. Sensforce’s

SFMANAGE for Industry 4.0 enabled use cases). Data exchange can happen with established technologies such as REST APIs or data provision tools / distributed databases for divide-and-conquer algorithms like Apache Hadoop/Hbase or Cassandra.

6. DISCUSSION AND FURTHER DEVELOPMENT

This study reveals how adequately developed rapid service prototypes represent a pragmatic and effective way for the SMEs to overcome their specific initial hurdles, i.e., to solve the chicken-and-egg problem mentioned before. The results show how the prototypes can demonstrate and visualize the service benefits in an adequate way while providing evidence that their implementation effort is reasonably low. This is possible, in particular, if adequate data science methodologies are applied – while being aware that they may not achieve the theoretical optimum performance. The segment of the SMEs in the focus of this study are interested in making a step towards data-driven servitization with reasonable effort, but not in getting close to the absolute performance optimum at any cost. A systematic set of service patterns were identified and described that enable the SMEs to reach this goal. The study described in this paper provides a set of patterns that complements the existing theory in terms of delivering viable servitization procedures for manufacturing SMEs. They serve as blueprints for small enterprises to overcome the entry hurdle and to unblock the chicken-and-egg situation described. SMEs are equipped with templates and tools to help them enter the field of smart services and create value for themselves and their customers. Additionally, proven technological approaches for this first prototyping are discussed both in the domain of algorithms and of data management platforms and interfaces.

A follow-up project will enable the SMEs to overcome the initial hurdles in a broader, efficient and scalable way through a practical development toolbox. This will enable them to take a significant step forward in development. The overarching methodological approach will build on the basic principles of design thinking and will link these with the methods of data science. Using prepared use cases, the developers of the SMEs will iterate the phases of the user-centered design process alternating with data science steps and develop their own prototypes for smart services under guidance.

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AUTHORS

Jürg Meierhofer
Institute of Data Analysis and Process Design,
Zurich University of Applied Sciences,
CH-8401 Winterthur, Switzerland
juerg.meierhofer@zhaw.ch

Martin Dobler
Research Centre for Business Informatics
Vorarlberg University of Applied Sciences
AT-6850 Dornbirn, Austria
martin.dobler@fhv.at

Klaus Frick
Institute for Computational Engineering
Interstate University of Applied Sciences of Technology NTB
CH-9471 Buchs, Switzerland
Klaus.frick@ost.ch

Lukas Schweiger
Institute of Data Analysis and Process Design,
Zurich University of Applied Sciences,
CH-8401 Winterthur, Switzerland
Lukas.schweiger@zhaw.ch

A PARADOX THEORY APPROACH TO TENSIONS IN DIGITAL SERVITIZATION: THE CASE OF THE AEROSPACE AND MARITIME INDUSTRIES

Zsofia Toth, Christian Kowalkowski, Alexey Sklyar, David Sörhammar, Bård Tronvoll, Oliver Wirths

ABSTRACT
Purpose – The purpose of this paper is to explore tensions associated with digital servitization, both pertaining to business growth (intra-firm level) and supply chain development (inter-firm level). Specifically, the study relies upon paradox theory as a framework to identify paradoxical tensions.
Design/methodology/approach – Based on cases from aerospace and maritime industries, this qualitative study adopts an exploratory multiple-case study approach. The in-depth data were collected through 56 semi-structured interviews and multiple site visits.
Findings – Eight paradoxical tensions associated with digital servitization were identified. While these tensions are specific to digital servitization, some of them are rooted in 'traditional' servitization. The findings suggest that four of the identified tensions – such as the tension of platform-based coopetition – impact supply chain development. Interestingly, most tensions rooted in 'traditional' servitization – such as the tension of performance priorities – characteristically affect business growth.
Originality/value – By proposing a conceptualisation of paradoxical tensions for digital servitization, this research contributes to the literature on servitization and on operations and supply chain management. Specifically, the identified paradoxical tensions are categorised along the dimensions of two impact areas: business growth and supply chain development. The tensions are also reviewed as either rooted in 'traditional' servitization or as characteristically novel for digital servitization settings.

KEYWORDS – Digital servitization; servitization; tensions; paradox theory; digitalization; digital transformation.

1. INTRODUCTION
As firms are adapting to market changes by developing innovative offerings and reconfiguring their operations, tensions emerge in the organisation and across the supply chain. These tensions are often grounded in the strategic shift frequently referred to as *servitization*, in which manufacturing firms are increasingly competing through new combinations of industrial goods and services (Raddats *et al.*, 2016, Baines and Lightfoot, 2013). Today, servitization is largely enabled and driven by the opportunities of digital transformation; by equipping physical objects with sensors and connectivity, and analysing the data streams flowing from connected products, manufacturers can provide new complementary digital services (Bilgeri *et al.*, 2019). Merging the physical and digital worlds has become an emerging area within the servitization domain under the term *digital servitization*; defined as the utilisation of digital technologies for transformational processes from a product-centric to a service-centric business model (Coreynen *et al.*, 2017; Sklyar *et al.*, 2019). However, despite being a topic that is front and centre for firms, little theory exists to guide firm's actions in structuring operations for digital transformation (Zeithaml *et al.*, 2019). As Raddats *et al.* (2019) point out, increasing our knowledge about how firms successfully can manage digital servitization is a key research priority.

Responding to recent calls for more research on organisational tensions (Niesten and Stefan, 2019), this study seeks to unravel the complexities of digital servitization by examining tensions associated with business growth and supply chain development. Business growth-related occurrences typically

refer to intra-organisational matters, whereas supply chain development concerns the inter-organisational context (Powell, 2013).
Pressures for balancing change and stability create paradoxical tensions in organisational change processes (Lewis, 2000). Research on organisational change has benefited from applying a paradox theory approach (e.g. Abdallah *et al.*, 2011) because of its ability to study a variety of different contradictions. Previous applications include the change in organisational values and power relations, innovation contexts (Andriopoulos and Lewis, 2010), as well as servitization contexts such as tensions between aiming for efficiency and effectiveness (Kohtamäki *et al*., 2018). Hence, rather than just a general agreement on why manufacturers pursue digital servitization, we need a better understanding of how they can handle the paradoxical tensions inherent in the change process. To address this fundamental issue, we build on paradox theory to investigate two main research questions: *What are the paradoxical tensions that manufacturers face when pursuing digital servitization? How do paradoxical tensions differ across the impact areas of business growth and supply chain development?*

By identifying paradoxical tensions in digital servitization, we propose a conceptualisation of such tensions and thus contribute to the research on servitization and on operations and supply chain management. We categorise the identified tensions along the dichotomy of two impact areas—business growth and supply chain development—with the aim to provide an in-depth understanding into how tensions occur in digital servitization and how this affects the two impact areas.

2. LITERATURE REVIEW

2.1 Digital servitization

For decades, servitization of manufacturing has been facilitated by *digitization*, which is defined as "the conversion of analogue information in any form such as text, images, sound or physical attributes to a digital format" (Ng and Wakenshaw, 2017, p. 3). However, as Paschou *et al.* (2018) point out, digital technology alone is insufficient for creating new opportunities for value creation and capture. To bring about long-term competitive advantage through digital servitization, firms need to master *digitalization*, which involves the socio-technical processes that accompany digitization (Lusch and Nambisan, 2015). In digital servitization, an increasing portion of the coordination is digitally managed; digitally and non-digitally conveyed services have a different sense of tangibility, with the digital element often targeting the coordination of physical entities and thus the idea of ownership becomes subtler (Chowdhury and Akesson, 2011).

2.2 Tensions and a paradox theory approach

The shape and form of tensions are diverse. Tensions can culminate in conflicts, typically when actors perceive that other actors are compromising their goal attainment. Tensions can also remain at the level of verbal or nonverbal expressions of discomfort, or as latent tensions embedded in interactions (Smith and Lewis, 2011). Sources of tension might include the lack of homogeneity, for example in terms of occupational identities (Collinson, 2004), rivalry, and coopetition (Chen *et al.*, 2007). Other sources of tensions might concern new product and service development (Menguc and Auh, 2008), hybrid business models (Mitronen and Möller, 2003), and transitions in organisational structures (Spekman and Carraway, 2006). Tensions might also arise with the creation of contractual arrangements (Rese and Roemer, 2004), as well as due to differences across adopted technologies (Slater, 1993), organisational culture and orientation (Merrilees *et al.*, 2011).

2.3 Paradoxical tensions in servitization

Tensions in servitization research have been the focal point for only a few studies (e.g. Altmann and Linder, 2019; Burton *et al.*, 2016), whereas most of the extant research develops argumentation without an in-depth understanding of the tensions relevant to servitization. Although tensions can have a positive impact for some firms within the supply chain (such as an opportunity to replace a supply chain partner hindering its development), research has mainly considered the negative consequences. For example, Burton *et al.*'s (2016) find various types and sources of tensions that can undermine servitization efforts, mainly derived from challenged expertise, pressure to learn, cost-focused challenges, and actors' influence on the value chain. In turn, Turunen and Neely (2011) report tensions from servitization-driven task uncertainty and interdependency; similarly, Jovanovic *et al.* (2016) demonstrate that the attempt to manage direct and indirect sales separately can create major tensions in servitization. Also, platforms built for collaborative activities can be rife of tensions (Czakon & Czernek, 2016).

Compared to more traditional forms of servitization, digital servitization comes with additional challenges on how service operations of manufacturers can be improved and consequently the way relationships evolve in the supply chain. Applying paradox theory can be beneficial for studying digital servitization, as it allows multiple viewpoints of tensions and contradictions involved with actors' values, beliefs and strategies – both at business growth and supply chain development levels (Schad and Bansal, 2018). The scarcity of studies addressing tensions in digital servitization is striking. There is, however, a body of work on tensions surrounding technological innovation, where paradox theory has been applied (e.g. Jarvenpaa and Wernick, 2011; Srivastava and Gnyawali, 2011), which proves useful for studying the digital side of servitization. Beyond technological issues, organisational context in general has an inherent tension-filled nature and applying a paradox theory approach helps with gaining a more in-depth understanding on tension-handling strategies, outcomes, and the multiplicity of rationalities that trigger such tensions (Smith and Lewis, 2011).

3. METHODOLOGY

For an in-depth understanding of how tensions unfold through digital servitization and how this affects business growth and supply chain development, we apply a multiple case study approach. This approach allows investigating the phenomenon and theory-building (Meredith, 1998) through the formulation of conceptual contributions (Siggelkow, 2007). Case studies are appropriate for exploratory investigations, where a more substantial understanding on the studied phenomena is required (Voss *et al.*, 2002), and researchers are seeking to find answers for 'how?' and 'why?' questions (Yin, 2009). An exploratory approach was taken as a step toward developing a better understanding of the paradoxical tensions that emerge through digital servitization – a topic of which the surface has been scratched but requires more knowledge-base. To enable in-depth insights, a multiple-case study approach was herein preferred over a single-case study (Yin, 2009). Methodologically, we applied an abductive approach with systematic combining (Dubois and Gadde, 2002), which enabled us to develop the initial theoretical framework through matching the empirical evidence of the study to relevant literature.

In order to capture different patterns pertaining to tensions and to deepen contextual understanding (Yin, 2009), firms in the aerospace and maritime industries were approached. For the data collection phase, a two-step sampling procedure was implemented by first using firmographics (i.e. type of industry and firm size), and secondly, identifying key informants within the chosen firms (i.e. based on relevant experience, influence, and position). The aerospace and maritime industries were chosen for the empirical investigation because both are under similar institutional pressures. These are well-established industries with a few dominant players, and stable supply chains with potential technological lock-ins. In such traditional contexts, tensions may become more apparent compared to more turbulent industries with different dynamics.

Data was collected through semi-structured in-depth interviews as well as during site visits, including attendance at group meetings and internal workshops. Firms are based in Western Europe with multinational customers and suppliers. University guidelines were followed to ensure ethical data management practices and that the identities of the managers and firms remained confidential. Gaining multiple perspectives for each firm was important for consistency between managerial perceptions. There was a total of five site visits in the maritime case and 10 site visits in the aerospace case, combined with 36 and 20 interviews respectively. The respondents had a thorough understanding of digital servitization strategies and practices at their respective firm. Interviews normally lasted between 60 and 120 minutes (see Appendix for more details), were audio-taped and transcribed. Secondary sources such as corporate websites, financial reports, and internal materials were also consulted to strengthen the validity of our findings.

The data analysis was based on interview transcripts and detailed write-ups about each firm and supply chain context. The transcribed interviews were coded by three members of the research team but were discussed with the rest of the team. The research team used these documents collaboratively to identify paradoxical tensions for each case. The managerial perspective provided the units of observation, and the units of analysis were the maritime/aerospace firms. Data were summarised by constructing overarching themes and identifying patterns across interviews and write-ups (Raja *et al.*, 2018).

4. RESULTS AND ANALYSIS

4.1 Paradoxical tensions of organising

Digitally enabled control. This tension mainly concerns the issue of centralisation versus decentralisation, and it occurred at both the maritime and aerospace firms while implementing strategic initiatives on digital servitization. Resistance towards the transformation appeared across hierarchical levels, and to overcome such resistance, managers behind the transformation initiated large-scale measures – enabled by novel digital tools – to increase control by centralising the firm's organisational structure. For example, in the maritime case, local country-level units had traditionally exerted considerable power and independence in terms of both strategic and operational decision-making. However, the digital servitization initiatives reduced the units' power and independence, which created local resistance. Aided by digital tools such as a support case management system ("ticket management system"), centralised units were able to receive access to the information that had previously only been available at the local level. Interestingly, the next step of the transformation involved returning some control to the local units in order to enhance customer relationships and improve local presence (for example, due to the shipbuilding industry relocating from Europe to Asia). At the same time, centralised control was maintained through the creation of several digital operations centres that provided central units with direct access to customers and their vessels.

Platform-based coopetition. This tension mainly concerns the issue of platform membership versus platform non-membership. We follow the definition of Loux et al. (2020) on platforms and see them as ecosystems that provide a specific alignment structure to address the need for coordination among the actors. Membership in the platform is defined based on the firm's access the network and alignment structure associated with the platform. Engagement through platforms can take various forms, such as orchestrating, facilitating and stimulating (Blasco-Arcas et al., 2020). In the aerospace supply chain, original equipment manufacturers supported maintenance, repair, and overhaul providers with licenses, tools, and intellectual property to operate as part of its licensed network. However, the manufacturers and service providers also competed for the end customers' service contracts, which created tensions around data sharing. Increased data availability demonstrated the potential to improve competitiveness of the supply chain, at the expense of the relative competitiveness of individual data-sharing parties. On the one hand, manufacturers utilised data to improve the reliability and future generations of their aircraft and engines. On the other hand, manufacturers were also developing predictive digital services, thus potentially lowering maintenance costs and improving aircraft reliability. To offer these digital services, original equipment manufacturers claimed ownership of the data and required airlines to upload it onto the manufacturer's platform. Many airlines and maintenance, repair, and overhaul providers feared that sharing data would be equal to both losing data ownership and increasing dependence on the manufacturers. As a result, some airlines in turn claimed ownership of the data generated by their assets, although data-sharing was deemed necessary to benefit from digital services.

4.2 Paradoxical tensions of learning

Information superabundance. This tension mainly concerns the issue of being uninformed versus being over-informed. The amount of generated information, depending on its nature and use, was often described as "a blessing and a curse" from both the airline and maritime industry. The maritime customers would initially receive very detailed information, which typically included fault details of the focal firm's equipment. The result was a decline in customers' quality perceptions of the firm's offerings, which led the focal firm to stop displaying all of the details to its customers. There were also concerns that the need for some existing services (or even for the service provider) might disappear if customers receive all the available information.

Digital upkeep. This tension mainly concerns updating, upgrading and maintaining IT systems and software, and thus whether digital upkeep is necessary or unnecessary. Maritime customers appeared to 'take it for granted' that IT systems enabling digitally conveyed services would be maintained and upgraded by the provider, which was deemed critical for both ensuring uninterrupted operations and addressing potential cyber security issues. Despite its crucial role, maintaining such systems was associated with certain tensions.

4.3 Paradoxical tensions of belonging

Organisational identity shift. This tension mainly concerns the issue of approving others' digital solutions versus developing their own digital solutions. The roles firms take due to digital servitization press them to reflect on organisational identities. For instance, classification societies in the maritime industry traditionally had a strong position with a 'clear role' – to approve third-party industrial products and services for the maritime market (e.g., in relation to safety).

In the aerospace case, aviation authorities such as the US Federal Aviation Administration and the European Aviation Safety Agency are responsible for certifying firms that design, manufacture, operate and maintain aircraft. For authorities and aerospace firms, passenger safety is paramount, which leads to strict and complex maintenance regulations that need to be fulfilled (e.g., parts are exchanged after a certain life limit as a preventive measure to avoid failure).

Professional identity shift. This tension mainly concerns the issue of traditional versus innovative professional values that arose primarily from the maritime case. Captains traditionally exerted considerable power over vessels and planes under their command. However, the situation changed due to digital servitization. For example, maritime digital services such as GPS-based navigational advice initially aimed at reducing fuel consumption, that later also allowed operation centres to track vessel positions.

4.4 Paradoxical tensions of performing

Performance priorities. This tension mainly concerns the issue of financial versus innovation performance. Technology investments required for servitization led to a consolidation in the aerospace maintenance, repair, and overhaul market. Through digitalization and thereby digital servitization, the market consolidation was fuelled even further as it required large investments to build digitally enhanced service capabilities. Our findings suggest that only original equipment manufacturers and the largest maintenance, repair, and overhaul providers were able to attract a sufficient number of customers and leverage economies of scale to build digital solutions. This consolidation process led to inherent tensions through shifts in the power balance.

Data utilisation. This tension mainly concerns the issue of data ownership versus giving away data. Despite signing long-term service contracts, until recently customers in the maritime industry had not been requesting ownership of their data. The issue of data ownership became increasingly important, with customers starting to insist that they should own the data. This situation could potentially slow down the technological progress with digitally conveyed services, and even prevent providers from offering the currently available services (e.g., applying advanced algorithms to derive business-critical information from the raw data).

4.5 Paradoxical tensions across the impact areas

To further improve our understanding of the identified eight paradoxical tensions, we can categorise them along the two impact areas: business growth and supply chain development, which allows capturing dynamics at the firm level and beyond (e.g., Powell, 2013). To this end, we again apply the theoretical background of the four overarching paradoxical tension categories of Smith and Lewis (2011): organising, learning, belonging, and performing. Our findings from the aerospace and maritime cases suggest a balance across the two impact areas in digital servitization, specifically, four identified tensions have more effect on business growth while the remaining four tensions have more impact on the supply chain development.

The first column of Table 1 outlines the explored tensions that impact business growth in digital servitization. Under this category, the tensions concern issues of digitally enabled control, digital upkeep, professional identity shift, and performance priorities for digital servitization. The second column depicts the impact on supply chain development in digital servitization. Under this category, the tensions relate to issues of platform-based coopetition (i.e., competition and cooperation facilitated by platforms), information superabundance, organisational identity shift, and data utilisation. Importantly, the tensions assigned to either impact area are not mutually exclusive. For instance, while platform-based coopetition typically incites tensions within the supply chain, there are also indirect effects on business growth from the focal firm's perspective. Overall, the offered categorisation allows a more in-depth examination of the identified tensions in digital servitization, as well as suggesting the dimensions for categorising any additional tensions.

Table 1. Paradoxical tension categories and their impact areas in digital servitization

		Impact areas in digital servitization	
		Business growth	*Supply chain development*
Paradoxical tension categories	*Organising*	Digitally enabled control	Platform-based coopetition
	Learning	Digital upkeep	Information superabundance
	Belonging	Professional identity shift	Organisational identity shift
	Performing	Performance priorities	Data utilisation

5. DISCUSSION

By investigating two cases, the aerospace and maritime industries, this study takes an exploratory view on paradoxical tensions associated with digital servitization. Despite the capacity of unmanaged tensions to hinder the latter, the extant servitization literature has largely ignored such an important issue. To address this research gap, our study introduces a conceptualisation of paradoxical tensions for digital servitization. In Table 1 we categorised eight identified tensions along the impact areas of either business growth or supply chain development.

Considered together, tensions associated with supply chain development are largely novel to digital servitization, rather than rooted in more 'traditional' servitization. Our findings thus empirically confirm Raddats *et al.*'s (2019) notion on the increased multi-actor involvement being critical for digital servitization. Similarly, while extant literature stresses that digital servitization helps firms to enhance their competitiveness (Vendrell-Herrero *et al.*, 2017), our data suggests that the latter is to be achieved through collaborative efforts. Overall, although some tension is inevitable in managing business relationships and for any innovation, our findings indicate that keeping tensions within reasonable boundaries across the impact areas is vital for overall digital servitization performance, as suggested by the balanced distribution of tensions along the dimensions of business growth and supply chain development.

Finally, studying tensions did not provide an entirely gloomy picture. For example, some tensions associated with digital servitization involved not only frustrations but also more positive sentiments (e.g., excitement and curiosity). Such a noteworthy duality seems to be due to simultaneously occurring uncertainties and opportunities of digital servitization. While creating potential conflicts within and among organisations, tensions may foster creativity and hence support the innovation process. In the aerospace case, for instance, the increased tensions between certain divisions have eventually contributed to building improved communication practices between them.

5.1 Theoretical contributions

By identifying paradoxical tensions in digital servitization, this study addresses the research gap of how tensions unfold through digital servitization and which tensions affect business growth and supply chain development. We thereby offer contributions to the research on servitization and on operations and supply chain management.

As our first contribution to the extant research, we categorise the identified tensions along the dichotomy of business growth and supply chain development. In relation to the former, the tensions have a distinct business growth relevance, yet indirectly can also affect the supply chain development. For instance, a high-level strategic dilemma is between centralisation and decentralisation (Sklyar *et al.*, 2019), where the identified tension of digitally enabled control seems critical for digital servitization. Regarding supply chain development, we address calls for research on digitally-enhanced management under the increased multi-actor involvement (Raddats *et al*., 2019); optimisation of supply chain digitalization (Schniederjans *et al.*, 2019); and impact of data-related issues on supply chain management (Guha and Kumar, 2018). Specifically, our study contributes to the empirical evidence of tensions on platform-based coopetition, information superabundance, organisational identity shift, and data utilisation. Importantly, we found that these four tensions not only predominantly affect supply chain development (rather than business growth) but also are mostly novel to digital servitization rather than are rooted in more 'traditional' servitization.

5.2 Managerial implications

Our findings provide implications in terms of *actions* and *thinking*, both *present* and *future* (Jaworski, 2011), for managers working on digital servitization and in a broader innovation arena. For *present actions*, we invite practitioners to vocalise important tensions in a proactive manner instead of sweeping them under the carpet. Here, of major concern are tensions that discourage managers from actions necessary to achieve digital servitization outcomes. For *present thinking,* we suggest a tension audit with the discussed framework as a starting point. Awareness of the identified tensions can prepare the managers to handle and transform them toward business growth and supply chain development.

For practitioners working on digital servitization, *future actions* may include skill development workshops on proactive tension management. Here, the focus might be on professional and organisational identity shifts, accelerated tensions between centralisation and decentralisation, and balancing different types of performance measures. In turn, *future thinking* might include learning from how previous tensions and conflicts were (mis)managed, as well as acceptance of a non-distractive level of tensions — especially creative ones — since it might be inherent to digital servitization. Tension management could be further improved by strategically addressing the dual imperative of digital servitization: a conscious balance between building new digital businesses and digitizing existing service operations. Here, anticipation of organising- and learning-related issues can help the management of other relevant tensions that might appear along the way.

Overall, major resources could be saved through managing expectations on tensions in digital servitization, as well as agreeing on early-stage processes of buyer-supplier collaborations. If such considerations are included into strategic planning for digital servitization, potential harmful effects can be minimised toward both business growth and supply chain development.

6. CONCLUSIONS

While servitization has been transforming traditional strategic approaches (Lightfoot *et al.*, 2013), digital servitization further continues this transformation. Taking a paradox theory perspective, our study identifies eight paradoxical tensions associated with digital servitization. We acknowledge that some of the explored tensions — such as the one pertaining to data utilisation — might have inherent links to not just one but rather multiple categories from Smith and Lewis' (2011) framework (which comprises categories of organising, learning, belonging, and performing). Also, while not evident in our data, there may be other categories of paradoxical tensions that potentially could extend this framework. Thus, rather than contributing to paradox theory, our study is more focused on digital servitization and associated complexities within the four paradoxical tension categories. A potential limitation of our research is that the perspective of small- and medium-sized enterprises was not addressed. Future studies should therefore examine tensions in digital servitization in the context of SMEs. The time-perspective of the explored tensions is another interesting question connected to their emergence and has yet to be addressed from a longitudinal perspective. Furthermore, as digitally-supported products are merging the trends of digitalization and servitization, future research should also address these yet unexplored opportunities for manufacturers (e.g., Svahn *et al.*, 2017; Raddats *et al.*, 2019; Gebauer *et al.* 2020), and investigate roles of different actors in data-related processes (Zwitter, 2014) within and beyond digital servitization. For instance, the rapid rise of artificial intelligence (AI) across industries warrants research into associated tensions that may relate to both business growth and supply chain development. Future studies could help in operationalising tensions, their antecedents, effects and the effectiveness of mitigation tactics.

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SOLUTION PROVIDER'S MICROFOUNDATIONS IN THE DEVELOPMENT OF PRODUCT-SERVICE INNOVATIONS

Tuomas Huikkola, Marko Kohtamäki, Rodrigo Rabetino, Hannu Makkonen, Philipp Holtkamp

ABSTRACT
Purpose: The present paper was set out to study how a solution provider manages organisational processes and routines to support product-service system (PSS) development.
Design/Methodology/Approach: This single-case study investigates in-depth one large international solution provider to understand the detailed microprocesses and routines shaping the microfoundations of product-service system development.
Findings: The study suggests that technology companies should consider creating a flexible structure to unleash many types of innovations instead of establishing tailored models to foster different innovation types and avoid falling into the exploitation trap of using innovation to only support the existing business without aiming for new explorative openings.
Originality/Value: The present study opens up the black-box of new product-service innovation (PSI) development model.

KEYWORDS: Product service innovations; new solution development; servitisation-based innovation

1. INTRODUCTION

The development of new product-service solutions has become increasingly important for technology companies to increase their value for customers (Cusumano et al. 2015. This transition from pure products to integrated product-service systems has been defined as *servitisation* (Vandermerwe & Rada, 1988), in which the development of novel product-service innovations (PSIs) plays a central role. When searching PSIs, solution providers develop organizational processes and routines to enable innovative behaviors to understand and facilitate the microfoundations of PSIs. An emerging literature on organizational microfoundations suggests that organizations should understand the behavioral mechanisms underlying organisational innovation to shape organisations that enable novel PSISs to emerge (Felin, Foss & Ployhart, 2015). Studies have defined microfoundations as "*the distinct skills, processes, procedures, organizational structures, decision rules, and disciplines—which undergird enterprise-level sensing, seizing, and reconfiguring capacities are difficult to develop and deploy*" (Teece 2007: 1319). Perhaps surprisingly, the existing servitisation literature has overlooked the microfoundations of PSIs.

Whereas the previous research has advanced our understanding about product development and service development as distinct phenomena, the literature on new service development (NSD) has mostly neglected the integrated character of product-service investments (Ulaga & Reinartz, 2011) by focusing only on service development (de Brentani, 1989) or product development *per se* (Santamaría et al. 2012). Because PSIs include elements from both customer-oriented service business and efficiency-oriented product business, they must be aligned during the solution design phase (Ulaga & Reinartz, 2011). There are also other differences between the NSD process and the NPD process, for instance, the NSD process specifically plays the roles of customers and other stakeholders in solution development. Moreover, NPD places greater emphasis on the prestudy and concept study phases, whereas in NSD, the launch and follow-up phases are emphasised (Kowalkowski & Kindström, 2012). Thus, very little is known about the innovation processes leading to new product-service systems.

The present study aims to understand the microfoundations of PSIs (Cusumano et al. 2015) by studying *how a solution provider facilitates PSIs by establishing organizational processes, structures, and practices.* The present study uses an in-depth single-case study to investigate a large solution provider's PSI processes and the associated organisational practices. This study contributes to the intersection of the product-service innovation and microfoundations literatures by: 1) identifying the microfoundations of PSIs; 2) demonstrating the micro-processes and routines in PSIs; and 3) describing how the new innovation model can contribute to a firm's strategic renewal.

2. THEORETICAL BACKGROUND

2.1 Servitisation

Industrial services/solutions have attracted increasing academic attention (Raddats et al. 2019). Servitisation studies have demonstrated the increasing importance of effective bundling of products, services and software to develop customized integrated solutions (Ulaga & Reinartz, 2011).

Manufacturers search constantly for new sources of income from novel solutions since differentiation through pure technology/product development becomes increasingly harder (Rabetino et al. 2015). To address these challenges and escape the commoditization trap, manufacturers have started to sell total solutions (Huikkola et al. 2016), integrated solutions (Davies et al. 2006), tailored solutions (Landry et al. 2013), operations and maintenance (O&M) types of solutions, and even performance-based or outcome-based business contracts to their clients (Visnjic et al. 2018). The development of these types of solutions requires resources from both product and service business units (Ulaga & Reinartz, 2011).

2.2 New Solution Development

Service or solution innovation has been defined as the "rebundling of diverse resources that creates novel value for the beneficiaries themselves or in their assets, activities, and processes in a given context" (Kowalkowski & Ulaga, 2017: 149). This definition also encompasses product-service systems (PSS) by incorporating customers as active participants in the service innovation process (Tuli et al. 2007).

In manufacturing companies, service units have typically been considered more similar to money-generating units rather than innovation-generating units. Manufacturing companies are not accustomed to allocating resources to service development initiatives. Therefore, no budget has been created for the development of new services. Services have emerged through daily operations rather than as a result of intentional and systematic processes. Hence, new service development is a novel issue for manufacturers, and the development of new services has lacked systematic processes and models, unlike traditional product development or R&D work.

The extant service marketing and management literature has recognised that product development is generally back-heavy and requires resources for technology development and prototyping, whereas service development is generally more front-heavy, requiring resources for market introduction and piloting phases (Kowalkowski & Ulaga, 2017). The extant NSD literature has identified general processes for new service innovations. For instance, Zeithaml and Bitner (2003) developed a model consisting of front-end planning and implementation phases. In front-end planning, firms must address the questions related to a firm's overall mission and strategy when generating new ideas. In concept development and feasibility analysis, firms must be aware of the potential market demand and answer the question of whether the concept is feasible from a business perspective. In the implementation stage, firms need to consider whether they have accounted for all factors affecting service delivery through prototypes and market testing. When introducing concepts into markets, firms must identify key problems related to service delivery and customer perception.

Product-service innovations (PSI) include elements from both NPD and NSD. As NPD is described as back-heavy and NPD as more front-heavy (Kowalkowski & Ulaga, 2017), PSI should be more balanced in terms of the focus areas in each phase. In the ideation phase, NSD should include black-box types of innovations (typically developed by focal company personnel such as engineers) and white-box types of development from the customer end (e.g., field personnel, such as salespeople and technicians).

In the conceptualisation phase, PSI requires a wide range of collaboration between the manufacturing and service units because PSI innovations affect both CAPEX and OPEX units (Oliva & Kallenberg, 2003). Hence, in the incubation phase, it is already important to have cross-functional collaboration within the firm to ensure that different business viewpoints are included (Porter & Heppelmann, 2015). In practice, this may be problematic because some service innovations may hinder product sales, and some product innovations may hinder future service sales. In the testing and development phase, developing prototypes and minimum viable products (MVP) and piloting them with the customer are critical steps to ensure the idea's initial functionality and potential acceptance. In PSI, these activities could include, for instance, simulations, games, and physical prototypes to assess how valuable customers perceive the idea to be and to identify potential bottlenecks relevant to the innovation. In the productisation (execution) phase, the solution will be industrialised, meaning that it will have a price tag and process description so that it can be sold and delivered both internally and externally. After this, the solution will be ready to be marketed, sold, and revamped.

2.3. Microfoundations and product-service innovations

Eisenhardt & Martin (2000) identify, for instance, cross-functional R&D teams, NPD routines, knowledge-transfer routines and different performance measurement systems as important microfoundations of dynamic capabilities. Thus, microfoundations revolve around the routines of scanning, screening and imagining opportunities (Teece, 2007). While some individuals within companies may possess the needed cognitive and creative skills, researchers have suggested that firms should be able to embed these market-scanning, interpretative, and creative processes within the management system that enables firms to systematically gather technical information, monitor customer preferences, and shape opportunities to develop new solutions (Teece, 2007). In today's high-velocity business environment (Bingham, Eisenhardt & Furr, 2007), top management needs to be careful when allocating resources to discover and search for new opportunities, as management attention is a scarce resource that should not be directed to every opportunity or threat that search efforts reveal (Teece, 2007).

Academic discussion about microfoundations attempts to address how micro factors are related to macro conditions. These micro-macro links are at the core of the discussion of microfoundations (Barney & Felin, 2013), and extant studies have investigated these links through both quantitative (Mazzucchelli et al. 2019) and qualitative methods (Del Giudice et al. 2017). In the innovation context, Mazzucchelli et al. 2019 identified seven microfoundations of strategic innovations. Three of these microfoundations were related to individual characteristics, namely, individual attention to detail, creativity, and openness, and four were related to individual knowledge-sharing behaviors, namely, individual motivation, control, ability, and engagement. Therefore, the existing microfoundations literature has acknowledged the need to study the antecedents, processes, and effects of these microfoundations on the micro-macro axis. The purpose of this paper is to assess the need for a new innovation model, the processes and practices related to this new model, and possible outcomes of the new innovation model initiative. Hereby, we build on Teece's (2007: 1319) definition of microfoundations: "*The microfoundations of dynamic capabilities—the distinct skills, processes, procedures, organizational structures, decision rules, and disciplines—which undergird enterprise-level sensing, seizing, and reconfiguring capacities are difficult to develop and deploy*". This approach acknowledges that there are organizational processes, procedures, structures, and disciplines that either enable or hinder firms in the face of change. Therefore, microfoundations attempt to open up this black box of the micro-macro axis.

3. RESEARCH METHODOLOGY

3.1 Research design

This study uses an extended case study method to develop an in-depth understanding of how a solution provider utilises a flexible product-service innovation method when developing new solutions. The present study analyzes the case of an industrial solutions provider. We selected this company because it is one of the leading solution providers in its sector, offers customized solutions for global markets, and has been active in initiating new innovation processes. Thus, the company provides a powerful case of Product-Service Innovation (Siggelkow, 2007) and an opportunity to develop interesting insights into the microfoundations of solution development (Eisenhardt & Graebner, 2007).

3.2 Data collection & analysis

We utilised an extended case study method to reconceptualise and extend the extant theory on NSD. This approach utilizes an iterative approach by juxtaposing data and theory in each iteration, forcing the researcher to seek additional data and explanations to rebuild additional concepts and theories (Eisehardt & Graebner, 2007).

To analyse firm's product-service innovation processes and practices in detail, we conducted altogether 23 executive interviews between years 2016 and 2019. This gave us insight into firm's key challenges, opportunities related to establishment of new innovation model. First, we conducted a literature review on servitisation-based innovations and new service development. Based on results derived from this phase, we crafted our initial questionnaire template for manager interviews. After the first interviews, we were able to receive case fim's development model for product-service innovations. Based on this, we revamped our questionnaire template to follow the strict modes used by the case company. Next, we utilised this template to develop a better understanding of processes and routines under each development mode. Initially, we interviewed managers responsible for general model development. Moreover, we discussed the holistic model with several managers to confront the practices.

Based on the data, we identified 12 second-order themes related to origins and triggers of new innovation model development (challenges faced in the old model; breaking path dependency; executive support), new model establishment (the new model's four processes: ideation, incubation, transformation, growth), managers' responses to the new model (shared language; becoming more customer-centric and flexible; increased clock speed), and outcomes (development of growth businesses; emergence of new innovations). Because of space limitations, we discuss in this paper four key processes in solution development, namely 1) collecting ideas, 2) incubation, 3) transformation, and 4) productisation.

4. FINDINGS

4.1 Collecting ideas (phase 1)

Ideation refers to sensing new opportunities in the markets (Teece, 2007). These opportunities can be *exploitative* or *explorative* by nature, depending on whether they contribute to taking advantage of existing business and processes or exploring new opportunities outside the firm's current scope (Birkinshaw & Gibson, 2004).

Our respondents highlighted that the most important aspects of the ideation phase are to involve as many people as possible in ideation, encourage people to express and share their ideas, and create a culture that does not hinder or discourage people from presenting and generating ideas. Respondents stated that most ideas will be rejected at this point because they might be duplicates, overexploitative, or inferior. Managers had created a rule of thumb related to the number of ideas that will eventually lead to final execution. Based on interview data, only 1-2% of ideas will eventually be productised and sold to clients. This means that the organisation needs to generate an abundance of ideas that can enter the pipeline in order to generate new solutions to be sold in the future.

To collect these ideas, the company uses both physical boxes and the social media tool to solicit ideas from both firm's personnel and external partners, such as universities, start-ups, customers, and suppliers. One particular challenge case firm faced was that innovations tend to come from the same groups or people. This is understandable because some are more innovative, creative, and idea-rich than others. On the other hand, the key question for case firm was to encourage all personnel to contribute.

Once the ideas have been collected, people are encouraged to comment on them. This community discussion is meant to iterate these ideas within a larger group of people. The goal of this practice is to give fuel to ideas, to make them more powerful by involving more people in the ideation phase. At the case firm, the tailored social media tool was utilized to comment on and evaluate ideas. Personnel were active in this phase, as managers noted that employees had made substantial contributions to different ideas.

To evaluate the feasibility of ideas, case firm utilised the *business model canvas* (Osterwalder & Pigneur, 2010) throughout the innovation process to refine the idea on its way to the execution phase. When reaching the decision phase in ideation, our respondents unanimously responded that the majority of ideas (~90%) will be rejected at the venture board. Therefore, at this stage, firm evaluates whether the idea has value potential that is worth pursuing further.

4.2 Incubation (phase 2/optional)

Incubation is an optional process and is meant to address the following question: Has the idea been validated to build a minimum viable product (MVP)? First, the validation needs to be conducted in collaboration with customers: would the idea make sense for them? Second, the validation needs to be conducted from the focal company's perspective: would the idea be economically reasonable?
To address these questions, case firm utilised market research to validate whether there is business potential for the idea. Firm also utilised the service design approach in this phase to drive the process. Small prototypes are intended to increase flexibility in the process. Therefore, solution provider can use simulations to understand the potential of the solution. The key idea behind this phase is to make sprints and obtain fast results about the idea's potential feasibility – everything has been designed to increase the organization's flexibility. On the other hand, the incubation phase has been designed to give extra resources and capabilities to the process owner or initial ideator.

One benefit for an organization from a new innovation model is to increase its overall clock speed. One respondent stated how case firm was able to develop the same business concept in just three weeks when it normally would have required 6 months. Thus, incubation facilitates an organization's learning curve by producing preliminary results on the idea, testing the idea more quickly, and obtaining instant feedback on its functionality, thus following the iterative feedback-loop type of learning (Thomas, Sussman & Henderson, 2001).

4.3 Transformation (phase 3)

In the transformation phase, the key goal is to determine whether the MVP's value, urgency, and complexity have been adequately validated internally and externally to roll out and continue larger-scale development. The first practice is handover to a dedicated transformation team. Thus, the development of the MVP is at the center of the transformation phase. The decision of whether the concept should go into production or be rejected depends on the validation: is there a need for the solution and is it economically viable? At this point, there must be a clear indication of demand. There has been an incentive to make the process more agile, and one practice adopted with this goal in mind is to use smaller-scale models, such as those created by 3D printing, before scaling up.

Overall, governance and the need for solution verification increase remarkably in the transformation phase. At this point, the solution needs to be validated, and this validation dictates whether the concept will be revamped or rejected. On the other hand, compared to the incubation phase's decision-making process, the venture board's decision-making is less influential in the transformation phase – the key criterion at this point is the solution's validity both internally and externally.

4.4 Productisation (phase 4)

As only 1-2% of the ideas go on to the growth phase according to interview data, they have already gone through many processes and evaluation rounds. At this point, the concept has been validated and verified both internally (e.g., in financial terms) and externally (e.g., customers have expressed willingness to buy this solution). To ramp up a novel solution, a focal company needs to train its personnel, especially its salesforce, to sell this solution to dedicated clients. Additionally, firms must consider how the solution is produced, productised, and how new solutions will be bundled into existing offerings. Is it seen as a bundle or as an add-on item? These considerations increase complexity within the organization as separate units and functions within the firm need to be convinced about the new solution; how will it be produced, sold, and delivered?

Figure 1 below presents case firm's new innovation model and its associated practices. It shows that when progressing in the model, organizational support, governance, risk, and strategic value increase in each phase. It also shows that in the ideation phase, idea screening and sensing are key processes. In the incubation phase, (customer) value identification is a key process, and in the transformation and growth phase, value quantification and verification become essential. The model itself gives room for flexibility and is not meant to be exhaustive but provides general structure and guidelines for proceeding with the idea and concept.

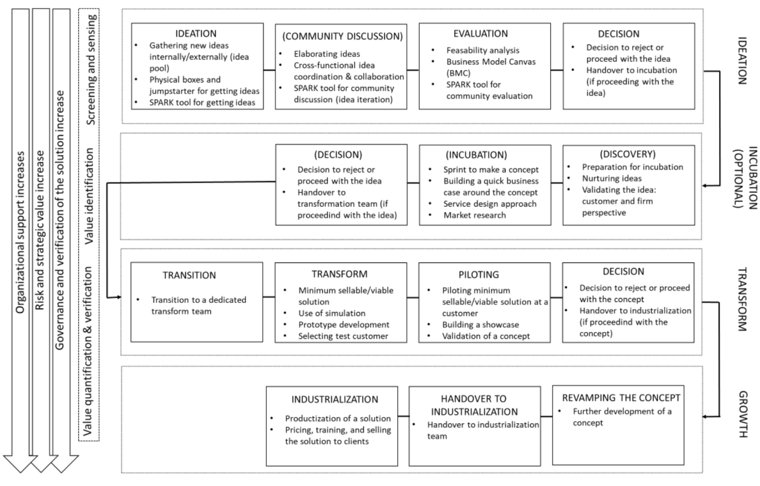

Figure 1: New product-service innovation model and associated practices.

5. DISCUSSION

The increased importance of services and software has forced manufacturers to question their existing innovation models, which are typically product-oriented (Kowalkowski & Ulaga, 2017). To address new challenges, technology companies have renewed their processes and routines to foster not only new product and service development but also solution development models and activities. To facilitate these bundled innovations, manufacturers can establish a flexible and holistic innovation model that considers product, service, process, and business model innovations. To manage such innovations, firms must establish clear processes, procedures and decision-making rules. The present study has investigated these microfoundations, micro-processes, and routines to drive this change through an extended single-case method.

5.1. Theoretical contribution

This study investigated one relatively large Finnish solution provider, and focused on the product-service innovation process the firm used to address the question of microfoundations in bundled innovations. The study's contributions are threefold. It: 1) identifies the microfoundations of PSIs; 2) shows the micro-processes and routines in PSI; and 3) describes how the new innovation model can contribute to a firm's strategic renewal.

As a first theoretical contribution, we identified altogether 12 second-order themes related to the origins and triggers of new innovation model development (challenges faced in the old model; breaking path dependency; executive support), new model establishment (new model's four processes: ideation, incubation, transform, growth), managers' responses to new model (shared language; becoming more customer-centric and flexible; increased clock speed), and outcomes (development of growth businesses; emergency of new innovations).

The second theoretical contribution relates to the demonstration of micro-processes of PSI, i.e., the illustration of these micro-level processes and practices, which are utilized to support PSIs. Thereby, this study extends the extant literature on servitisation by describing how product-service innovations emerge and are managed at the corporate-level. Holistic framework for PSI's include four key phases: 1) ideation, 2) incubation, 3) transformation, and 4) growth. In ideation phase, routines include tools for gathering new ideas such as physical development boxes, jump starter, and use of social media tools. Another important routine was related to the elaboration of ideas that contain elements of cross-functional collaboration. This cross-functional collaboration is an important enabler of PSIs since bundled innovations have impacts on both OPEX and CAPEX businesses. To evaluate an idea's feasibility, a firm can establish frameworks and tools, such as *business model canvas* or *value proposition canvas,* to evaluate them better. The incubation phase is optional and provided to afford additional resources to the developer. Analogy would be reminiscent of "nitro innovation," boosting an individual developer to develop it further with additional help. In the transformation phase, the key idea is to build and pilot a concrete prototype (whether physical or digital; minimum viable product, MVP). In the last phase, growth process, a solution's productisation related issues, such as pricing and training, become increasingly important. Identifying these practices can help other solution providers to benchmark processes and associated practices related to bundled innovations.

As a final theoretical contribution, this study shows the need to establish an enabling flexible structure to generate increased numbers of ideas through the organization. Enabling flexible structures makes it possible for firms to learn, innovate, and generate wealth beyond traditional hierarchical control (Adler, 1999). In contrast, enabling a flexible structure would be a coercive (rigid) structure (Adler & Borys, 1996) that would represent traditional hierarchical control to manage innovations. Although this model has been typically used in a negative manner, coercive structure provides needed guidance and more clarified responsibilities within the organization to drive innovations (Adler & Borys, 1996). We found that corporations tend to use flexible structures to manage PSIs. Hence, firms balance between coercive and enabling structures as optimal mechanisms to drive and manage bundled innovations. Moreover, a unified innovation model can help firms to break free from the silos of innovation generating (CAPEX) and money generating (OPEX) units. Instead of developing tailored models for different types of innovations (product, service, process, or business model innovations), our findings suggest that single flexible model might prevent firms from overinvesting in exploitative businesses and help it to increase its innovation scope toward explorative businesses (Sirén, Kohtamäki & Kuckertz, 2012).

5.2 Managerial contributions

This study demonstrated how product-service innovations emerge and are managed in a relatively large international solution provider. Managers from different business disciplines can benchmark this framework and associated practices.

Managers can also identify key bottlenecks related to bundled innovations. Managers need to break the efficiency logic of pure product and service innovations and highlight the logic of collaboration between the units to generate life-cycle rather than instant benefits. This leads to reconsideration of optimal structures for driving PSIs. When SBUs use coercive structures to emphasize efficiency benefits, corporations use enabling flexible structures to take advantage of both logics, hence motivating distinct units to collaborate and contribute to firm-level advantage, potentially with at the cost of SBU advantage. As with any business, developing product-service innovations should generate more customer value compared to alternative options in which customers buy products and services separately. Moreover, this collaboration should be incentivised within the firm, for instance, by establishing incentives that support cross-functional collaboration and bundled innovations. Moreover, our findings suggest that corporations could consider creating a flexible, “one-size fits all” framework for innovations rather than establishing separate, tailored innovation models for different types of innovations, whether they are product, service, process, or business model innovations. This may be challenging to initiate because needs are different in different types of innovations. Finally, our findings suggest that managers could formulate different rules of thumb related to resource allocations for different types of innovations. By following Google’s 70/20/10 rule, technology companies in mature industries can use similar guidance when deciding how to allocate resources to existing business, emerging business, and out-of-the box business development initiatives. This type of heuristic comes from experience, and the distribution of resources and investments may depend on a firm’s industry-specific conditions and the urgency of renewal requirements. This would simplify the guidance and make innovations more flexible and manageable through s systematic structure.

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AUTHORS

Assistant Professor Tuomas Huikkola
School of Management, University of Vaasa,
Vaasa, Finland, 65200, +358294498448,
tuomas.huikkola@univaasa.fi

Professor Marko Kohtamäki
School of Management, University of Vaasa,
Vaasa, Finland, 65200, +358294498459,
marko.kohtamaki@univaasa.fi

Associate Professor Rodrigo Rabetino
School of Management, University of Vaasa,
Vaasa, Finland, 65200, +358294498451,
rodrigo.rabetino@univaasa.fi

Professor Hannu Makkonen
School of Marketing and Communications, University of Vaasa, Finland, 65200, +35829449 8102, hannu.makkonen@univaasa.fi

General Manager Philipp Holtkamp
Wärtsilä Corporation, Vaasa, Finland, 65100,
+358505958632, Philipp.holtkamp@wartsila.com

AN EXPLORATORY STUDY OF DIGITALLY-ENHANCED ADVANCED SERVICES FOR DOMESTIC APPLIANCES IN THE UK

Maria Holgado, Peter Ball, John Oyekan, Ashutosh Tiwari

1. INTRODUCTION

Traditionally, service research in the domestic appliances market have focused on after sales services and their operations, as a means to achieve competitive advantage and revenues of 20-30% of total sales for appliance manufacturers (Murali et al. 2016). Additional sources of revenue and longer engagement with customers along the whole product lifetime could be achieved by more integrated offerings of products and services. Servitisation strategies are progressively shifting manufacturers from basic to more advanced service offerings to complement their service portfolio (Benedetti and Neely 2018). Advanced services deliver a capability to the customer through the performance of the product, e.g. customer support agreement, risk and reward sharing contract, revenue through-use contract (Baines and Lightfoot 2014). Rental and pay-per-use schemes are other examples of advanced services. These services can potentially increase manufacturers' revenues, provide a stable source of revenue and unique differentiating factor from competitors (Oliva and Kallenberg 2003); however, their implementation and attainment vary in different industries due to specific industry conditions (Visnjic et al. 2019). There are limited instances of how advanced services may be applied in consumer markets such as the domestic appliances market.

The objective of this work is to investigate how innovative digital technologies can enable advanced services in domestic appliances and enhance decision making through data management and analysis across the service delivery networks. The research builds on the review of relevant literatures which identified gaps in how domestic appliances manufacturers can leverage the opportunities brought by servitisation and digital technologies.

We have conducted an exploratory qualitative study involving both academic and practitioners in order to obtain insights from a multi-disciplinary and multi-stakeholder perspective. Preliminary findings suggest a strong context dependency on customer appliance usage and behaviour as well as on service provider technical skills and resource availability. Identified potential technological enhancement for domestic appliances comes primarily from sensor, data analytics and connectivity technologies. Leveraging on these technologies will provide additional functionalities either as add-on services or within an advanced service offering.

2. BACKGROUND

Manufacturers' service offerings have been classified in multiple ways in literature, e.g. focused on a product or to end-user's process and being transaction or relationships-based (Oliva and Kallenberg 2003). Reviews of service offering classifications are available in Saccani et al. (2014) and Gaiardelli et al. (2015). Broadly, they can be categorized into base (e.g. warranty and spare parts provision), intermediate (e.g. helpdesks, training, scheduled maintenance, repairs and overhauls) and advanced services (e.g. customer support agreements and outcome contracts) (Baines and Lightfoot 2014). Advanced services are the more sophisticated and complex services that focus on delivering a capability to the customer through product performance (Baines and Lightfoot 2014). They are also known as outcome-based contracts (Visnjic et al. 2017; Sjödin et al. 2020a), pay-per-use contracts (Martinez et al. 2017), result-oriented services (Tukker 2004) or performance-based contracts (Selviaridis and Wynstra 2015; Glas et al. 2019), among others. Advanced services are common in very diverse fields such as the industrial durable goods market, the defence industry and software industry (Visnjic et al. 2017; Ng et al. 2009).

The servitisation transformation process of a manufacturer towards successfully delivering advanced services constitutes four stages of progress defined as (Baines et al. 2020): exploration (i.e. investigating about the concept and finding out opportunities), engagement (i.e. evaluating and demonstrating the potential until organisation acceptance), expansion (i.e. increasing scale and speed of advanced services implementation) and exploitation (i.e. optimising the delivery of the advanced services portfolio). Measuring progress of this transformation journey requires a complex and multi-variable framework, integrating internal and external views as well as financial and non-financial measures (Ziaee Bigdeli et al. 2018). Supportive individual-level tactics can help overcome issues along the path towards servitisation from the internal perspective, i.e. in relation to adapting organizational culture, strategy, structures, and processes (Lenka et al. 2018). Other success factors include internal alignment of the servitisation strategic orientation of the company with both its internal organisation and its service portfolio offerings, and external alignment with the customer and the service network (Alghisi and Saccani 2015). Moreover, Baines et al. (2020) identify five forces determining progress along the servitisation transformation process which are internal to the organisation, such as organisational readiness and organisational commitment, and external to the organisation, such as the extent of customer pull, the strength of technology push, and the structure of the value network positioning.

The service network perspective becomes key in this type of services. The delivery of advanced services to the customer involves not only the manufacturer but also other actors, e.g. suppliers, partners, intermediaries, within the value network in order to bring the performance outcome to the customer. According to Martinez et al. (2017), companies adapt their service offerings and processes to the evolving customers' needs and requirements in close collaboration with key suppliers and partners. The study done by Story et al. (2017) identified unique and critical capabilities for different actors as follows:

- For manufacturers: balancing product and service innovation, developing customer-focused through-life service methods, and having distinct and synergistic product and service cultures;
- For intermediaries: coordination and integration of third party products/services;
- For customers: co-creating innovation and having processes supporting service outsourcing.

The concept of service co-creation jointly with customers is frequently discussed in the servitisation literature, in both consumer and industrial goods markets (Oertzen et al. 2018). It involves implicitly and actively the customer in the process of value creation (Vargo et al. 2008). The relationship with the customer is one of the key aspects of servitisation (Rabetino et al. 2017). In the case of advanced services, the service providers have the opportunity of establishing long-term relationships with customers (Visnjic et al. 2017), and of learning more about customers' needs and operation conditions (Grubic 2014). This feedback can be used to improve the service offering to better match actual, and evolving, customers' needs (Allmendiger and Lombreglia 2005; Grubic 2014).

One of the key forces in a servitisation transformation process is the availability of and access to technologies, particularly to digital technologies, i.e. technology push' (Baines et al. 2020). The links between digital technologies and servitisation have been acknowledged in recent literature, and the concept of 'digital servitisation' has been coined (Vendrell-Herrero et al. 2017). It is defined as "*the transformation in processes, capabilities, and offerings within industrial firms and their associate ecosystems to progressively create, deliver, and capture increased service value arising from a broad range of enabling digital technologies* (Sjödin et al. 2020b).

Advanced services support customers after they have got delivery of a product. In order to enable these services, technology enablers that could be used include Internet-of-Things (IoT), Augmented Reality (AR), Virtual Reality (VR), and blockchain as well as additive manufacturing during product manufacturing (Johnson 2017) to mention a few. The IoT type technologies enable the collection of data from a source to transmitting it to a location where algorithms could either be brought to bear to extract insights from the data or visualized in order to provide remote customer support service, pay per usage contract models as well as open the opportunity to charge services via the pay by the load models (Paritala et al. 2017).

In consumer products, there have been interest in the use of IoT and Artificial Intelligence (AI) in appliances such as dishwashers, smartphone operated roller shutters and smart vacuum cleaners (Kaczorowska-Spychalska 2018). The area that these technologies have gained the most penetration is in the control of smart appliances such as speakers, thermostats, tvs and lights (Mocrii et al. 2018). However, these are currently not used for advanced service provision yet. The sensors and actuators for these devices are currently added as an afterthought to carve out unique niche market spaces. However, in the future, though lithography solutions, these will be inherent fabricated as part of the product itself (Zhu et al. 2018) and hence open up unique opportunities for advanced services currently not realized.

3. RESEARCH METHOD

This work was conducted through literature review and qualitative research methods, which included a focus group with multidisciplinary scholars, and a set of semi-structured interviews with personnel from organisations that are involved (or to be potentially involved) in the delivery of advanced services for domestic appliances.

The multidisciplinary focus group took the form of a workshop, with participating scholars from different disciplines. The workshop helped to advance the scoping of advanced services in domestic appliances, to validate literature review findings, and to identify any missing themes. Next, the workshop outcomes were used to design the questionnaire for the semi-structured interviews. Interview participants included practitioners involved in the design, manufacturing and service of domestic appliances, as well as other stakeholders of the service network e.g. technology providers, consumer associations. Details on the methods employed are provided in next subsections.

This approach brings together academia and industry views to form a comprehensive outlook on current status and potential challenges and barriers to a wider implementation of advanced services to domestic appliances.

3.1 Multi-disciplinary workshop

Workshop participation was by-invitation only and invitees were selected to cover a guide range of disciplines within the social sciences, engineering, computer science and information systems. Eight scholars eventually participated in the workshop in November 2019. The workshop objectives were defined as follows:

- to discuss the range of advanced services that could be applied to domestic appliances;
- to create a map of digital innovations, including themes such as the potential data collection and analysis enhancement;
- to identify relevant aspects that need to be taken into account for the development of advanced services for domestic appliances.

The workshop was organised to provide an initial introduction and overview on the research, followed by group discussions based on a set of three templates to cover three key topics: (1) Designing service offerings for domestic appliances; (2) Understanding the customer journey for advanced service offerings; (3) Analysing digital technologies in advanced service offerings. While the templates for exploring topics 1 and 3 were developed ad-hoc, topic 2 was explored through the use of a service blueprint (Bitner et al. 2008). The workshop finalised with a joint discussion on the emerging themes.

3.2 Interview-based study

We conducted an exploratory qualitative study based on a set of nine semi-structured interviews with practitioners working for a wide range of organisations related to the domestic appliances sector. These organisations are involved in areas along the life cycle of domestic appliances, e.g. design, manufacturing, service. We followed a purposeful sampling approach (Creswell 2006, p.125) and selected participants that could provide insights and contextual information from different angles.

Participants selection criteria were the following: (1) include a wide range of domestic appliance manufacturers; (2) include both manufacturers which own brands and which do not own brands; (3) include potential suppliers or partners, e.g. technology providers; (4) include professional bodies and / consumer associations, as interested stakeholders. Selection was done by searching list of companies within the sector in Orbis database and direct internet search. Participants were contacted via email, whenever it was available, or via LinkedIn. Response rate was around 40%. The final sample included 4 participants from manufacturing companies, an independent consultant, a participant from a research institution, 2 participants from a technology provider, and a participant from a consumer association. The latter was included to obtain insights on the consumer perspective.

Most interviews were conducted via Skype (only one was face-to-face) in February and March 2020, and had durations between 30 min and 1h 20 min. Interviews were transcribed and then analysed following a theme-based coding.

4. PRELIMINARY RESULTS AND DISCUSSION

4.1 Summary of workshop key findings

Context dependency emerged as one of the key themes while discussing potential advanced services for domestic appliances. It was not particularly clear what contextual features were essential to designing and implementing the advanced services; some potential aspects could be related to e.g. usage intensity, appliance lifetime and replacement rate, technical skills and customer relationships. Thus, the term ‘context’ needed to be unpacked further to identify the key elements that can make the advanced service offering successful or not.

Further analysis needed also to include a better understanding of different types of customers, their needs and their actual demand for this type of services. This could include aspects of customer loyalty and retention, communicating with the customer about the service offering, and understanding the customer needs in terms of appliance functionality.

Technological enhancement for domestic appliances seems to originate primarily from the use of sensor, analytics and connectivity technologies, according to workshop discussions. Leveraging on these technologies to provide additional functionalities to the customer either as add-on services or within an advanced service offering needs to be considered when designing the service portfolio, according to contextual features and customers’ needs and requirements. Implications on product design, technical safety, legal and contractual issues, and customer perceptions of the advanced service offering were also identified as further areas of inquiry within this research.

4.2. Preliminary findings from practitioners interviews

This section presents an overview of our key findings related to mapping the status of service offerings for domestic appliances, and to the use of enabling technologies in future advanced service offerings.

Table 1 presents a summary of findings related to the current and prospective service offerings based on each of the exploratory interviews conducted. It also includes insights on the drivers or enablers for the transition to advanced services. It is worth that the outlook obtained was quite consistent across all categories of current services, including the absence of advanced services within the current offerings. The envisaged offerings for intermediate services and advanced services had higher variation, which highlights the broad range of ways in which more outcome-oriented business models could be defined for domestic appliances.

All interviewees acknowledged the perception of the domestic appliances industry moving towards advanced services. Drivers and enablers vary from market-led e.g. increased competition and threat from technology platforms, to technology-led e.g. increased availability of technologies at lower costs, and benefits-led e.g. envisaged lower environmental impact and higher revenue streams along the appliance lifetime.

Table 1: Overview of service offerings and drivers /enablers of change, based on interview insights.

Interviewee (Organisation type)	Base		Intermediate		Advanced	Drivers / enablers of the change towards advanced services
	Current	**Future**	**Current**	**Future**	**Future**	
Senior technical fellow (R&D Organisation)	Network monitoring through sensors.	Extending range of processes.	Monitoring of the processes themselves. Fault diagnosis.	Using environment data to make process more effective / efficient.	Using environment data to optimise process.	Sustainability, environmental impact, lower cost sensor systems, connectivity of devices, and lower cost availability of analysis.
Independent consultant	Spares provision, warranty.	Retrieving location, operation and service history in situ or remotely.	Scheduled annual maintenance by central heating professionals.	House buyers accessing service history (condition monitoring).	Track and trace of boiler's entire lifecycle.	Lack of visibility, control and reward in the value transactions downstream in supply chain.
Customer insight manager (Manufacturer 1)	Spares provision, warranty.		Maintenance plans for own and other household products.	From customer managing devices via own app to company smart maintenance plan.	IoT sensors (new products and retrofit) for remote diagnostics and support leading to pay per outcome.	Product becoming commoditised and risk of loss to supply chain value to technology platforms by not having relationship with customer enabled by IoT advances.
Product development manager (Tech provider)	Spares provision, warranty.		Heating management via smart sensors.	HVAC diagnostics, an emerging technology.	Energy response programme. Provider changes house thermostat to reduce grid peaks.	Threats from technology platforms.
Managing director (Manufacturer 2)	Spares provision, warranty.				Not alone, use distributors with a supply contract basis or a per outcome item basis.	Volume absent for domestic offer.
Managing director (Manufacturer 3)	Third party spares, warranty.	Warranty included in spare parts supply.	We offer everybody spare parts.	Maintaining the condition of the appliance.	Selling capability in a pay-per-output or rental basis.	Threat of dealer providing customer with low cost entry without need to for expensive upfront cost.
Senior technologist Manufacturer 4	Spares provision, warranty.	Services based on analytics of customer behaviour.	Technical helpdesk and in-house engineers fleet for repairs.	Services based on analytics of customer behaviour	Pay per use schemes potential for high demand communal kitchen and laundry areas	House space at premium for low use items, food ordering seen as cheaper. Digital technologies used for payment and checking availability.
Marketing manager Technology provider 2	Spares provision, warranty.		Service to support design and test		Installers not providers have relationship with customer due to volume	Need to build value proposition and identify revenue stream to offset cost of long term availability warrantees.

The technologies most often mentioned were related to IoT, i.e. sensor technology and connectivity, which confirms their enabling potential for advanced service design and provision. Sensors, especially smart sensors and devices such as smart thermostats and smart meters were seen as essential for understanding the usage patterns once the appliance is installed in households and for service providers to activate and perform potential service-related actions in a remote manner. Remote monitoring technology seems to be one of the key enablers, as highlighted in literature (Suppatvech et al. 2019; Grubic 2014). One of the interviewees indicated the potential use of data regarding the environment in which the appliance operates to optimise processes, e.g. washing at a temperature that minimises energy consumption while getting the job done.

Connectivity enabled by e.g. Wi-Fi technology is understood to be key for advanced services provision. Standard communication protocols will be required as a consequence of multi-device environments. Additionally, concerns were raised regarding appliances being only functional upon internet connectivity which will require stable access to connectivity.

Software applications and platforms were mentioned as helpful to provide ubiquitous information and control to customers, for example with mobile apps.

Another example is the potential use of data recorded directly on appliances for facilitating service interactions. Moreover, the potential use of blockchain to help managing small and frequent payments, e.g. in pay-per-use schemes, was also suggested.

Our findings indicate data requirements for advanced service providers regarding: (1) appliance performance and any deviations from targets indicated in labels or service agreements; (2) customer use of appliance and any deviations from recommended operating conditions or intended use; (3) customer preferences, wants and needs. Specific envisaged uses of these data items within an advanced service offering were identified as:

- Feeding back to the customers information about how the appliances are really performing in use, or the external factors which are influencing it;
- Providing advice to customers for achieving better performance and use of the appliance;
- Ensuring maintenance can be scheduled when it is actually needed rather than just an interval which is deemed to be appropriate;
- Identify issues that the appliance/s system may be having, as well as making sure that the system is set up to run optimally;
- Taking remote actions to ensure optimal performance, e.g. switching on/off appliance when energy costs are lower for the customer;
- Improving appliance design e.g. in terms of efficiency and sound, according to actual customer needs and wants.

Challenges and barriers mentioned during the interviews were manifold, and some of the emerging themes were the following: (1) development of a sound advanced service business model, (2) impact on current business model and sales, (3) balancing the cost of embedding the technology and setting up the platform / system, (4) access to the broad range of skills and resources needed to set up the system (5) resistance from external actors such as installers and technicians, (6) balancing the service oriented mind-set with the current product orientation, (7) balancing the potential to provide a wide range of functionality with simplicity and easiness to use for customers, (8) communicating the value for money of these advanced services to customers, (9) need for competitors to work together, (10) dealing with technical issues potentially affecting appliance durability and longevity.

Some of the above mentioned challenges and barriers are common to the transformation towards delivering advanced services and have been observed overall in the servitisation literature (Alghisi and Saccani, 2015), while there are new ones related to the specific case of domestic appliances, and how the industry structure is currently organised, as well as to the specific challenges related to the cost and potential complexity implied when integrating novel technologies. Thus, these are interesting areas to focus further research in order to support companies to overcome these envisaged challenges and barriers for the implementation of advanced services in domestic appliances.

5.CONCLUDING REMARKS

This work builds on perspectives from service innovation, operations management and digital manufacturing. Servitization research foundations on strategy, capabilities, and processes for transitioning to the provision of advanced services (Baines et al. 2020; Ziaee Bigdeli et al. 2018), and on conditions and tactics to overcome organizational resistance to servitization (Lenka et al. 2018) have been considered. The methodological approach followed in this exploratory qualitative study includes a multidisciplinary focus group with scholars from four institutions, and a set of semi-structured interviews with industrial stakeholders involved (or to be potentially involved) in the delivery of advanced services for domestic appliances.

Identified most promising technologies for advanced services in domestic appliances are sensor, data analytics and connectivity technologies. They can help collecting and processing customer and appliance performance related information. Besides this, software applications and platforms, and blockchain technology were mentioned for information sharing and control, and facilitating payment processing, respectively. Findings have uncovered the potential for value creation of implementing technology-enhanced advanced services in this particular consumer market, although a set of challenges and barriers have also been identified and will be the subject of further research.

This work contributes to the servitisation research field by improving understanding of how digital technologies can support the delivery of advanced services for domestic appliances. It uncovers interdisciplinary research areas to advance knowledge on the drivers, benefits, barriers and mechanisms to introduce these advanced services. The research findings could inform both the UK industrial and research strategy agendas by providing evidence to future policies related to smart appliances development. Managerial implications of this work include support for manufacturers of domestic appliances to identify pathways to develop and enhance their current service offerings towards higher value advanced services.

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AUTHORS

Dr Maria Holgado
Department of Management, University of Sussex Business School, Brighton, UK, BN1 9SL
m.holgado@sussex.ac.uk

Prof Peter Ball
The York Management School, University of York, York, UK, YO10 5GD
peter.ball@york.ac.uk

Dr John Oyekan
Department of Automatic Control and Systems Engineering, University of Sheffield, Sheffield, UK, S1 3JD
j.oyekan@sheffield.ac.uk

Prof Ashutosh Tiwari
Department of Automatic Control and Systems Engineering, University of Sheffield, Sheffield, United Kingdom, S1 3JD
a.tiwari@sheffield.ac.uk

SERVICE CONFIDENCE OF MULTIPLE ACTORS IN BRINGING NEW DATA-ENABLED SERVICES TO MARKET

Khadijeh Momeni, Eija Vaittinen, Markus Jähi & Miia Martinsuo

ABSTRACT

Purpose: The emerging trend of digitalisation in manufacturing firms has created new opportunities in the servitization process through development of new data-enabled services. Despite these services appearing promising both for manufacturing firms and customers, the empirical evidence has shown that firms face different problems in selling these services. The study explores service confidence from multiple actors' perspectives (service unit, sales unit, external salespeople, and customers).

Design/Methodology/Approach: An embedded single-case study was carried out with a machine manufacturer, including its sales and service personnel, customers and external salespeople. Data were collected via 30 interviews. Through conducting a thematic data analysis, the requirements for building confidence in data-enabled services were divided into four categories: internal, external/customer-related, relational and offering-related.

Findings: This paper reveals the criticality of building confidence to bring data-enabled services to market. The findings reveal different dimensions of confidence and demonstrate that introducing data-enabled services requires the confidence of all actors involved in servitization.

Originality/Value: This paper conceptualises service confidence towards data-enabled services through six dimensions—attitude towards services, confidence in service value, confidence in service reliability, relational confidence, competence, confidence in data security and management.

Keywords: Data-enabled services, Servitization, Confidence

1. INTRODUCTION

The increased use of information and communication technologies and data analytics has enabled manufacturers to enhance the value of their existing services, such as repair and maintenance, and also develop new services, such as operation optimization and digital technical analyses (Lerch and Gotsch, 2015). Such data-enabled services are here defined as a manufacturer's activities that add value to customers' processes through digital data and the delivery of specific functions in the customer's business process. Previous studies have explored the requirements for operations to deliver advanced services (Baines and Lightfoot, 2013) and digital capabilities as well as their link with different service transformation trajectories (Ardolino et al., 2018) and related service journeys (Martinez et al., 2017). However, such studies have only partly covered data-enabled services. The main focus has been on the development and idea generation of the new services or general servitization rather than on the requirements for bringing the new services to market (Kindström and Kowalkowski, 2009).

The adoption of new services may be challenging and requires attention from multiple actors. Convincing a new customer to adopt new services may require references from existing customers about the value of the new services (Jaakkola and Aarikka-Stenroos, 2019). Introducing new services, including data-enabled services, requires the involvement of multiple actors, both within the manufacturing firm, such as salespeople and service personnel (Kindström et al., 2015), within the customer firm (Jähi, 2020; Raddats et al., 2017) and among other firms involved in the service supply chain, such as distributors or retailers (Aminoff and Hakanen, 2018; Vaittinen and Martinsuo, 2019).

Adopting data-enabled services requires alignment among the mindsets of different actors in the business network and alignment between their mindsets and capabilities (Töytari et al., 2018). However, relatively little research has explored the motives, mindset, perceptions and requirements of different actors to launch data-enabled services and the dynamics between actors. Salespeople and customers have different concerns regarding data-enabled services, which decreases their confidence and hinders the active selling and buying of these new services (Vaittinen et al., 2018; Vaittinen and Martinsuo, 2019). This research is motivated by the need to understand how manufacturers can build confidence in data-enabled services within their own organisation as well as among their external salespeople and customers. In this paper, service confidence is understood as a multidimensional construct that deals with feeling certain or believing that services are valuable and reliable and that the service provider can provide services in an effective and credible way.

To address this research gap, this study aims to conceptualise service confidence from multiple actors' viewpoints towards data-enabled services. The research questions are as follows: What kinds of requirements do different actors have towards building service confidence in bringing data-enabled services to market; and what are the different dimensions of service confidence? The focus of this study is on manufacturing firms and their key stakeholders involved in bringing new data-enabled services to market during servitization.

2. LITERATURE REVIEW

2.1 Adding New Data-Enabled Services

Many business-to-business manufacturers in mature markets are turning towards servitization as a way to avoid the so-called 'commodity trap' and increased price competition and to gain economic benefits (Baines and Lightfoot, 2013; Kindström and Kowalkowski, 2009). The servitization of manufacturing firms calls for changes at the strategic and operational levels. Changes in organisational forms and structures, performance measurement systems, management perspective and the service-related knowledge and skills of employees are among the key changes that may occur during the servitization journey (Martinez et al., 2017). Service addition in manufacturing firms is inhibited due to various internal and external barriers, such as technical competences, attitudes, business models, internal processes and customers' willingness to co-create value and pay for services (Matthyssens and Vandenbempt, 2010). The cognitive barriers may be quite significant: firms experience uncertainty about the outcomes of service-related investments and the economic potential of a service business, which may hinder the realisation of the related financial potential (Gebauer and Friedli, 2005).

Advances in digital technologies have enabled manufacturers to change their business models by providing new data-enabled services to enhance maintenance, repair and operational services (e.g. remote monitoring) and to provide advanced analytics and integration to manufacturing supply chains (Ehret and Wirtz, 2017). In particular, Internet of Things (IoT)-based services are often driven by production and process optimisation within customers' production systems (Kiel et al., 2017). In addition to new offerings and processes, it is important to consider the structural and human resource implications of IoT-based services (Baines et al., 2017). To utilise digital technologies, industrial firms need to develop digital capabilities, such as processing, analysing and interpreting data from the installed base (Ardolino et al., 2018), and they must require an alignment of the business models of different actors (Kohtamäki et al., 2019).

Previous research has already covered how and through which capabilities, sales approaches and methods manufacturers can add new services into their portfolios and move from product sales to service sales. New requirements are also needed for the sales function and the roles and competencies of salespeople (Kindström et al., 2015), the alignment of expectations between salespeople and customers and the capabilities needed for value-based selling and use-based pricing (Töytäri et al., 2011). Most of these studies deal with services (generally) and advanced services (specifically) instead of data-enabled services. To succeed in bringing data-enabled services to market, there is a need to convince salespeople about the reliability of such services (Vaittinen and Martinsuo, 2018) and often merely services in general.

2.2 Confidence in New Services

There is a consensus about the importance of a customer's acceptance of new services and the critical role of salespeople (Kindström et al., 2015). However, the literature on internal salespeople's role in servitization is quite scarce (Kindström et al., 2015), and it is even more rare for external salespeople. While advanced data-enabled services can potentially have a significant impact on customers' business processes (Story et al., 2017), customers need to be convinced about the benefits that will accrue to them (and not only the manufacturer) from data-enabled services. In complex service businesses, there is a need to go beyond dyadic interaction to explore dynamic interactions among multiple actors in the network (Alexander et al., 2017). Aminoff and Hakanen's (2018) study of manufacturers and distributors revealed that servitization implies new requirements for both manufacturers and distributors' operant resources; manufacturers need to develop relational ties and support distributors, and distributors need to develop relational ties and develop new solution sales, delivery and co-creation capabilities.

While the confidence of actors in bringing new services to market has not been studied previously, some studies have covered the challenges and barriers of servitization and offered insights on factors that may relate to service confidence. These factors can be divided into four main categories: strategy, roles and structures, capabilities and mindsets. The lack of a clear strategic direction may cause insecurities and confusion at the operational level (e.g. in sales and marketing functions) (Lenka et al., 2018). The value co-creation in supplier–customer relationships is often hindered by role ambiguities (i.e. unclear expectations, responsibilities and demands) (Sjödin et al., 2016). These role conflicts and confusion can dilute accountability (Lenka et al., 2018). The lack of capabilities or the mismatching of resources and capabilities can hinder the servitization process (Töytäri et al., 2018). Moreover, having service capabilities and experience in providing basic services could also facilitate offering new advanced services (Alvarez et al., 2015; Sousa and da Silveira, 2017). Finally, the mindset (i.e. beliefs, rules and norms) within the firm and at the interface of the firm and customers and other organisations regarding new services affects both the offering and the acquiring of services (Töytäri et al., 2018).

Few studies have explained and resolved the cognitive barriers to offering data-enabled services (Töytäri et al., 2018), and little is known about the early phase of bringing new data-enabled services to the market as well as the requirements within the organisation and outside its boundaries. It is these gaps that our study seeks to fill.

3. RESEARCH METHOD

To deepen the understanding of the service confidence of multiple actors in new data-enabled services, a qualitative case study was conducted in one manufacturing firm. The case company has a revenue of ~100 million Euros, and ~500 employees. The firm offers complex systems and services to industrial customers. It operates in the engineering and manufacturing sector, and its offerings are tailored for each customer and sold globally. The case was selected based on the increased importance of services in the company, its extensive effort towards developing new data-enabled services and its utilisation of both internal and external salespeople. The main data-enabled services include 24/7 technical remote support, predictive maintenance and remote system upgrades. The firm also offers and develops more advanced data-enabled services, such as data-based consulting services.

To collect rich data from the four actor groups in a real-life context, an embedded case study was conducted. Data were collected through 30 interviews: 6 in the service unit, 9 in the sales unit, 7 among external salespeople and 8 among customers. The interviewees were selected in collaboration with knowledgeable persons in the company to ensure that each participant was actively involved with either developing, selling or delivering services. The common interview themes with all actor groups included the current state of the service portfolio and experiences with the case company's services. In addition, some themes that were specific for each actor group were covered, such as the service portfolio and development with service people, the selling process and the needed skills with both sales groups, the relationship of the case company with both external actor groups and service procurement and delivery with customers. All interviews were recorded and transcribed.

A data analysis was conducted through a thematic analysis to define the codes and to identify the main themes. Each actor group's transcriptions were firstly read through and explored inductively to identify the requirements for bringing data-enabled services to market. While the focus was on data-enabled services, comments on other services were included when they were relevant to confidence in data-enabled services. By comparing the tentative themes for each actor group, the requirements for building confidence in data-enabled services were divided into four categories (Table 2). From these requirements, six categories of dimensions of service confidence emerged (Table 3).

4. FINDINGS

4.1. Requirements for Service Confidence

To bring new data-enabled services to market, the case company had to address service confidence issues in the different actor groups involved in offering and purchasing the new services. The most important requirements of each actor group for building confidence in data-enabled services are shown in Table 2. These requirements were categorised into four themes: internal, customer-related, relational and offering-related requirements.

Table 2. Requirements of different actor groups for building confidence in data-enabled services

	Service unit	**Internal sales unit**	**External sales firms**	**Customers**
Internal: requirements of different actor groups within their own organisation	• Value proposition communication (internally/to customers) • Service capabilities (resources, expertise, skills) • Customer service capabilities	• Service sales experience • Understanding customer value • Training on the practical service sales process • A clear service sales process • Clear and simple service sales material	• Being comfortable with services • Challenges: separate service sales and a strong product business	• Understanding added value (benefits vs. sacrifices) • Understanding links to existing systems and operation • Understanding links to production optimisation
Customer-related: requirements related to customers' organisations	• Customer understanding of added value • Data access to develop and pilot services • Data access to enable service delivery	• Customer demand • Customer knowledge about the value of the service • The customer's perspective on the cost of the contract	• Customers' understanding of their service needs • Customers should gamble less (i.e. could they go one more year without some service and save money)	*Non-applicable*
Relational: requirements of the actor groups in relation to/from other actors	• Clarification of value creation/capture between actors	• Collaboration with the service unit during the sales process	• Support from the case company • Faster responses from the case company • A good reciprocal relationship and knowing people	• Understanding impacts on dependency • Understanding impacts on relationship building
Offering-related: requirements concerning the service offering and service delivery	• Selection and prioritisation of services to be developed • Technical implementation • Secure data access • Data management and ownership	• Knowledge of service content • Understanding the pricing • Productised service • The capabilities of service delivery people • Solution reliability • Trust in the quality of basic services • Enough service delivery resources to support customers	• Knowledge of service content • Trust in service quality • Challenge: some are not selling the case company's services-only systems	• Understanding the offered service concept(s) • Service capability (availability, expertise) • Solution reliability • Data security

Requirements for Service Confidence in the Service Unit

For the internal service unit, convincing them of and communicating about the benefits of novel, data-enabled services was a focal requirement. For the internal organisation and a majority of the customers, data-enabled services represented novel solutions, and their particular content, potential benefits and needed capabilities were uncertain. Internally, the organisation had been focused on machine selling, and introducing data-enabled services required different, more service-focused orientation. Moreover, data-enabled services provided a means to develop closer customer relationships. Externally, customer value and communicating it to customers needed attention. The case company was also dependent on access to customers' data to build new services. Moreover, data-enabled services provided means to develop closer relationships. Interviewees generally expected that customers would see the benefits and the value-added. Data-enabled services necessitated skills, capabilities and resources in service delivery and customer service. Therefore, it appears that introducing data-enabled services is not only a technical issue because such services can also affect customers' processes beyond delivered solutions, which could require new skills and capabilities in certain areas, such as in developing a customer's entire production system. Some interviewees from the internal service and development areas were cautious about using customer-originated data as a basis for novel services. They stressed that the case company needs to avoid the impression that they would make money by using customers' data. Accordingly, introducing data-enabled services calls for discretion and communication with customers to clarify intentions, use of data and data security.

Requirements for Service Confidence in the Internal Sales Unit

Within the organisation, the salespeople needed the right competences, tools and techniques for selling data-enabled services and a clear service sales process. The salespeople were also more confident in offering services, including data-enabled services, when the customer proactively asked for the service and knew the value of the services as well as about possible increases in the contract's cost. Some respondents also explained that the customers' feedback on the quality of different types of services affected their willingness to sell more services. Organisational support through cooperative activities with service people was also important for improving salespeople's confidence in offering new data-enabled services to customers. However, interviews with salespeople did not highlight any specific relational requirements regarding external salespeople; the head of the sales unit explained that, when their own salespeople have concerns regarding the reliability of data-enabled services, they do not expect external salespeople to offer this type of service to customers. The most frequent reason for not selling data-enabled services was related to the service offering. The salespeople needed more information on the content and on the value of the services for customers, the reliability of the new services, the service delivery capabilities and the availability of service delivery resources. The findings revealed that the attitudes of salespeople towards data-enabled services were affected by their perceptions of the reliability of basic services and the capabilities of service delivery people in general.

Requirements for Service Confidence in External Sales Firms

External salespeople's internal requirements were often related to time pressures caused by other work and to services being the task of some other department in their company. In about half the external salespeople's interviews, services were highlighted as a way to keep the machines running; they also said that, in the future, there would be more emphasis on advanced data-enabled services. Only a few interviewees thought that customer needs regarding services would not change at all in the future. Almost all the interviewees considered the existing advanced services or the basic services from the case company rather expensive. A few interviewees also noted challenges with the availability of services. A few of the external salespeople also highlighted that customers usually do not understand their service needs before they face a problem, whether it is lack of training or a lack of support when the production line stops. The external salespeople expected support and materials for selling the case company's systems. They wanted to understand the case company's situation and priorities as well as know the people at the case company. The need for responsiveness was highlighted in more than half the external salespeople's interviews: two saw the case company as very responsive, whereas a few hoped for more responsiveness and resources to be able to answer their own and their customers' queries in a timely fashion. From the offering perspective, many external salespeople hoped that the case company's service offering would be well packaged and that they would have more knowledge about the company's services and systems. In addition, the reliability of the system and the services was described as an important aspect of the offering in the majority of these interviews. The reliability of the production was highlighted as a key requirement for their customers. Reliability was also noted as a challenge with current services (e.g. the delivery of spare parts was considered too slow).

Requirements for Service Confidence in Customer Firms

A majority of the interviewed customers expressed that they need to understand how data-enabled services would help them in practice. For example, they want to understand the actual service concept(s), the connection to the installed base, the related benefits and the price. Some customers also linked data-enabled services to broader production optimisation needs, and they were eager to know how they could benefit in that regard. A majority of customers emphasised that the case company's products are quite reliable, and they expected the same from the data-enabled services. Some customers also emphasised dependency issues in relation to data-enabled services. New services could tie customers closer to the case company. Depending on the viewpoint, it could be either a positive or a negative issue. Service capability, including service personnel availability and expertise, emerged as a focal issue to a majority of the customers interviewed. Worries about the case company's service capabilities primarily focused on the existing help-desk services. However, as many novel data-enabled services would rest on the same service infrastructure, it would play a role in how customers might respond to other data-enabled services. While a few customers explicitly raised concerns about the data security of novel data-enabled services, it was not highlighted as an insurmountable obstacle if the services would provide large enough benefits.

4.2 Dimensions of Service Confidence

The data analysis that was conducted across the requirements revealed six dimensions of confidence in relation to data-enabled services (See Table 3). The importance of the different dimensions was not the same for all actor groups. Table 3 shows how prevalent the dimensions were in the interviews.

Table 3. Dimensions of confidence in data-enabled services and how prevalent they were in the interviews of different actors (empty not mentioned at all, + some attention, ++ moderate attention +++ strong attention in the majority of the interviews)

Dimension	Definition	Service	Internal sales	External sales	Customer
Attitude towards services	How different actors feel about the service business and the case company's services	++	+++	+++	++
Confidence in service value	How the benefits that a customer receives exceed the price paid for data-enabled services and what kind of value the actors perceive that they get from the services	+++	+++	+++	+++
Confidence in service reliability	How well the system maintains its promised level of quality over time How well data-enabled service delivery fulfils the service promise in terms of responsiveness and quality of service delivery	++	+++	+++	++
Relational confidence	How different actors support one another in the process of offering data-enabled services	++	+++	+++	++
Competence	How each actor has the right knowledge and skills regarding data-enabled services How the case company supports different actors in developing their competences	++	++	++	+
Confidence in data security and management	How well the data are secured and that data management and ownership can be handled	+++		+	++

5. DISCUSSION

This study aimed to conceptualise service confidence in data-enabled services from multiple actors' viewpoints. The findings are framed as categories of requirements for service confidence and further divided into dimensions of service confidence. The study complements previous studies of servitization, which have mainly focused on the challenges of and required capabilities within manufacturers' (Gebauer and Friedli, 2005; Sousa and da Silveira, 2017) or in manufacturer–customer relationships (Kindström et al., 2015; Sjödin et al., 2016; Raddats et al., 2017). While this study acknowledges the internal and customer-related requirements, the findings emphasise that the requirements of external salespeople should also be considered to enhance service confidence. This aspect has been acknowledged in previous research (Vaittinen and Martinsuo, 2019). Importantly, the findings of this study show that, in addition to internal and relational considerations, manufacturers also need to consider offering-related requirements in building confidence because data-enabled services have specific characteristics that need to be understood by different actors. This paper also contributes to the discussion on digital servitization by offering new insights that are related to the motives, mindset, perceptions and requirements of different actors to launch data-enabled services, while the majority of prior studies have focused on strategic capabilities or business models (Ardolino et al., 2018; Kohtamäki et al., 2019).

We introduced the concept of service confidence as an important part of the manufacturer's transition towards more data-enabled services. The developed concept of service confidence can be seen as an attempt to integrate empirical evidence and conceptualise this less understood phenomenon. The analysis of the case company confirms prior research stating that the right mindset and attitude towards services are required for offering data-enabled services, not only for service adoption by customers (Töytäri et al., 2018) but also for building the confidence needed to bring data-enabled services to market. Data-enabled services have been recognised as a way to enhance customer value (Kiel et al., 2017; Momeni and Martinsuo, 2018). The findings of this study reveal that the customer (Töytäri et al., 2011) as well as the internal/external actors need to be confident about the total benefits of data-enabled services to successfully bring them to market (Vaittinen and Martinsuo, 2018). The analysis of the findings shows that the issue of reliability covers both data-enabled services and service delivery. The latter includes data-enabled services and the experiences of different actors about the delivery of other basic services. Our findings confirm the importance of relational ties between different actors (Aminoff and Hakanen, 2018) and show that having confidence in receiving support from other actors when bringing data-enabled services to market forms an integral part of total confidence in such services. Capabilities within the organisation and the business network have proven important to finding success in the adoption of data-enabled services (Töytäri et al., 2018). Moreover, strong existing capabilities for delivering basic services can facilitate the delivery of more advanced services (Sousa and da Silveira, 2017). Finally, the findings confirm that confidence about data security and management is needed, especially for actors who are involved in service delivery (i.e. service people and customers).

6. CONCLUSIONS

This study contributes to the servitization literature by exploring the cognitive needs of bringing data-enabled services to market (Gebauer and Friedli, 2005; Töytäri et al., 2018) and by providing a deeper understanding of the needs of different actors during this process. The research demonstrates that building confidence in data-enabled services in a multi-actor setting is needed when introducing new data-enabled services to the market. In addition, the findings show that the concerns and requirements of different actors regarding data-enabled services affect their confidence in offering (and accepting) new services. A connection was found between providing data-enabled services and basic services (Alvarez et al., 2015; Sousa and da Silveira, 2017). The confidence in data-enabled services does not exist in a vacuum; it is also related to previous experience with the service supplier and that supplier's credibility.

While advances in digital technologies have enabled manufacturers to provide new types of services to their customers, manufacturers struggle with the challenges of offering data-enabled services. The findings of this study indicate that, to build confidence in data-enabled services, manufacturers need to ensure that the requirements of each actor as well as the relational requirements between the relevant actors are met. The study also developed a conceptual framework of service confidence based on identified confidence dimensions. These findings could help manufacturers in their servitization development plans by emphasising the importance of the cognitive needs of different actors.

Notably, conducting the case study in one context limits the generalisability of the findings. This case study included data from the manufacturer, external salespeople and customers, but it would have benefited from data from external service providers and/or software suppliers. Regarding the relationship between the actors, this study did not cover the external sales–customer relationship. Additional multi-actor studies are needed to improve the validity of the findings because a single case cannot be generalised to a wider population, and different contexts may provide further dimensions and requirements to complement those in this study.

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AUTHORS

Dr Khadijeh Momeni
Industrial Engineering and Management, Tampere University, Tampere, Finland, FI-33100
+358451637676, khadijeh.momeni@tuni.fi

Dr Eija Vaittinen
Gofore Plc, Tampere, Finland, FI-33100
+358449991890, eija.vaittinen@gofore.com

Markus Jähi
Smart industry and energy systems, VTT Technical Research Centre of Finland ltd, Tampere, Finland, FI-33720
+358408421397, markus.jahi@vtt.fi

Prof. Miia Martinsuo
Industrial Engineering and Management, Tampere University, Tampere, Finland, FI-33100
+358408490895, miia.martinsuo@tuni.fi

DELIVERING HEAT-AS-A-SERVICE (HaaS): THE ROLE OF THE DIGITAL TWIN

Victor Guang Shi, Cansu Kandemir, Ruby Hughes, Miying Yang, Ahmad Beltagui, Andreas Schroeder, Omid Omidvar Tehrani, Raphael Wasserbauer

ABSTRACT
Purpose: Manufacturing companies use advanced services to safeguard against product commoditisation, increase loyalty with customer, protect the natural environment and reduce the social inequality. The core concept of advanced services concentrates on the strategic shift from transactional selling to the provision of complex products-service bundles, whereby manufacturers offer capabilities and outcomes instead of products alone. Doing so requires creative deployment of digital technologies such as the digital twin to enable successful advanced services.
Design/Methodology/Approach: This study focused on the needs to identify digital twin information assets to overcome problems during advanced services delivery. The research adopts a design science approach which describes a method that seeks to produce a pragmatic proposition for application to a specific contextual problem.
Findings: The proposed digital twin information assets involves three categories. First, the product information assets. Second, the service process information assets. Third, the use environment information assets, input from all three types of information assets create the digital twin that enables the advanced service value creation.
Originality/Value: Contribute to understand the role and use of digital twin information assets for successful advanced service delivery.

KEYWORDS: Heat-as-a-Service, Advanced Services, Digital Twin, Information Asset

1. INTRODUCTION

Manufacturers offering Advanced Services (AS) range from construction equipment manufacturers' service contracts based on volume of rock extracted from the ground to trucking manufacturers offering pay-by-the-miles contract to logistic service providers (Baines et al., 2017). They have in common a focus on delivering outcomes, rather than products. This study is focused on a UK based manufacturer of domestic heating products, seeking to deliver the outcome of Heat as a Service (Haas) using a digital twin.

Successful advanced services implementation requires creative realisation of value from digitally enabled services (Baines & Lightfoot, 2014). Despite many potential benefits of digitalisation for advanced services, manufacturing practitioners are still unclear how they can fully capitalise on the value of digital technologies (Schroeder, Ziaee Bigdeli, Galera Zarco, & Baines, 2019).

In the transactional based value delivery system, the heating product manufacturers receives payment based on delivery of product and aftermarket service warranties of their product. Once the manufacturer has delivered its finished product to the building contractor, the responsibility for its maintenance is then transferred to the customer, any ongoing service operations of the assets become cost to the customer and revenue streams to the manufacturer (or independent service providers). According to Baines and Shi (2015) such misalignment of incentives has prohibited the continued circular economy potential, therefore, potentially increased greenhouse gas emission from domestic heating (BEIS, 2019).

In the advanced service value proposition such as HaaS, manufactures receive payment based on delivery of the agreed temperature or comfort rather than the heating systems. The relationships with the social housing customers is ongoing. The heating manufacturers would continue to hold the responsibilities and ownerships of the heating systems to ensure annual 'cost down' commitment to the social housing customers.

The Digital Twin (DT) concept offers the potential to reduce the risks of advanced service delivery. The traditional engineering design techniques such as engineering design vee and quantitative scenario analysis are often inadequate in addressing unpredicted and undesirable risks (Grieves & Vickers, 2017). For example, modelling coordination of complex network of interdependent actors for the purpose to balance cost and service level performance of advanced service offering (Pawar, Beltagui, & Riedel, 2009). The digital twin through mirroring the physical model in virtual space and in real-time enables the remote monitoring of the product, analyses the failure behaviour of its actual use and the prediction of its maintenance requirement (GE, 2018).

The purpose of this study is to explore the role of digital twin through a single case study of an UK based heating product manufacturers that has had an accomplished history in product based after-market service operations and an established remote monitoring capacity of their heating system. While the manufacturer realises potential economic, environmental and social benefit of digital twin in enabling HaaS value proposition, there is still uncertainties of what DT information assets can be developed when offering HaaS for their social housing customers. This study extends the DT application to the AS delivery process and the use environment level, to identify different types of DT information assets, where information assets captured in the digital twin environment can be grouped by three different categories, the product level, the service delivery process level and the customer use environment level.

2. BACKGROUND

A complex socio-technical network of interdependent firms is required to facilitate the creation and delivery of the advanced service value proposition (Garcia-Martin, Schroeder, & Bigdeli, 2019). Undesirable behaviours both deliberate and accidental at local level can potentially cascade into system level performance failures.

Theoretically, advanced service delivery risks can be traced back to Perrow's seminal work on the inherent risk of complex systems (Perrow, 1984). Considering in advanced services, scholars found when customers are removed from the asset ownerships without capability to safeguard against the asset, could potentially lead to increased cost (Baines & Lightfoot, 2014; Shi et al., 2017). Also, tightly coupled connections of the diverse and complex inter-organisational interactions can put advanced service delivery at risk to unpredicted undesirable behaviours (Grieves & Vickers, 2017).

Scholars suggest, DT can help advanced service providers to de-risk the number of complex system problems during advanced service delivery. For example, the DT of an aero engine represents core aspects of product physical equivalent (e.g. extent of use), correlating component sensor reading predicts its behaviour (e.g. deterioration, failure) and suggests when and how it should be repaired (Zaccaria, Stenfelt, Aslanidou, & Kyprianidis, 2018). DT technology can also be applied in supply chain and operations processes, Ivanov (2020) use digital twin in supply chains to predict the economic impacts of COVID 19 outbreaks, they found the timing of the closing and opening of facilities at different supply tiers contribute more impact on supply chain performance than an upstream disruption duration or the speed of epidemic propagation. This process-focused DT facilitates dynamic simulation with optimisation to evaluate global supply chain performance in real-time. More recently, DT has been applied to understand the use environment in hospital operations, where digital representations of medical devices, treatment processes and patients flows are integrated to manage, simulate and optimise hospital management, design, and healthcare (Liu et al., 2019).

Previous servitization research has considered DTs, it has generally focused on the creation of product level information assets to support AS delivery (e.g. Martinez Hernandez, Neely, Ouyang, Burstall, & Bisessar, 2018). The present study explicitly distinguish digital twin information assets can be developed beyond product level. Specifically, information asset at the AS delivery process level and the customer use environment level. Since digital twin information assets can be accessed and used with the consent of inter-organisational owner. For example, digital twin information assets at service delivery process level requires shared data from independent service fleet such as their timetable, daily capacity, skill levels and GIS locations, as well as social housing customers' availability, expected lead times, satisfaction of services received and expected comfort. These information assets can be used together with AS provider's core product level information assets such as sensor reading that connect to condition monitoring and predictive maintenance algorithms developed for heating systems.

Hence, complex socio-technical scenarios with complex inter-organisational interaction create digital twin information assets at different levels. This study contribute to creating a novel understanding of digital twin information assets for advanced services, which is validated and refined through its application to the case of a Heat-as-a-Service (HaaS) value proposition created by a domestic heating product manufacturer.

3. METHOD

The research adopts a design science approach which describes a method that seeks to produce a pragmatic proposition for application to a specific contextual problem (Oliva, 2019). In doing so, it generates a contribution to knowledge by simultaneously expanding the problem and solution space (Hatchuel, Weil, & Le Masson, 2013). In other words, understanding the problem of how to manage an AS delivery network by developing a potential solution in the form of a delivery network DT. The research centred on a collaboration between the academic team and a manufacturer of domestic heating products. These parties met frequently over a 9-month period to develop a proof of concept model of the proposed DT. This necessitated and enabled an understanding of the context and information assets requirement, leading to identification of three types of digital twin information assets for implementing HaaS and directions for further research on DT as an enabler of AS.

Currently, the manufacturer – referred to as HeatCo. – produces a wide range of heating products, for domestic and industrial use. With many thousands of products in use, there is a large installed base, but no contact with the customers and hence no opportunity to deliver additional value through service. Indeed, HeatCo's products are normally sold to independent contractors that deal directly with a customer, organising installation and maintenance services, including an annual inspection to maintain the warranty. These products are typically guaranteed for up to 10 years, yet HeatCo gains only limited insight due to a lack of direct customer interactions.

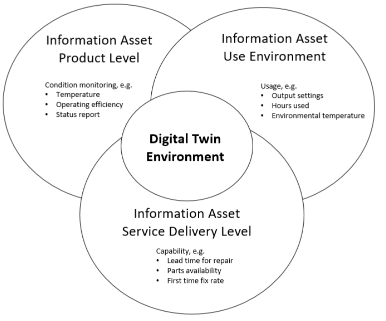
HaaS is seen as a promising and potentially necessary strategy, and the first step has been to install sensors into the control board of the heating device, to gather data on the product and facilitate service delivery. The research in this setting involved capturing some of the available data – from approximately 700 domestic customers – for analysis. This helped to reveal current potential and further data requirements for developing digital twin information asset at the product, service and use environment level.

4. RESULTS

The envisioned HaaS delivery network focused on three main categories of actors – manufacturer, service contractor, user/customer – to identify information assets from the product, service and use level, as shown in figure 1. Whereas the current business model sees limited interaction between the actors, the HaaS model relies upon integration between them and alignment of their interests. At present, customers pay for a product and services separately. A customer cannot predict their usage and cannot see a direct relationship between their use of the product (e.g. the temperature on a given day) and their monthly fuel bill.

The aim of HaaS would be to agree a fee based on the outcome, in this case degrees of temperature in specific parts of the home at specific times. The manufacturer is then charged with the responsibility of ensuring this outcome. Consequently, HeatCo requires digital twin at the use environment level, information assets such as how often and how much the product is required, as well as interact with digital twin at product level – information assets such as its heat efficiency in relation to product design specifications. These digital twin information assets at different levels enable three actions. 1) Improvement of product design based on use; 2) Prediction of product errors and maintenance requirements; 3) Prioritisation of repairs and co-ordination of maintenance. The last requires information assets at service delivery level with the independent contractors who are best placed to deliver the maintenance and allows HeatCo to incentivise work. For example, contractors may be paid according to the quality of their work, and the access to customer feedback information, as well as receiving greater payments for completing high priority repairs.

Figure 1 – Digital twin information assets at different level for envisioned HaaS delivery network

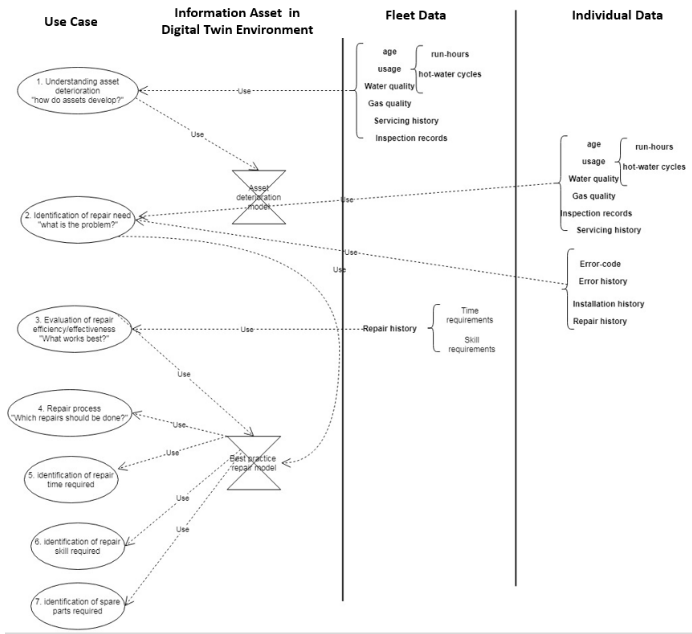


The envisioned AS is enabled by digital twin information assets at different levels of application. A number of challenges and use cases were used to guide the development of the DT proof-of-concept. One of these, demonstrated in figure 2, relates to the problem of reducing second-visits. In a nutshell, the issue is that presently customers may report a malfunctioning product, but without an accurate diagnosis, a visiting service engineer may not be able to repair the fault first time. This necessitates a second visit, for example if the engineer arrives with the wrong parts or has insufficient time available to carry out the full repair. The DT can address such problems by integrating digital twin from the product level to increase the likelihood of a correct diagnosis, and digital twin at the service delivery level to ensure an engineer with the correct skills and the availability of the correct parts.

Figure 2 provides a schematic representation of how information assets are developed and interact in the DT environment. Combination of different digital twin information assets can help to create digital twin environment, which describes the range of data captured across the number of installations. Individual data describes the specific installation or service contract in question. 'Information asset created' (represented by the hour-glass) describes the thresholds and algorithms that capture the logic of the installations. In operation the DT environment continuously captures and analyses the fleet data to understand the patterns of product/asset deterioration. This fleet data includes input from product level (e.g. age), and the customer use level (e.g. run-hours) and service delivery level (e.g. servicing history). The integration of these diverse data sources provides insights into the deterioration patterns of the product as a critical information asset. Hence, the DT platform creates and holds this information asset and interprets the individual data to help the manufacturer understand the likely state of a specific installation and, together with any error-codes, determine the repair need. A reliable prediction of the repair need can reduce the risk of an engineer's second visit.

Figure 2 further shows how the DT environment would utilise the fleet level data on previous repairs in order to determine the effectiveness of repair approaches and specify a best practice repair model that suggests the approximate time and specific skills required for a faulty installation in question. Again, with the creation and application of the asset repair model the manufacturer can better schedule the repair engineer and reduce the risk of a second visit.

Figure 2 – information asset associated with 'second visit' challenge



5. DISCUSSION

The research set out to explore how the digital twin can support the delivery of advanced services. The research used the case of a heating product manufacturer to identify the use of different types of digital twin information assets to overcome complex problems of AS and investigate how these challenges can be addressed by the DT. Several key insights have been generated by this research.

The research has provided considerable insights into the identification of digital twin information assets for AS. A sizable number of studies already emphasise how the recent information technology innovations (i.e. internet of things and DT) can contribute to AS, based on their ability to monitor the product (e.g. Schroeder et al., 2019); but often little insights are provided on the specific nature and pathway of the contributions. Our research shows that digital twin information assets used for product monitoring is only a necessary but not sufficient intermediate step to overcome complex problems of advanced service delivery. Successful advanced service delivery requires integrated development of information assets in the digital twin environment.

The research has helped to clarify the critical dual role of the DT in AS. The DT's role as a remote monitoring tool is widely recognised. It serves to provide a near-real-time digital replication of the product which facilitates the manufacturer's remote diagnostics and repair efforts (Zaccaria et al., 2018). However, our study contributes to identify and integrate DT information assets at different levels to effectively operationalize and scale the remote diagnostic efforts. DT technology enables the manufacturer to routinely capture fleet data across different use-contexts and service-arrangements to create the critical insights that help to interpret the data from the individual product or service in question.

By highlighting the DT's role in creating these information assets our study also emphasises the need to understand the DT development as a long-term effort. Creating an understanding of the patterns and trends that help to interpret and predict the state of a product requires capturing data from different products across different use-scenarios over extended time-frames. Hence, while the use of DT to monitor products can be set up in relatively short term, the use of integrated multi-level DT requires long-term efforts and strategic considerations.

The study has shed light on the DT as a critical tool in the delivery of AS but has also shown that, in order to make full use of its potential, the extended scope of AS need to be reconsidered. An AS implies a long-term transformation effort that goes beyond the consideration of products to include services and customers. In order to draw on its full potential the DT development needs to reflect this extended scope of the AS and we hope that this study contributes to the consideration of this extended scope in future DT developments.

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AUTHORS

Dr. Victor Guang Shi
AMRC, University of Sheffield
S60 5TZ
guang.shi@sheffield.ac.uk

Dr Cansu Kandemir
AMRC, University of Sheffield
S60 5TZ
c.kandemir@sheffield.ac.uk

Dr Ruby Hughes
AMRC, University of Sheffield
S60 5TZ
ruby.hughes@sheffield.ac.uk

Dr Miying Yang
University of Exeter, College of Engineering
EX4 4PY
M.Yang2@exeter.ac.uk

Dr Ahmad Beltagui
Aston Business School, UK; Advanced Services Group
B4 7ET
a.beltagui@aston.ac.uk

Dr Andreas Schroeder
Aston Business School, UK; Advanced Services Group
B4 7ET
a.schroeder@aston.ac.uk

Dr Omid Omidvar Tehrani
Aston Business School, UK; Advanced Services Group
B4 7ET
o.omidvar-tehrani@aston.ac.uk

Dr Raphael Wasserbauer
Linköping University, Department of Management and Engineering
581 83
raphael.wasserbaur@liu.se

BUSINESS ECOSYSTEMS FOR DIGITAL SERVITIZATION

Alexander Arzt, Sebastian Haugk, Heiko Gebauer

ABSTRACT
Purpose: This paper aims at conceptualizing an holistic approach for assessing and characterizing ecosystem types in the context of digital offerings.
Design/Methodology/Approach: We conducted a systematic literature review to summarize relevant aspects of ecosystems in the context of digital servitization.
Findings: We developed a framework in form of a morphological box that combines various relevant aspects of ecosystems within five overarching dimensions.
Originality/Value: Our framework can be of value for both researchers and practitioners for assessing and characterizing ecosystems in the context of digital offerings.

KEYWORDS: Digitalization, Ecosystems, Servitization, Digital Offerings, Internet of Things, Digital Platforms.

1. INTRODUCTION
In the past decades, manufacturing companies shifted from selling products to offering combinations of products and services (Vandermerwe & Rada 1988). This phenomenon, subsumed by the term servitization, has been described extensively. Recently, digital technologies such as connectivity, the Internet of Things (IoT), Big Data, and Artificial Intelligence opened up new opportunities for value creation (Gebauer et al. 2020, Paschou et al. 2020). Manufacturing companies use digital technologies to expand their product and service portfolio through digital offerings, such as digital hardware features, software applications or novel data-driven services. The convergence of the phenomena of digital technologies and servitization has emerged under the term digital servitization (Paschou et al. 2020, Kohtamäki et al. 2019, Bustinza et al. 2018, Vendrell-Herrero et al. 2017). Many manufacturing companies proceed to sell outcome-based services, combining their physical and digital capabilities to guarantee performance levels of products and services. Such a business model innovation implies a shift in how value is created, delivered, and captured (Sjödin et al. 2020). This evolution affects firm boundaries and implies ecosystem thinking. Developing and providing digital offerings requires high investments and specialized capabilities. Therefore, companies form partnerships with various actors in order to share resources and capabilities to co-create value (e.g. analyzing and maintaining product components, developing software). Thereby, IoT platforms are means to store, combine and analyze data, and to share responsibilities in the value creation process. Thus, companies are able to address complex customer problems, such as guaranteeing outcomes of whole systems of assets (Gebauer et al. 2020).

Interaction across firm-boundaries implies ecosystem thinking. The ecosystem concept relates to the relational view of the firm, which focusses on the assumption that competitive advantage can be gained through the joint contributions of specific alliance partners and the service ecosystem (Dyer & Singh 1998). Accordingly, an effectively managed and organized network can be a source of competitive advantage (Senn 2017, Eloranta & Turunen 2015). The term 'ecosystem' has become popular in servitization literature. However, there is still confusion about its differentiation to related terms (Adner 2017), such as business network (Möller et al. 2005), service system (Maglio & Spohrer 2008), or platform (Gawer & Cusumano 2014). Definitions among scholars vary depending on perspectives on and contexts of ecosystems.

2. METHODOLOGY
Based on a literature review, we discuss how ecosystems are perceived in literature related to digital servitization. We shed light on existing approaches for assessing and describing ecosystems.

Thereupon we undertake first steps to build a framework for characterizing and categorizing ecosystems in the context of digital offerings.

We conducted a systematic literature review (Tranfield et al. 2003). The Scopus database was used to identify relevant literature. We screened title, abstract and keyword fields of journal articles in the subject area ‘Business, Management & Accounting’ and ‘Computer Science’ using various terms connected to ecosystems in the context of digital servitization such as ‘servitization’, ‘ecosystem’, ‘network’, ‘system’, ‘platform’, and ‘digital’. We included only journal articles in English language that were published since 2010. 51 articles met these search criteria and were retrieved. Two members of the research team read the abstracts of these articles and decided about whether it should be included based on its relatedness to the ecosystem focus. At this point 36 articles were selected to be analyzed. Through a snowballing approach (Greenhalgh & Peacock 2005), other papers in the original sample’s references and subsequent papers that referenced the original sample’s articles were considered. 11 additional papers were added to the final list. In total 47 papers met all criteria for inclusion in the review.

3. ECOSYSTEM CONCEPT

3.1 Origins

The term ‘ecosystem’ originates in ecology and refers to "animals and plants in a particular area, and the way in which they are related to each other and to their environment" (Longman 1978). A key aspect of ecosystems is that the entire system is affected by interdependent participants and their individual activities and interactions. Moore (1996) applied the term in a business context to describe economic communities. He developed the business ecosystem concept emphasizing relationships between companies and various actors such as suppliers, customers, stakeholders, competitors, trade associations or government organizations. Moore (1996) defines business ecosystems as “an economic community supported by a foundation of interacting organizations and individuals – the organisms of the business world. (...) Over time, they coevolve their capabilities and roles, and tend to align themselves with the direction set by one or more central companies” (S. 26). Related to Moore’s approach, Iansiti & Levien (2004) examined relationships between actors in complex business environments. They define business networks as ecosystems organized around a keystone species. In that sense ecosystems are “characterized by a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival” (Iansiti & Levien 2004, p. 40).

However, scholars’ understanding and usage of the term ‘ecosystem’ varies. Mostly the term is used for describing constellations of interconnected actors in various context (Jacobides et al. 2018). Senn (2017) summarizes that “ecosystem thinking is about understanding the complexity of value creation in actor-to-actor networks and applying consequential implications to strategy and business model development” (p. 246). Adner (2017) differentiates two perspectives on ecosystems. The ecosystem-as-affiliation perspective focuses on communities of associated actors defined by their networks and platform affiliations whereas the ecosystem-as-structure perspective focuses on configurations of activity defined by a value proposition. Following the ecosystem-as-structure perspective, Adner defines ecosystems as “the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize” (Adner 2017, p. 42). In this ecosystem understanding, multilateral relationships are not decomposable into multiple bilateral relationships. However, when actors pursue multiple value propositions, they can be part of various ecosystems in different positions (Adner 2017). Based on an extensive literature review, Jacobides et al. (2018) subsume ecosystems as “a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled" (p. 2264).

3.2 Service ecosystems

The service ecosystem concept derived from S-D logic (Vargo & Lusch 2004) as a way to understand business models in an increasingly connected world (Ng & Wakenshaw, 2018). In accordance with S-D logic, service-for-service exchange is the basis for service science. Thus, service ecosystems provide a framework for studying the interaction, the integration of resources and capabilities, and the value co-creation processes among multiple actors and service systems (Vargo & Lusch 2017). Vargo & Lusch (2011) define service ecosystems as “spontaneously sensing and responding spatial and temporal structure of largely loosely coupled, value-proposing social and economic actors interacting through institutions, technology, and language to (1) co-produce service offerings, (2) engage in mutual service provision, and (3) co-create value“ (p. 185). They connect actors through services that foster mutual value creation and a shared institutional logic. Service ecosystems are characterized as relatively self-contained and self-adjusting systems of actors, which integrate dynamic resources and share service capabilities to co-create value (Lusch & Nambisan 2015, Ng & Wakenshaw 2018).

In practice, service ecosystems are means for new service offerings, improved efficiency and growth (Senn 2017, Subramaniam 2019). Gebauer et al (2013) emphasize that each actor within service ecosystems contributes to service offerings. The respective contribution depends on core competences of the actor and its cooperation with other actors. Service ecosystems provide coordination between units that still maintain their autonomy. Service ecosystems require a set of dynamic capabilities to initiate the formation of the network and operational capabilities to realize service components (Gebauer et al. 2013). Dynamic capabilities refer for example to the ability to recognize business opportunities, to react adequately to surrounding conditions, to mobilize ecosystem actors and to orchestrate them in dynamic cooperative and competitive activities (Enkel et al. 2020, Bogers et al. 2019). Moreover, communicative capabilities (e.g. to build trusting relationships) and knowledge management capabilities (e.g. absorbing and assimilating distant knowledge, reusing acquired knowledge) boost efficiency and effectiveness of ecosystems (Enkel et al. 2020).

3.3 Impact of digitalization on ecosystems

Digital technology enables new ways for generating, sharing, retrieving, and storing data, information or knowledge and changes the way organizations manage their boundaries. Companies are required to engage in managing entire ecosystems where complementary partners co-create new solutions (Enkel et al. 2020). Thus, digitalization advances servitization and leads to an increasingly networked economy. Digital technologies such as connectivity, IoT, and artificial intelligence enable novel product and service offerings in complex business scenarios that reshape industry competition (Beverungen 2019, Coreynen et al. 2017, Porter & Heppelmann 2014). Kohtamäki et al. (2019) define digital servitization as “the transition toward smart product-service-software systems that enable value creation and capture through monitoring, control, optimization, and autonomous function” (Kohtamäki et al. 2019, p. 383).

Manufacturing firms use digital technologies to expand product capabilities through digital features, to increase customer value through data-driven services and applications, and to optimize service delivery efficiency (Gebauer et al. 2020). Industrial manufacturers shift from selling products to selling outcome-based services that reduce customer risks through performance guarantees of products and services (Sjödin et al. 2020). This trend requires the development of new strategic assets and competitive advantages based on data and information (Paschou 2020). Digital offerings entail high investments into technology, large and robust data sets and specialized capabilities for data analytics which is beyond firm boundaries. Therefore, companies integrate suppliers, customers, partners, and stakeholders in a mutual value co-creation process (Papert & Pflaum 2017). In summary, digital technologies drive a transformational process of industrial firms as they develop and operate digital offerings across organizational boundaries within ecosystems (Kohtamäki et al. 2019, Bustinza et al. 2015, Kowalkowski et al. 2017, Rabetino & Kohtamäki 2018, Salonen & Jaakkola 2015, Sklyar et al. 2019, Porter & Heppelmann 2014).

Digitalization does not only drive ecosystem thinking, it also facilitates the management and reconfiguration of ecosystems (Kohtamäki et al. 2019, Sklyar et al. 2019, Parida et al. 2016). For example, scholars argue that digital technologies can increase the embeddedness of ecosystem actors (Story et al. 2017) and facilitate new relationships and strengthen existing ones (Parida 2016). Through connectivity and IT infrastructures ecosystem actors can integrate their resources and share knowledge more easily (Senn 2017). Digital technologies can serve as means to align ecosystem actors, to improve coordination and generate further collaboration (Sklyar et al. 2019). However, in order to exploit these opportunities, new organizational procedures and structures are necessary which require a sufficient understanding of the ecosystem and the ability to influence it (Kowalkowski & Ulaga 2017, Cenamor et al. 2017).

3.4 Digital Platforms

Digital platforms are closely related to ecosystems and serve as an organizational form based on a shared technological architecture and governance mechanisms to manage autonomous complementors pursuing mutual value propositions (Saadatmand et al. 2019, Adner 2017, Jacobides et al. 2018, Ozalp et al. 2018). There are various conceptualizations of digital platforms. From a technical perspective, platforms are an extensible codebase that can be complemented by the ecosystem that comprises third-party modules. From a sociotechnical perspective, digital platforms consist of technical elements, such as software and hardware, and organizational processes and standards (De Reuver et al. 2018). Digital platforms incorporate various modules, such as applications, services or systems, often from third parties, that extend the functionality of a software product. As such, digital platforms leverage the value of digital and information technologies for advanced service offerings (Cenamor et al. 2017). Digital service platforms enhance interaction, resource integration and coordination to facilitate efficient interaction and value creation in service ecosystems (Hein et al. 2019, Cenamor et al. 2017, Lusch & Nambisan 2015). Companies use platforms to leverage the expertise and ingenuity of complementors to create new capabilities (Saadatmand et al. 2019, de Reuver et al. 2018, Nambisan 2017).

Platform ecosystems refer to the platform and its network of complementors (McIntyre et al. 2017). Drawing upon the value platform concept and the focus on value in use, Perks (2017) suggests that “the value of a platform is determined by the network actors based on the platform’s perceived ability to facilitate (…) achievements of the actors’ goals” (Perks 2017, p. 7). IoT based business ecosystems comprise an interdependent community beyond the boundaries of traditional industry relations including for example sensor manufacturers, software and application developers and customers in various different environments (Rong et al. 2015). Platform complementors are in a state of coopetition, competing individually and cooperating by interacting through the digital platform (Cennamo & Santaló 2019, Ozalp et al. 2018). IoT platforms in the B2B context are used for business-critical processes involving sophisticated services requiring complex value co-creation practices. Therefore, platform owners need to ensure device management, sensor and machine compatibility, data storage, and communication protocols according to the demand of industrial customers (Hein et al. 2018). In order to facilitate resource integration, digital platforms provide boundary resources such as application programming interfaces (APIs) or software development kits (SDKs) (Ghazawneh & Henfridsson 2013).

4. DIMENSIONS FOR CHARACTERIZING ECOSYSTEMS

In the servitization literature, ecosystems have been approached from various perspectives regarding different dimensions. In the following, we bring various approaches together and summarize what aspects have been addressed to describe and assess ecosystems.

4.1 Ecosystem context

The context dimension comprises general conditions and the mission of ecosystems. For example, ecosystems can focus on realizing new or more complex value propositions (product/service innovation), on improving existing offerings, or on improving efficiency of value creation processes. Subramaniam et al. (2019) differentiate between production ecosystems and consumption ecosystems. Production ecosystems entail interdependencies in the value chain context (e.g. production and service delivery) whereas consumption ecosystems involve interdependencies afterwards when products or services are consumed. Moreover, ecosystems can be differentiated based on their scope. For example, Gawer and Cusumano (2014) differentiate between company-specific and industry-wide digital platforms. In addition, we suggest that ecosystems can be industry-specific, cross-industry-specific or non-specific (e.g. open industry boundaries). Another contextual aspect concerns the involved actors. Ecosystems with few actors may differ significantly from ecosystems involving a large number of heterogeneous actors. Ecosystems can involve mostly intrafirm actors, associated actors within an existing firm network or rather unassociated actors. These actors can be similar or different, for example in terms of size, revenues, or industry and customer focus. Research reported that the number and heterogeneity of actors contributing to the platform is positively correlated to the variety of complements and, thus, to a successful platform (Jacobides et al. 2018). However, if complementors are heterogeneous, it can be difficult to ensure a stable quality level of complements (Wareham et al. 2014). Lusch and Nambisan (2015) emphasize structural flexibility which refers to how easily different configurations of actors can participate and collaborate in the ecosystem. It is argued that, through interaction, ecosystem actors learn from each other and thus increase the capabilities within the ecosystem.

4.2 Relationship among ecosystem actors

The relationships between ecosystem actors has been characterized through several terms. Lusch & Nambisan (2015) emphasize structural integrity, which refers to the degree of coupling between ecosystem actors as an indicator for ecosystem engagement. Structural integrity of service ecosystems is provided through shared competences, relationships, and information based on common standards and protocols. In order to bridge the cognitive distance between the involved actors, service ecosystems promote a shared worldview through shared institutional logics and shared business or cultural assumptions so that actors obtain a common perspective and can interpret resource integration opportunities and align more quickly on resource exchange (Lusch and Nambisan 2015, Hein et al. 2019). Sklyar et al. (2019) draw upon the embeddedness concept from Granovetter (1992) which emphasizes that economic action and outcomes depend on the pairwise relations of the respective actors and on the overall structure of the network of relations (Granovetter 1992, p. 33). The degree of embeddedness depends on the closeness between actors within the ecosystem, which manifest in high levels of adaptation (Baraldi et al. 2012). Moran (2005) differentiates between intrafirm and interfirm relational embeddedness. Gebauer et al. (2013) emphasize the horizontal and vertical dimension in the context of service networks. The vertical dimension refers to collaborating firms that cover different hierarchical levels in the value chain. The horizontal dimension refers to firms that are on the same hierarchical level but in different value chains. This includes for example firms creating additional service components, third party products or integration services. Ecosystems can involve vertically related actors, horizontally related actors or both. Complementors are in a state of coopetition, which means they are collaborating and competing at the same time. They contribute resources and capabilities, which benefit the overall ecosystem. At the same time, they focus on their own portfolio and expertise to create value-adding solutions while striving for competitive differentiation. We differentiate between direct (e.g. similar components) and indirect competition (e.g. different components, but similar goals) among ecosystem actors. The level of competition can be intense, moderate or low. Scholars suggest that moderate competition stimulates innovation whereas intense competition tends to undermine it (Boudreau 2012). Thus, platforms need to secure a balance between complementarity and competitiveness among complementors (de Reuver et al. 2018).

4.3 Actor role within the ecosystem

In the process of value co-creation, ecosystem actors take different roles. According to Lusch and Nambisan (2015), all firms within service ecosystems undertake the dual roles of service offerer and service beneficiary. They differentiate between the three beneficiary roles ideator, designer, and intermediary that all integrate existing resources and knowledge with peers to enable new service opportunities. Ideators integrate knowledge about needs and specific work contexts to envision new services. Designers mix and match knowledge components or resources to develop and configure new services. Intermediaries make non-obvious connections between ecosystems and distribute knowledge across multiple service ecosystems in order to facilitate service innovation (Lusch &

Nambisan 2015). Ecosystems comprise physical layers (products and services) and digital layers (platform, data, digital services) (Senn 2017). Ecosystem actors provide value across these layers. Rauen et al. (2018) mention six layers of IoT platform ecosystems: IoT infrastructure providers, platform providers, software developers, equipment manufacturers, service providers, and plant operators. As firms are in a state of coopetition, they can be competitors and complementors on the same layer (e.g. competing or complementing services) or across layers (e.g. competing or complementing products and services) at the same time.

4.4 Governance

In order to facilitate value co-creation, ecosystem governance is necessary. Vargo & Lusch (2011) emphasize the importance of institutions as human-made rules, norms and beliefs. Accordingly, the more actors share an institution, the better the coordination is within the ecosystem. Coordination mechanisms can involve implicit and explicit norms as well as formal and informal enforcement guarantees of institutions (Langley et al. 2020). Institutional arrangements create expectations of actor behaviour and have regulative, normative and cognitive functions in the value creation process (Langley et al. 2020, Kleinaltenkamp 2018). Thus, they define how interactions among the ecosystem actors are governed and can range from an open policy to restrictive rules (Hein et al. 2019, Lusch & Nambisan 2015, Schreieck et al. 2018). However, as ecosystems in the context of digital servitization include many different actors, their respective institutional arrangements intersect and overlap. They can be incompatible and conflicting, what then leads to tensions within and across organizations (Langley et al. 2020, Vargo et al. 2015). Therefore, Vargo & Lusch (2015) emphasize the contextual and phenomenological nature of value and regard value-in-context as a central aspect to value creation and critical innovation factor.

Platforms can serve as enabler for coordination and distribution of responsibilities among different actors for value co-creation. Assuring complementor engagement and their compliance with the platform's rules and processes is a critical success factor (Saadatmand et al. 2019). Transparency of rules and transparency of the actors' contributions is important to provide an architecture of participation and interaction (Lusch & Nambisan 2015). In that context, it is necessary to create and maintain a coherent, shared identity for the platform and to balance the interests of complementors and other players in the ecosystem (Parker et al. 2017). Platform organizations are challenged to discover and implement complex value propositions through the ecosystem and to promote and facilitate autonomous co-creation of independent complementors to satisfy customer needs. At the same time, they need to ensure benefits from the collective value-creation efforts (Dattée et al. 2018). Therefore, institutional logics such as organizational structures, activities, actors, positions, and links need to be aligned (Lusch & Nambisan 2015, Adner 2017).

Jacobides et al. (2018) argue that ecosystems are the result of a partly designed process. For example, they can be open or closed, imposed or emergent, based on clear rules or on expectations. In the context of digital platforms, openness does not only relate to organizational arrangements, e.g. entrance and exit rules, but also to technologies such as APIs and software development kits (SDKs) (De Reuver et al. 2018). As rights and rules may be embedded in the technology itself, the platform architecture has implications for its governance (Saadatmand et al. 2019, Jacobides et al. 2018, Nambisan 2017). Boundary resources are necessary to operate ecosystems and to facilitate scalable resource integration. On digital platforms, boundary resources comprise software tools such as programming interfaces (API) and software development kits (SDKs) and regulations facilitating an arms' length relationship between platform provider and app developer (de Reuver et al. 2018, Hein et al. 2019, Ghazawneh & Henfridsson 2013). These tools can help to increase compliance of complementor technology with platform standards.

Decision rights can be concentrated on few ecosystem actors, distributed across various actors, or shared among all contributors. The distribution of decision rights among ecosystem complementors affects their opportunities for value capture (Saadatmand et al. 2019). Pagani (2013) considers a value network as a configuration of control points. Accordingly, within value networks, profits and competitive advantages reside dynamically at control points. Thus, ecosystems involve control point constellations and positions of greatest value and/or power. Control point holders control how networks operate, how benefits are redistributed, and how digital business strategies are executed. Decisions about the degree of architectural openness (e.g. data access, component interoperability, extension coupling) and the allocation of decision rights shape platform complementor opportunities as well as the perceived uncertainty and complementors' willingness to cope with it (Saadatmand et al. 2019, Nambisan 2017). Ecosystems involve tensions between value creation and value capture, especially when direct competitors cooperate to co-create digital solutions (Gnyawali et al. 2016). The experience of B2C platforms reveals a tendency that only few companies dominate ecosystems, thereby capturing a disproportionate share of the economic value. Similarly, IoT platforms can be dominated by certain companies or by various companies of a certain platform layer, such as IoT infrastructure providers, platform providers, software developers, equipment manufacturers, service providers, and plant operators (Rauen et al. 2018). Thus, functioning ecosystems require sufficient trust among collaboration partners and mechanisms that ensure that each partner gains a fair share of the economic value (Gebauer et al. 2020).

4.5 Ecosystem evolution and dynamics

Ecosystems evolve over time. For example, Senn (2017) mentions ecosystem-envisioning, business-model-development, and realization as phases of ecosystem transition. Perks (2017) describes four overarching network orchestration mechanisms: envisioning, inducing innovativeness, legitimizing, and adjusting. Likewise, platform ecosystems unfold gradually through collaboration between platform initiators, partners and customers. Papert & Pflaum (2017) mention the following phases for the formation of IoT platform ecosystem: definition of services that should be realized, definition of own value contributions for the realization of these services, identification of roles providing the remaining value contributions and establishing the corresponding business relationships with suitable companies, compensation negotiations with cooperation partners, and IoT service realization with ecosystem partners. We suggest that ecosystems may differ depending on their evolutional stage. The early stage relates to a phase when ecosystems e.g. around platforms just begin to form. The adolescent stage implies that basic ecosystem structures have evolved but still are in a phase of testing and experimenting. The time-tested stage means that ecosystem structures have proven as suitable and successful. However, through resource integration and service exchange, ecosystems change over time. Vargo et al. (2015) argue that with each instance of resource integration and service exchange, the nature of the system and the context for the next iteration and determination of value creation potentially change. Therefore, service ecosystems can be described as open systems with blurred boundaries (Wieland et al. 2012). Ecosystem dynamics and predictability may vary, for example depending on context and involved actors. De Reuver et al. (2018) mention paradoxical relationships of change and control related to recombinability of digitized elements and generativity. Accordingly, digital platforms need to simultaneously remain stable and be sufficiently flexible in order to foster complementor engagement and growth. Eaton et al. (2015) conceptualize platform dynamics through boundary resources that are collectively tuned by distributed actors. However, ecosystem dynamics can only observed during longer periods. The effects of design choices cannot be reliably predicted at its inception (Germonprez & Hovorka 2013).

5. A HOLISTIC FRAMEWORK FOR CATEGORIZING ECOSYSTEMS

Our literature review identified relevant aspects for assessing and describing ecosystems in the digital servitization context. To bring these elements together, we build a framework that comprises five dimensions: ecosystem context, relationship among ecosystem actors, role within the ecosystem, governance, and ecosystem evolution and dynamics. These dimensions are depicted as a morphological box (Table 1).

Table 1: Morphological box for categorizing ecosystem

Ecosystem Context			
Ecosystem mission	product/service innovation	product/service improvement	process efficiency
Offering-Focus	product-Focus (physical/digital)	service-Focus (physical/digital)	solution-Focus (Product-Service-System)
Ecosystem scope	industry-specific	cross-industry-specific	non-specific
Ecosystem focus	consumption	production	both
Structural flexibility	low	moderate	high
Number of actors	few	moderate	many
Size of actors	small	mixed	large
Scope of actors	intrafirm	associated	not associated
Variety of actors	similar	diverse	
Relationship among ecosystem actors			
Structural integrity	low	moderate	high
Relational Embeddedness	low	moderate	high
Actor relation	vertically related	horizontally related	complex
Competition	direct	indirect	
Level of competition	low	moderate	intense
Actor role within the ecosystem			
Role	ideator	designer	intermediary
Layer focus	physical layer	digital layer	
Context focus	consumption	production	both
Governance			
Governance approach	imposed	emergent	
Decision rights	dominated	distributed	shared
Ecosystem openness	open	regulated	closed
Rules	informal	formal	
Complementor tools	absent	few	numerous
Complementor conformity	low	moderate	high
Value distribution	concentrated	shared	
Ecosystem evolution & dynamics			
Dynamics	steady	moderate	turbulent
Predictability	low	moderate	high
Evolutional stage	early	adolescent	time-tested

6. CONTRIBUTION AND OUTLOOK

Based on a systematic literature we examined existing approaches for assessing and describing ecosystems in the context of digital servitization. We developed a framework that combines various relevant aspects within five overarching dimensions. As a next step, we will apply our framework to ecosystems in practice. Following a case study approach, we will identify and analyze companies and corresponding ecosystems. We examine various ecosystems e.g. regarding their evolutionary processes, ecosystem dynamics, governance mechanisms, and business success. Here, we take into consideration the perspectives of different ecosystem actors and compare their interests and actions. During this process, we will test and readjust our framework in order to develop a valuable tool for assessing, describing and comparing various ecosystems. Our research aims at outlining specific types of ecosystems in the context of digital offerings. This will be of interest for research and practice.

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AUTHORS

Alexander Arzt
Fraunhofer Center for International Management and Knowledge Economy IMW
alexander.arzt@imw.fraunhofer.de

Sebastian Haugk
Fraunhofer Center for International Management and Knowledge Economy IMW

Heiko Gebauer
Fraunhofer Center for International Management and Knowledge Economy IMW
Linköping University, Sweden
University of St. Gallen, Switzerland

VALUE PROPOSITIONS ENABLED BY DIGITAL TWINS IN THE CONTEXT OF SERVITIZATION

Shaun West, Jürg Meierhofer, Oliver Stoll and Lukas Schweiger

ABSTRACT

Purpose: The motivation of this paper is to investigate how digital twins can enable the design of new value propositions in digitally enabled servitization. This is important, as the application of this technology is an opportunity to deliver new value propositions for customers, and for the supplier to gain deeper understanding of the actual performance of the equipment (Kowalkowski and Ulaga, 2017). This builds upon the assessment of service value co-creation supported by digital twin technologies (Meierhofer & West, 2019).

Design/Methodology/Approach: Ten cases have been assessed in this paper using different dimensions, and a cross-case analysis to consider value co-creation, value measures, support to the value proposition, and the servitization context. All of the cases are from an Innosuisse-supported project in Switzerland and were selected for their diversity.

Findings: Classifying the digital twins by service proved useful to understand each one and its position within the business system. Knowing which business functions the twin supports helps to identify and confirm value co-creation opportunities as well as the possible areas impacted. It also provides different servitization perspectives that can support new and disruptive models, which is helpful for firms looking for new services to support their customers. The lifecycle perspective confirms the links between different phases and can provide new insight for the development of digital twins. The cross case analysis confirmed that a digital twin could support the development of new value positions within the context of servitization, as well as allow others (e.g., installers or asset owners) to develop and sell their own value solutions.

Originality/Value: Confirmation that digital twins can support firms to build new value propositions.

KEYWORDS: Smart Services, Digital Twin, Customer Value Proposition, Servitization.

1. INTRODUCTION

The motivation of this paper is to investigate how digital twin technologies can enable the design of new value propositions within the context of servitization. This is important as the application of the digital twin provides the opportunity to deliver new value propositions for the customers and for the supplier to gain deeper understanding of the actual performance of the equipment (Kowalkowski and Ulaga, 2017).

The different phases of the lifecycle of the servitized product (beginning, middle, and end of life: BOL, MOL, EOL) (Wuest & Wellsandt, 2016) need to be considered, as the issues that people face change along the lifecycle. For example, the digital twin can provide value in the form of services for product design and engineering, for product operations and usage monitoring, and for after-sales services and prognostics, including health monitoring. Additionally, the design and optimization of the shop floor can be supported by digital twin enabled services.

In business contexts, the services which can be supported by digital twins are typically decision support systems (Kunath & Winkler, 2018), where digital twin simulation allows exploration and evaluation of decisions and consequences. According to Sala et al., (2019), simulation is a very common decision support instrument in maintenance and capacity planning in product-service-systems (PSS), focusing on the MOL life-cycle phase. Kunath & Winkler (2018) explain how a digital twin of a physical manufacturing model is applied to scheduling, the calculation of delivery dates and dynamic pricing, as well as the dynamic administration of supply processes. Zhou et al., (2016) describe digital twin experiments with variations of the number of technicians or the service policy, e.g., the number of maintenance periods after which the equipment is replaced. Further literature (Huynh et al., 2010, Xia et al., 2009) discusses using a digital twin for decision support for products and processes. This leads us to the research question:

"*how can the digital twin enable value propositions within the context of servitization?*"

2. BACKGROUND

The concept of servitization has emerged as part of the transition from goods to services (Baines & Lightfoot 2013). In it, the focus of value creation moves from the manufacturer to co-creation between the manufacturer and the customer (Vargo & Lusch 2008). With the use of digital twins, accorsing to Barbieri et al., (2019), manufacturers can provide services either for themselves (often efficiency-oriented) or for their customers (new value propositions). The business challenge is how to support the creation of new value propositions in the cyber-physical world where co-creation of value becomes the norm (Negi & Brohman, 2015). Opresnik & Taisch (2015) describe the importance of big-data, and by association digitalization, within the value creation processes associated with servitization, and in doing so provide a context for value within a typical PSS in servitization. Existing research on digitally enabled servitization models lends itself to be applied and interpreted for the digital twin (Meierhofer et al., 2020). The approach for this is two-fold:

i. the actors (including indirect stakeholders, direct stakeholders and beneficiaries) are identified by their roles in their service ecosystem depending on the phase of the product lifecycle;
ii. the available technical components for digital twins are determined, i.e., various data sources and their transformation into information and knowledge.

In the digital twin, these components are made up of the different layers of the twin in their smart product environment (Porter & Heppelmann, 2014). Their contribution to value creation depends on the business perspective, e.g., the business capability of the twin, the service classification (Ulaga & Reinartz, 2011, Kowalkowski & Ulaga, 2017), or the phase of the product lifecycle (Thoben et al., 2017). Here data is used to drive value creation; however data alone cannot create value (Lee et al., 2014). Data can be considered as information only when organized and presented in context to be processed into relevant, usable and meaningful answers (Rowley, 2007; Frické, 2009). Only then can knowledge be built up and dispersed across all stakeholders (Choo, 1996). Interaction design research established the existence of three essential elements that characterize interaction (Shedroff, 1999):

i. control and feedback between the parties – the ability of the person who receives the information to manage and provide feedback to those who have generated it;
ii. productivity – the ability to (co)create experience;
iii. adaptability – the ability to modify the data and information management process based on who receives the information.

These three principles are in line with the concepts reported in the managerial literature about Service-Dominant (S-D) logic in PSS. According to Vargo and Lusch (2004; 2008) value in PSS delivery is continuously created through simultaneous interactions of different actors, who act as the resource integrators, forming ecosystems of service offerings and exchanges (Sklyar et al., 2019). Value is defined by the beneficiary in the context of co-creation. It is co-generated through the reciprocal application of resources (Baraldi et al., 2012) by the integrators for the benefit of a receiving entity (Vargo et al., 2008). In such a configuration, the system integrator manages and orchestrates the ecosystem to ensure that each member remains in good health and is able to actively contribute (Kindström & Kowalkowski, 2014). In particular, "the elaboration of solution results from a value co-creation process involving actors from both the supply network and the customer network" (Cova and Salle, 2008).

Value co-creation can be achieved by establishing different types of participant engagement, since collaborative organizations are "simultaneously innovative and efficient, agile and scalable" (Lee et al., 2012). Value co-creation within B2B environments remains elusive and complex to quantify (Kohtamäki & Rajala, 2016), because the value creation process is not linear, automatically following the provider's activities. Value co-creation processes can take on different forms characterized by different levels of participation of the various actors (Wolfson, 2016). Nevertheless, value capture necessitates the active involvement of at least two actors in the service ecosystem (Anderson et al., 2006). This is confirmed by Künzli et al., (2016) who state that “each actor takes part in adding value during the life cycle of the offer in different spatial and temporal settings”. Companies may recognize the need to collaborate with partners to build digital ecosystems, but they can lack the necessary trust to succeed (Gebauer et al., 2020).

3. METHODOLOGY

The format developed provides detailed descriptions of the cases under analysis, and tests the reliability of the theory (Eisenhardt, 1989; Yin, 2009). All of the use cases are from the initial ‘proof of concept’ stage of the development process and were selected from a project the authors were directly involved in over an extended period. Each characteristic of the use case was independently evaluated by the three authors and cross-checked to converge towards a general consensus (Baxter and Jack, 2008). From the investigation of each individual case, a cross-case analysis was created to allow further discussion. The teams developing the cases were from at least four organisations for a multi-perspective view point.

An assessment of a sample of ten digital twin case studies was conducted. To describe a digital twin within the appropriate dimensions, we applied a structure of: service classification, phase of the product lifecycle, layer of the smart product environment, and capability of the twin. Based on these classifications, we investigated how these digital twins contribute to new servitization value propositions.

4. RESULTS

For each case the purpose and the value propositions provided will be described, along with the main source of customer value.

Breakdown support twin for ships – the twin mimics the current status, allowing drill-down to individual ships and subsystems within each ship. The twin then supports decision making for planning and scheduling routes based on actual status and unplanned corrections. The value is from the reduction in disruption when changes occur, and understanding the down-time associated with unplanned events.

Footfall around public transport interchanges – the purpose is to better manage the flows of individuals around a station based on the current and future station layout and train schedules. The value comes from improved traveller safety through the re-platforming of trains and/or investments in new walkways to improve flows.

Operations scheduler digital twin for a joinery factory – the purpose was planning optimization around a production process with bottlenecks in individual competences and machine capabilities. The main source of value is efficient production planning, with known delivery dates and costs.

Operations smart factory planning and materials flow digital twin – a system capability twin matched demand to support the development of a dynamic operations planning twin. The main value is from the provision of planning support for the ‘optimal’ production schedule, and for creating an agile planning tool presenting the cost of changes along with a different planning solution.

Operations support in facility management – the digital twin provides operations support for Facility Management (including routine maintenance, planned maintenance and unplanned maintenance). Value would be created from reduced spares holding and faster task scheduling.

Server room temperature management and control digital twin – the purpose of this twin is to improve overall equipment up-time and provide further business stability through equipment risk mitigation. Value accrues from operational support, temperature stability, and routine reporting.

Smart factory asset management digital twin – the purpose was planning, to support the different models of maintenance and operation to find the optimal mode. It also allows new equipment to be integrated into the system to simulate outcomes. The value is created from an agile O&M schedule, allowing run-ons to be examined for additional maintenance costs. Additional value comes from improvement plans for modifications to improve factory performance.

Tunnel drainage system advisor – the purpose of the digital twin is to monitor the water levels and give predictions based on the weather conditions and other factors that influence the water level in the tunnel. The value comes from keeping the tunnel safe and operational, measured by performance.

Tunnel maintenance, repair and overhaul digital twin – the twin supported maintenance service delivery by improving planning of maintenance and increasing the efficiency of field service engineers. The main source of value from the digital twin was identified as keeping the tunnel operational, with an availability metric to measure performance of the MRO team.

Table 1: Overview of the ten cases

Case	Supported business functions	Service classification	Life-cycle	Environment	Capabilities / level of delegation
Breakdown support twin for ships	Inbound logistics, operations, service	Product life cycle services, process support services	MOL	Smart products	Monitoring Optimization
Footfall around public transport interchanges	Operations Infrastructure	asset efficiency services, process support services	BOL MOL	System of system	Monitoring, Optimization,
Operations scheduler digital twin for a joinery factory	Logistics, operations, marketing and sales human resources management.	process support services	MOL	System of system	Monitoring Control Optimization
Operations smart factory planning and materials flow digital twin	Inbound logistics, operations, outbound logistics, marketing and sales, procurement.	services, process delegation services	MOL	smart connected product, product system and system of system	Optimization
Operations support in facility management	Operations Infrastructure	process delegation services	BOL MOL	System of system	Monitoring, Optimization
Server room temperature management and control digital twin	Service, infrastructure.	Product life cycle services, process support services	BOL MOL	IoT products, smart products, smart connected product, product system and system of systems.	Monitoring, Optimization Autonomy
Smart factory asset management digital twin	Operations	Product life cycle services, asset efficiency services	BOL, MOL	System of system	Optimization
Tunnel drainage system advisor	Operations Infrastructure	asset efficiency services, process support services	BOL MOL	System of system	Monitoring, Optimization,
Tunnel MRO digital twin	Operations, infrastructure, technological development, service	Product life cycle services	BOL MOL	System of system	Monitoring, Control, Optimization
Wood cutting patent digital twin	Logistics, operations, outbound logistics, marketing and sales, service, human resources management.	Process delegation services	MOL	Smart product	Optimization

Table 2: Cross-case analysis describing the digital twin support of value propositions

Case	Value co-creation?	Value creation measure	Digital twin supported value proposition	Servitization context
Breakdown support twin for ships	Yes	Reduced cost of disruption due to unplanned changes to schedules.	The digital twin provided options to help with the decision making processes	OEM led, move to provide advanced services.
Footfall around public transport interchanges	Yes	Safety based on localized crowding. Improved used of infrastructure.	The orphaned digital twin allowed "what if" scenarios to be played out to support decision making.	Asset owner led, move to provide services internally.
Operations scheduler digital twin for a joinery factory	Yes	Lead time and on-time delivery in the correct order	The digital twin provided process simulations based on capacity of machine and people. Options were provided with consequents to support decision making.	Asset owner led, could provide as a service to others.
Operations smart factory planning and materials flow digital twin	Yes	Improved resource planning leading to reduced lead times and forecastable raw materials.	The digital twin demonstrated how it could provide options for the planning of the factory based on multiple constrains.	University based, could be transferred to both OEMs and asset owners.
Operations support in facility management	Yes	Reduce cost for services and improved customer experience.	The digital twin supported "what if" planning situations based on real operational (reliability, product operational life) data.	Facility management led, could be transfer to system integrators.
Server room temperature management and control digital twin	Yes	System availability.	The digital twin managed the temperature regulation and returned with options when failures occurred.	Facility management led, could be transfer to system integrators or OEM.
Smart factory asset management digital twin	Yes	Production availability, planned downtime and unplanned downtime	The digital twin supported the team to identify the uptime and plan the optimal maintenance schedules for the order plan.	University based, could be transferred to both OEMs and asset owners.
Tunnel drainage system advisor	Yes	Tunnel availability, travel disruption.	The digital twin provided predictions of flooding and with integration into local weather data provided forecasts of when safety would be impacted based on actual operational data.	OEM and asset owner lead, could be re-applied by either party.
Tunnel MRO digital twin	Yes	Tunnel availability, cost of maintenance, MRO planning time.	Supported planning an longer-term budgeting by providing answers to support "what if" questions.	OEM and asset owner lead, could be re-applied by either party.
Wood cutting patent digital twin	Yes	Reduced use of materials, reduced planning time.	The digital twin supported value creation by improving the yield per SQM of wood. The integration with the stored cutoffs allowed further improvements to costs.	Asset owner led, could provide as a service to others.

5. DISCUSSION

The service classification (Kowalkowski & Ulaga, 2017) provided a solid framework for organizing the value propositions created. This was helpful as the teams were building the value story for the digital twins, as it helped to develop solutions that were not just based on "risk" or "condition" based maintenance. The lifecycle model of Thoben et al., (2017), helped the teams to identify where the beneficiaries for the value propositions could lie along the lifecycle of the physical asset. However, the real use came from the second level details from the lifecycle mode of Terzi et al. (2010). The lifecycle helps to link the different actors and understand their roles and motivations around the physical asset and its purpose. It was this that moved some of the digital twins from operational advisors to ones that could support the OEM in new designs as well as being re-purposed, e.g., a digital twin as a training tool for operators. The environment dimensions of Porter & Heppelmann (2014) provided limited insights into the digital twin, there was general agreement that the majority of the use cases existed within complex systems-of-systems and therefore this should be accepted as the norm. It may be better in industrial product-service systems to assume that they are systems-of-systems as defined by Porter & Heppelmann (2014) because the assessment confirmed that the digital twins were operating in the high levels. This finding is not surprising, as most of the twins were designed to support decision making (Rowley, 2007; Choo, 1996; Frické, 2009), where the digital twin was set up to be self-managing within clear boundaries (e.g., delegated authority) and then to request human input when conditions required it.

Value co-creation was supported in all cases, all cases provided clear identification of the actors, and avatars and process descriptions were provided during the problem understating stage. This finding confirms those of Sklyar et al., (2019) and Kohtamäki & Rajala (2016), who state that value co-creation is a complex process to document. During the early development phase the storyboards from the cases clearly described the problem space, including the overall purpose and the questions that individuals ask during problem scenarios to enable them to make better decisions.

The development of metrics for each use case was not as simple as the team anticipated, as there was a tendency to over-complicate the business purpose; this is in line with Grönroos & Helle, (2010) who develop a S-D logic approach for metrics in manufacturing environments. The fall back was often to use metrics from the firm, rather than those that aligned with value creation or destruction. It may be preferable to use a more structured language here, such as with outcome based innovation (Ulwick, 2017) or system engineering requirements (BKCASE Editorial Board, 2016) to reduce the options for the digital twin development team. This part of the discussion requires focus on the appropriate metrics for service delivery and how to identify and then apply metrics that are, in effect, a proxy to the value creation (or destruction) processes. Given that, value-in-use would be the appropriate approach to apply (Vargo & Lusch, 2008) as it takes into account different situations as opposed to "value-in-exchange". Not applied here was the approach developed by West, Gaiardelli, & Rapaccini (2018) where a scoring system for implied value creation is based on a set of SD logic criteria.

The final dimension investigated how the digital twin supported value creation, and here it is clear that the digital twin enabled value to be (co-)created. It should be able to support efficient, agile and scalable iterations necessary to make optimal decisions as identified by Lee et al., (2012) with value co-creation within the ecosystem according to Sklyar, et al., (2019). A digital twin supported value creation in the ten different contexts, however they did this in different ways:

- as an advisor providing the options, their implications and possible consequences to "what-if" questions;
- as a trainer to help stakeholders learn to react to different situations;
- as a cyber-co-worker with a defined role and delegations of authority.

The segmentation of the roles that the digital twins are able to perform is in line with West, Gaiardelli & Rapaccini (2018) and also confirms the advantages of a modular rather than a monolithic structure. Many of the tasks that the twins are being asked to perform are based around the transition of technical to more commercial information, which shows that twins are able to support the decision making process through the translation of data into information. In the 'trainer' context, the twins have in effect coded the system know-how and become a didactical tool to support the sharing of that know-how with others. These results point to the conclusion that new business models could be developed based on digital twin technologies.

The ten cases described in this paper are not fully compliant with an OEM-lead servitization context (Baines, & Lightfoot, 2013), however they show that the application of digital twin enabled services can support servitization based business models of OEMs. The cases also provide insights into how and where non-OEMs, who provide service on their own assets or on equipment that they have installed, could develop new business models based on value propositions made possible through the use of digital twin based technologies. The cases here also provide a warning that there will be alternatives to traditional OEM-based servitization.

Returning to the research question identified in this paper, it has been shown that digital twins can enable the development of new value propositions that are within the context of servitization. There are instances where the digital twin supports the development of new value propositions that could be exploited by the asset owners, by installers, or non-OEM service providers. There is no assessment here made about the quality of the outcomes from the other potential providers, and as such this represents a limitation on this study. However, according to Kindström & Kowalkowski (2014) they could orchestrate the ecosystem to deliver the same or similar outcomes as manufacturing firms. Integrators may nevertheless lack trust, according to Gebauer et al., (2020). A measurement of the value created, or more rightly co-created, was integrated into the value propositions and was a necessary part of the development of each digital twin.

5.1 Theoretical and practical contributions

The study's new theoretical scheme shows how manufacturing companies can use the digital twin in a targeted way to create more value for multiple actors during both the BOL and MOL phases. Asset managers can find better ways to model their operations and support their business. Operations teams can learn how to better understand the production processes and constraints. Maintenance teams can understand the consequences of ineffective or deferred maintenance and the impact on the operations. The results indicate that the digital twin could be used outside of the OEM-focused definition of servitization, in particular:

- theoretical – shaping the topic of the digital twin through the lens of service dominant logic;
- practical – the schemes can be seen as blueprints for companies.

In summary, the digital twin can be considered an enabler for service value propositions in industrial PSS and in the servitization context. In this context a digital twin does not necessarily mean a comprehensive digital representation of an asset and associated processes, but rather a targeted and specific application of technologies to support an underlying service and the value proposition co-delivered with the beneficiaries.

6. Conclusion and recommendations

The digital twin can be used to understand and support multiple actor value co-creation, for ecosystem capability integration, and to understand value in use within the real environment. The digital twin is able to do this by supporting multi-actor decision making.

The results of the ten cases have confirmed that digital twins can enable new value propositions in the context of servitization. The results also demonstrate that digital twins can provide new value propositions outside the manufacturer-centered concept of servitization, and could allow equipment owners and operators or system integrators to develop new value propositions. The digital twin allowed system knowledge, much of it tacit knowledge, to be coded into a decision making support system. This is because in the cases examined, the digital twin is not an isolated virtual representation of equipment, but a set of supporting elements that integrate people, processes and machines in a representation of the real world. In particular:

- digital twin enabled value propositions can bridge many phases of the equipment lifecycle;
- many of the value propositions created supported management decision making;
- some of the value propositions allowed for delegated decision making within set limits;
- two of the value propositions were instances where the main role was as a trainer.

6.1 Recommendations

Companies should consider adopting a wider ecosystem view in terms of actors, equipment and lifecycle considerations when developing digitally-enabled value propositions. This means that they have to learn to embrace multiple points of view when understanding the environment and innovating solutions.

Future research should focus on the value co-creation processes presented in this paper by defining a set of patterns across different cases. This would help to operationalise Service Design logic, which is important for total value creation and capture. Such a framework should provide support with value identification and value co-creation in both a qualitative and quantitative way. The framework should also help with the creation and testing of value propositions.

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AUTHORS

Dr Shaun West
shaun.west@hslu.ch

Oliver Stoll
oliver.stoll@hslu.ch

Institute of Technology and Innovation Management
Lucerne University of Applier Sciences and Arts
Switzerland

Dr Jürg Meierhofer
juerg.meierhofer@zhaw.ch

Lukas Schweiger
lukas.schweiger@zhaw.ch

Institute of Data Analysis and Process Design
Zurich University of Applied Sciences
Switzerland

VALUE CO-CREATION IN MANUFACTURING SERVICE NETWORKS: PREREQUISITES, DRIVERS AND SERVICE CO-DESIGN OF DIGITALLY ENABLED SERVICES

Amara Cynthia Ajaegbu, Victoria Uren & Andreas Schroeder

ABSTRACT

Purpose: This study examines the role of value co-creation and digitalisation in the implementation of servitisation strategies in the UK truck manufacturing industry. The study identifies the roles digital capabilities play in servitisation and how these capabilities enable value co-creation, through relationship building and resource integration, in a joint process.

Design/Methodology/Approach: A conceptual framework was developed by using Service-Dominant Logic, with its focus on value co-creation as a theoretical lens. The empirical analysis involves qualitative case studies of four truck manufacturers.

Findings: Analysis of the literature on value co-creation in servitised industries identifies three key themes which direct the empirical analysis, namely strategic objectives, service design and service management, interaction involvement and relationships. The empirical findings show that in the joint sphere of value co-creation, specific *prerequisites*, in particular the development of relationships through regular reporting of analysis from telematics, are needed to understand customer demand. Demand *drives* stakeholders into the next level of the value co-creation process termed *service co-design,* in which products and services are tailored to individual customers' needs. Additionally, service co-design behaviours may lead to attaining a strategic alignment.

Originality/Value: The study contributes to servitisation literature on how digital capabilities impact value co-creation and has implications for management of advanced services.

KEYWORDS: Digital capabilities, value co-creation, service co-design

1. INTRODUCTION

Servitisation is defined as a process where manufacturers extend a traditional product-centric model to integrate a product-service model, which is more customers focused and relational in approach (Vandermerwe and Rada 1988, Baines, Lightfoot et al. 2009). This is a trend shared across many manufacturing industries, particularly heavy equipment manufacturers, such as the truck manufacturing industry which is the focus of the cases in this study. Within the last 10 years, the role of servitisation has become a central area of research in different fields, such as service management, service operations, strategic management and service innovation. Digitalisation is seen as a core enabler of servitisation. However, it is fair to say that we still some way from a satisfactory understanding of the causal links between servitisation, sustaining competitive advantage and digitalisation (Ardolino et al, 2016; Cenamor, 2016).

When selling solutions in place of products, key considerations are meeting customers' dynamic demands, and interactions with customers in order to provide customised services (Kohtamaki and Partanen 2016). The emergence of services therefore challenges product-based manufacturers to understand value co-creation. This provides the foundation to understand how to engage with customers to create distinctive services and customised solutions (Bustinza, Vendrell-Herrero et al. 2017). Generally, value co-creation is defined as a process by which products, services, and experiences are developed jointly, through interaction or collaboration, to create benefits and enhance business performance between organisations and customers (Prahalad and Ramaswamy 2004). It is argued that servitisation strategies can succeed if manufacturing companies engage in the co-creation (Gronroos and Voima 2013; Galvagno and Dalli 2014). However, there are few empirical studies on this topic that offer explanations of *how* value is co-created in servitisation.

For product manufacturers, co-creating value with customers necessitates the development and use of new capabilities (Sjödin, Parida et al. 2016). Several studies have suggested that manufacturers can rely on digitalisation as a sustainable path towards facilitating these changing and complex interactions (Parida, Sjodin et al. 2015, Cenamor, Sjodin et al. 2016, Vendrell-Herrero, Bustinza et al. 2017). Digitalisation is defined as the embedding of digital technologies into physical products to change the business model, to create new value producing opportunities and to provide new revenue (Yoo, Boland et al. 2012, Cenamor, Sjodin et al. 2016). Digital capability describes the advanced ability to use digital technologies to facilitate the deployment and delivery of services to create differentiation and added value (Sjödin, Parida et al. 2016).

Little empirical effort has been devoted to understanding the ways in which service providers utilise digital capabilities and the implications for sustainable competitive advantage and value co-creation in the wider service network. In line with this reasoning we adopt service dominant logic as a theoretical premise to tackle the following question: *how do digital capabilities enhance value co-creation in service networks*?

2. Literature review

The literature review is focused on providing a view of the most important developments in study of value co-creation as it relates to digitalisation to support servitisation. This section unpacks the themes which are deployed in the analysis.

In terms of value co-creation, do servitising firms gain from an orientation towards working directly with their customers and other users of their products and services in the service network? If so, what role do digital capabilities play in this process? A large body of recent studies would seem to confirm the first assumption, however, has not systematically addressed the roles of digital capabilities in facilitation of value co-creation in service networks. Therefore, academic discourse in services (Vargo, Maglio et al. 2008), managerial perspective (Ordanini and Pasini 2008), and service science initiative (Chesbrough and Spohrer 2006), argue that service firms can improve their value co-creation process and innovation performance by working with customers and other users in the service network in the service innovation process. However, this literature says little about the role of digitalisation and digital capabilities in this process. Literature suggests that value co-creation plays a vital role in the understanding the link between market intelligence (i.e., orientation towards customers as well as competitors) and business performance (Lusch and Vargo 2006, Kristensson, Matthing et al. 2008, Gronroos and Voima 2013, Roser, DeFillippi et al. 2013), and suggests that in servitisation a successful link of market intelligence to new product or service development may depend on customer use context and users' knowledge. Thus, there is an incomplete account of how customers' use context and customers' knowledge might be leveraged.

The reason for the emergence of co-creation may be attributed to the changed business landscape with services as a dominant component (Spohrer and Maglio 2008). Manufacturers require diverse service processes to create value for and with the customers (Story, Raddats et al. 2017). Many descriptions that differentiate types of services draw on the Mathieu (2001) classification of services, i.e. services in support of the product (SSP), as well as services directed towards customers' business processes termed service in support of customer (SSC), which is services in support of the customer's action (Baines and Lightfoot 2013, Story, Raddats et al. 2017). We will refer to these two levels of services as base and advanced services (Baines, 2013). Base services capture the support of product functionalities and reliabilities. Advanced service offerings focus on supporting customers' processes and achieving desired outcomes. These are more complex than base services, mostly because advanced services require a higher level of customisation, demand greater intensity in customer relationships, and need an increased focus on assisting customers in their value creation process.

The Service-Dominant (SD) logic approach suggests a view that places more emphasis on the customers' use contexts. The essence of S-D logic is to co-create value through the integration of customers' resources in the design stage (Spohrer and Maglio 2008). S-D logic proposes service as '*the application of knowledge and skills by one entity for the benefit of another*'. It serves as a lens through which value co-creation mechanisms can be better examined. In line with the principles of SD logic, value co-creation is achieved through continuous and simultaneous interactions among wide set of dynamic resources which form the service network and exchange (Vargo and Lusch, 2008a). Particularly, SD logic offers a new perspective which calls for a re-evaluation of service innovation to require consideration of interactions in the service network.

The concept of value co-creation in servitisation is focused on the collaborative process where manufacturers and customers integrate knowledge in a joint process (Vargo, Maglio et al. 2008). The design and delivery of services are achieved through a relational and collaborative process to create value from the perspectives of the actors involved. Value co-creation is a vital element of the servitisation strategy that requires an understanding of the dynamics of value co-creation among stakeholders, in order to know where involvement is most likely to influence outcomes, including the identification of where and how value is created in the use of products (value-in-use).

Servitisation requires a close link to customers which is usually referred to as customer centricity. What one customer considers important may not be of much importance to another customer. Gronroos and Voima (2013) consider value co-creation in the context of SD logic and developed a conceptual framework showing that value co-creation can only occur when customers and providers jointly engage and interact in the value creation process, termed joint sphere. The authors conceptualise value co-creation as a "joint collaborative process through direct interaction which adds value for one or both actors". Prahalad and Ramaswamy (2004), emphasise that co-creation is a joint value creation between the company and the customer that entails the joint definition of any solution to problems. Raja, Bourne et al. (2013) highlighted the importance of understanding customers' views on integrated products and services. The design stage of services thus includes both the manufacturer's and their customers' resources (Spohrer and Maglio 2008), while aiming to incorporate customers' different use contexts. In the context of understanding customers' needs, digital technology plays a vital role in creating new connections within the service network.

Gray and Rumpe (2015, p. 1319), defined digitalisation as "*the use of digital technologies to change a business model and provide new revenue and value-producing opportunities*." Digitalisation adds a new layer of connected intelligence that enhances the action of organisations, automates processes, transforms data, and incorporates digitally enabled systems into firms to increase their insight and control over tangible goods (Daugherty, Biltz et al. 2014). Digitalisation represents a combination of hardware and software. Digital technology innovations, such as IoT, telematics, have increasingly enabled an interconnected and complex world (Demirkan, Bess et al. 2015).

Past literature suggests that advanced services require the development and application of new capabilities (Parida, Sjodin et al. 2015, Sjödin, Parida et al. 2016, Story, Raddats et al. 2017). These new capabilities help firms achieve their strategic goals of creating, delivering and capturing value (Sjödin, Parida et al. 2016, Ardolino, Rapaccini et al. 2017). Despite the growing awareness of the importance of digital capability in servitisation, both practitioners and scholars struggle to grasp what the capability actually entails, and how this enables value co-creation by servitising firms.

Service science calls for an interdisciplinary study of service systems (Chesbrough and Spohrer 2006, Spohrer and Maglio 2008, Heiskala, Hiekkanen et al. 2011, Baines and Lightfoot 2013). This approach to understanding value co-creation considers the creation of value from a service system perspective, where resources are integrated through interactions with other service systems. These resources can be knowledge, shared information, technology, and competencies. The service science perspective applies scientific understanding to advance the ability to design, improve and scale up services (Spohrer and Maglio 2008). Within this community, two important ideas are prominent: service system and service design and management. The idea underlying the service system approach is that the customer should take part in the design of a service they will later use.

This study considers value co-creation in the context of service design, assuming that there is participation in what Gronroos and Voima (2013) describe as the joint sphere. Service innovation combines innovations in technology, business model, social organisations, and demand. It can be a result of the reconfiguration or reprogramming of existing service elements (Yoo, Boland et al. 2012). Service design can be seen as embedding user involvement in service development (Chesbrough and Spohrer, 2006). Thus, service design and service innovation partly overlap. A model by (Kumar 2009) provides a design perspective on innovation. It suggests that adopting and understanding the user's view is core to the notion of value-in-use (Vargo and Lusch 2008a).

3. FRAMEWORK

The literature review summarised current perspectives on value co-creation in various fields such as service design, service marketing, and management and service innovation. Value co-creation is a multi-disciplinary and complex phenomenon which comprises various characteristics such as resources integration (Lusch and Vargo 2006), ongoing relationship (Vargo and Lusch 2008a), collaboration (Vargo, Maglio et al. 2008, Mele, Colurcio et al. 2014), creation of value propositions (Vargo, Maglio et al. 2008), desired outcome (Rusanen, Halinen et al. 2014)and co-production activities, (Ordanini and Parasuraman 2011). While the existing frameworks and current perspective are useful, each offers slightly different perspectives and different levels of abstraction. There is a need to converge these concepts into meaningful categories to enable a multi-theoretical framework in order to facilitate a more insightful analysis. Therefore, this sub-section translates the theoretical understanding, key concepts, and approach to value co-creation identified in literature into a proposed conceptual framework which will be used later for the data analysis. Three themes of value co-creation were identified:

Theme 1: *Strategic objectives in value co-creation* (Mannervik and Ramirez 2006, Vargo and Lusch 2008a, Gronroos and Voima 2013).This theme demonstrates how the company's strategy and goal affects its value co-creation approach (Ojasalo 2010). It seeks to cover the contemporary discussion in SD logic and stems from marketing theory.

Theme 2: *Service design and service management* (Sanders and Stappers 2008, Kumar 2009, Yoo, Boland et al. 2012). This theme covers understanding from the service science perspective which considers service system, service design, and operations management perspectives when designing, improving and managing value propositions. This theme focuses on service development, including the process of developing and adapting value propositions (Lusch and Nambisan 2015). It includes co-design and co-innovation of services (Sanders and Stappers 2008).

Theme 3: *Interactions, involvement, and relationships* (Payne, Storbacka et al. 2008, Vargo, Maglio et al. 2008). Value co-creation stems mainly from collaborative and co-production service activities through the relational approach. Value co-creation requires active interactions and relationships between two or more actors (Vargo, Maglio et al. 2008).

4. METHODOLOGY

Due to the complexity of this phenomenon, we chose a qualitative case study method to investigate how digital capabilities enhance value co-creation in service networks. The empirical data comes from multiple case studies of four multinational truck manufacturing organisations operating in the UK. Though the firms are from a specific industry, they vary in size. All four have advanced service offerings that are connected with digital systems to develop innovative service bundles. These cases therefore have characteristics which allow relevant conclusions. The four cases are based upon high value manufacturers (truck providers, labelled TruckPro1-4), their customer organisations (labelled

TruckCus1-7), dealers (TruckSup1-3) and a digital technology provider (TruckTech). Each case represents a service network, comprising at least one TruckPro and two TruckCus, with TruckSup and TruckTech if appropriate.

Criteria based sampling was used to select four large truck manufacturing firms, in which service networks were, selected that provided detailed insight into the digital approach. The key reason for choosing these organisations was that servitisation has been mainly studied within the manufacturing industry (Baines et al 2013; Neely, 2008). The study also focused on firms with a strategic goal toward advanced service implementation. Additionally, because the present study focuses on advanced services, Baines and Lightfoot's (2013) conceptualisation was used to identify manufacturing firms that offer these types of services. These authors described advanced services to include certain features, for instance long-term contracts (three or five year's contract), performance incentives and outcome-based revenue structure.

4.1 Data Analysis

Data analysis consisted of two stages. Stage one, applied a thematic analysis in order to identify the constituents of digital capabilities necessary for servitisation. Stage two utilised the conceptual framework of value co-creation (see Section 3) to examine the cases to understand their value co-creation approaches. This paper reports the findings of the second stage. The first stage is reported elsewhere (Ajaegbu, Uren and Schroeder, 2020) in detail, but findings summarised here to provide context for the digitalisation activity.

In exploring the data, various steps was followed to ensure rigor, and the principles of thematic analysis were followed (Braun and Clark 2006). The first step concentrated on an in-depth analysis of the interview transcripts. For the second step, common and interesting phrases, words, or terms mentioned by the participants were coded according to the research question, to identify the first-order categories of codes (Miles and Huberman, 1994). In the third step, the initial codes were analysed further to ascertain relationships, patterns and links within the codes to identify smaller categories known as second-order themes. In the last step of the analysis, the precise focus of each theme was refined and related to the overall story of the analysis, as well as relation to literature.

5. FINDINGS

The broader study identified the digital capabilities used in servitisation, which have three elements, *data capturing capability, connectivity capability,* and *analytical capability*. These are reported in more detail in (Ajaegbu, Uren and Schroeder, 2020), but are summarised here to fill in the context of the digitally enabled services offered by the case companies. Following that, findings are reported for each of the three key themes of value co-creation in services identified in Section 3.

Data capturing capability enables the visibility of operations and provides valuable data. The main digital technology used in the truck industry is telematics for data capture, which enables the manufacturers to develop intelligent functionalities to monitor products' condition, as well as operational and contextual usage information, through embedded sensors. It emerged that insight into customer operations is focused on helping manufacturers understand how their products fit within different contexts. The focus is on providing manufacturers with the ability to respond to the customers' individual environments in real-time. Particularly, it emerged that visibility of customer operation allows stronger relationships within the service network, especially when manufacturers aspire to promote servitised offerings.

Connectivity capability aids information to be transmitted among interacting partners in the service network, enabling information flow. Through connectivity, data is transmitted from digitalised products to data processing centres. For advanced services, this capability improves the efficiency of operations, such as repair and maintenance activities. For example, it reduces or eliminates the need to be physically present to diagnose a problem or of getting a vehicle to the workshop and plugging in the diagnostic machine to discover faults. Additionally, connectivity enables manufacturers and dealers to proactively plan for maintenance.

Analytical capability facilitates data and information processing, generating insight for servitising firms. The findings demonstrate that this capability facilitates interactions between manufacturers and customers, enabling customised service delivery, and hence value co-creation. Data processing explicitly requires setting parameters and developing rules or algorithms that process and transform data into insights. Through data processing, the manufacturers acquire the understanding that provides the basis for critical decision making and market intelligence. For example, the study's findings show that analytical capability enables an understanding of how to avoid high-risk situations, which allows manufacturers to sell availability guarantees to customers.

5.1 Strategic Objectives

Value co-creation activities can be seen in themes related to strategic objectives. TruckPro1's motivation towards the service business model was largely linked to 'total cost of ownership: *"Why telemetry is important is because it is a big part of our total cost of ownership"*. The drive to becoming a solution provider was customer demand for increased reliability of their product. TruckPro 2 and its service network aims to mutually create suitable solutions, and also resolve problems through regular development meetings: *"We meet once every six to or eight weeks to review […], I get the meetings, I get the communication, that's kind of all we need really".* Through regular communications, the stakeholders understand and generate better knowledge of each other's businesses, which leads to better value-in-use for the whole service network. TruckPro2 offered specific training to their dealers' technicians to keep them up-to-date with the latest technology, and to also be able to provide better services to the customers. This implies that the stakeholders' outlook on service offerings is understood from a value-in-use perspective: ***"****We tend to get feedback from our networks, we do have customer involvement because we do get involved in selling what the customer wants, it's always a conversation we have."*

The use of telemetry and working closely enables truck manufacturers to understand service from a value-in-use perspective. TruckPro1 partnered with TruckTech to develop the right solution for the customers. Telematics configured in the truck enables data flow from the customers to TruckTech, who then supplies these data to TruckPro1 for further analysis. Analysed data is provided to the dealers for maintenance purpose and to the customers in the form of report. An important observation is the emphasis on multi-actors context, which highlights how information is shared among partners to improve knowledge and support the co-production of service activities: "*We will speak to the manufacturer on whether its procurements or buying the asset and things they won't fit into the asset or it may be ongoing issues with vehicles or even telematics maybe, so it's a constant-constant communication. Communication is key."*

In respect to strategic objectives, many respondents viewed regular meetings and regular communications as a key activity which enables them to achieve their objectives. Understanding of customers' processes enables the creation of value-in-use.

5.2 Service Design and Service Management

In service design and service management, value co-creation activities can be seen as constant exchange of information and knowledge shared in real-time in a web portal and during regular communications. For example, the repair and maintenance services required the manufacturer, dealers and customers to work together. The information coming from the customers can be seen as resources contributing to support services received from the dealers. This is in-line with S-D logic, which proposes that when resources are integrated, the value gets co-created. Through telematics systems, multiple stakeholders are connected, and information is exchanged among the service network, so that service developments are based on customers' needs. Additionally, listening and learning how to get the best out of the services increases customers' profitability, and more importantly, drives further collaborations for both parties.

Advanced service offerings are uniquely customised to fit a customer's needs, which may be influenced by legal and environmental factors, and therefore, are different for each customer. The findings illustrate that information related to operations, performance and service activities can be leveraged to reduce total cost and co-create a value proposition suitable for the customer's context. In relation to service design, collaborations and joint development of new services enable beneficial outcomes to both manufacturer and customers through the integration of resources. Customer demand was seen as the main driver to proactively adopt other value co-creation activities.

5.3 Interactions, Involvement, and Relationships

Value co-creation activities are prevalent in all themes, as seen in the excerpts provided. The customer companies have long-term relationships with the manufacturer. There are also personal relationships between the manufacturer and various customers. Service components increase the interaction between the manufacturing organisations and their network partners. The dealers are mainly in charge of delivering repair and maintenance services, routine checks and spare parts to the customers. Therefore, they play an integrating role in maintaining relationships. For key account customers, where they own their maintenance workshop, the technology partner plays the integrating role, as they provide the vital information required by service operations.

Data is important in developing relationships with customers. Standardised service offerings underpin manufacturer customer relationships, which allow future collaboration into the next value co-creation process: "*the entry package is all free of charge to introduce the customers to the data, and show them what's possible. And actually, we can do a lot of work just on the monitor package with the customers to help identify the vehicles that have not been driven as well as they could*". The customers reflected this view explaining their relationships with the manufacturers and dealers have developed over time. It was found that having personal relationships amongst the stakeholders enables deep insight into customer needs, and offers a foundation for more collaboration.

6. SUMMARY

The cases demonstrate how manufacturers develop comprehensive service solutions to improve customers' business processes, mutually with stakeholders. There is a focus on the service network, and long-term customer relationships enable manufacturers to develop knowledge of customers' business. Through regular meetings, customer demands are understood, and issues resolved together. Ultimately, customer demand *drives* value co-creation activities under *service co-design.* Key activities are i) resource integration through listening, learning and knowledge sharing, ii) processing customer information and feedback, and iii) developing new service solutions.

Participants valued long-term personal relationships with trust. It was noted that both in co-creative and traditional cases basic telematics data gathered from customer operations is used to develop a good knowledge of the customer business activities. Thus, factors under interactions, involvement and relationships appear to be *prerequisites* for the value co-creation approach. It seems that the co-creative cases have proactive dialogue whereas the traditional cases tend to be more reactive with interactions. Adopting the value co-creation approach appeared to generate good knowledge of customers' businesses in order to understand what matters to them (value-in-use).

The proposed framework, offers a platform for value co-creation activities and sees value co-creation in servitisation as a joint value creation process (Gronroos and Voima 2013) of creating solutions (Jaakkola and Hakanen 2013), by facilitating innovations (Spohrer and Maglio 2008, Heiskala, Hiekkanen et al. 2011), and developing strategic alignment through service co-design behaviour. This new framework of value co-creation in servitisation attempts to show that co-creation should be seen as a set of dynamic processes of innovating novel ideas/solutions or improving existing ones. At the core of the value co-creation process are service co-design behaviours utilising digital capabilities and resources. The framework provides a guide towards the practical implementation of value co-creation in servitisation and would allow other servitised companies to adopt this approach.

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THE PROCESS OF SERVITIZATION: HOW DO SERVICE INNOVATIONS EMERGE IN ORGANIZATIONAL NETWORKS?

Paul C. van Fenema, Kars Mennens, Tom Schiefer & Dominik Mahr

ABSTRACT

Purpose: Despite an increase in collective digital service models, there is a lack of research on how to structure the process of network service innovation. Addressing this gap offers a better understanding of how the coordination of resources and (intra- and inter-)organizational relationships lead to network value propositions and service innovation.

Design/Methodology/Approach: A qualitative research approach was taken through a nested case study approach within a larger network that conducts the maintenance of maritime equipment for the Royal Dutch Navy.

Findings: As an intermediate result of our ongoing case study, we designed a process and practices framework for iteratively developing new network value propositions and network business models through service innovation.

Originality/Value: We provide both academics and practitioners with scripts, a vocabulary, and practices to construct network service innovation models.

KEYWORDS: Service innovation, service networks, servitization, process framework, practices, digital innovation.

1. INTRODUCTION

Organizations collectively explore new service models to servitize their offering, take advantage of digital capabilities such as Artificial Intelligence (AI), and restructure B2B exchange (Raddats, Kowalkowski, Benedettini, Burton, & Gebauer, 2019). Current research on (service) innovation processes explains their drivers (Crossan & Apaydin, 2010), or analyzes them from socio-cognitive and co-creation angles (Hansen, 2017). We perceive a lack of research on how to structure the process of service innovation in a network. While some literature is emerging on designing or modelling processes for innovation, including service journeys, these tend to propose a 'cookbook' (Patrício, Fisk, Falcão e Cunha, & Constantine, 2011), i.e. a linear-prescriptive process model, rather than capturing the complexities of business reality.

To extend such work towards a more generative innovation process (Neuhüttler, Ganz, & Spath, 2019) and to bridge innovation process and outcomes we aim to understand *how organizations can structure the process of service innovation in a network*. We develop a process and a practices framework for service innovation in a network. The frameworks facilitate the orchestration of closed and open innovation models, include scripts for structuring the innovation process, and aim at the development of novel network services. Moreover, we identify interdependent practices supporting design of service innovations on a network level as well as explanatory analysis of service innovation evolution, i.e. both 'weak' and 'strong' process views (Berends & Sydow, 2019).

2. CONCEPTUAL BACKGROUND

2.1 Service Innovation

Academic research shows an increasing interest in the topic of service innovation through an increase in the number of publications and interest from multiple disciplines (Dotzel, Shankar, & Berry, 2013; Witell, Snyder, Gustafsson, Fombelle, & Kristensson, 2016). As a result of this attention from different research areas, the concept of service innovation is often interpreted in different ways and no common understanding regarding its definition exists (Flikkema, Jansen, & van Der Sluis, 2007; Witell et al., 2016). In fact, the process of service innovation lacks solid conceptualization. This has been a concern to both academics and professionals (O'Cass & Wetzels, 2018), in particular with extant pressure of digital transformation (Nambisan, Wright, & Feldman, 2019).

In this paper, we develop a process framework and identify practices for service innovation in a traditional manufacturing industry network. The process framework considers the dynamic nature of the relationship between service innovation outcome and its effect on the network value proposition and service innovation process. We define service innovation as "the creation of new value propositions by means of developing existing or creating new collaborative practices and/or resources, by means of integrating practices and resources in new ways" (Liu, Purvis, Mason, & Wells, 2020). This implies that a service innovation can be interpreted as a new development process or its outcome that is new to the firm and creates value in use, but does not necessarily need to be introduced to the market (Witell et al., 2016). In this research, we investigate the introduction of AI, manifested by machines that exhibit aspects of human intelligence, as a service innovation. AI constitutes a major source of innovation and is increasingly reshaping services (Huang & Rust, 2018).

2.2 Service Innovation in Networks

The systems of innovation approach asserts that "innovation is an interactive process that requires intensive communication and collaboration between different actors, both within companies as well as between firms or other organizations" (Tödtling & Trippl, 2005: 1205). In line with this school of thought, firms rely on external knowledge for innovation (Chesbrough, 2003). Such knowledge can accrue from collaboration with customers, suppliers, competitors, public sector or universities and other knowledge institutions (Laursen & Salter, 2006). External collaboration for innovation is even more essential in a services context (Mina, Bascavusoglu-Moreau, & Hughes, 2014), where innovations emerge from joint actions across a network rather than within the borders of the organization (Lusch & Nambisan, 2015). Networks provide access to vital resources for innovation (Rusanen, Halinen, & Jaakkola, 2014). Collaborative service innovation processes promise new business benefits which have been explored in literature on servitization strategies (Lay, 2014), service business models (Ojasalo & Ojasalo, 2018), and operational strategies (Baines et al., 2009). Arriving at these strategies and implementing them calls for network collaboration and organizational change (Kowalkowski, Gebauer, Kamp, & Parry, 2017; Vendrell-Herrero, Bustinza, Parry, & Georgantzis, 2017).

2.3 Network Value Propositions and Business Models

Value propositions and business models are increasingly conceptualized at the network level (Bankvall, Dubois, & Lind, 2017). According to S-D logic, a key imperative for firms is to offer value propositions which, after being accepted by customers, enable the mutual co-creation of value (Ballantyne, Frow, Varey, & Payne, 2011). A value proposition can be seen as a platform for value cocreation in the customer context. Both product and process can be part of the value proposition offered to customers as a service innovation (Witell et al., 2016). A recent study on the development of value propositions in service logistics found that the identification of the right partners is a critical success factor for developing new value propositions (Liu et al., 2020). This finding is consistent with S-D logic, which stresses the importance of multiple actors participating and collaborating in the offering of value propositions (Vargo & Lusch, 2016). The resulting dynamic interactions can lead to new network configurations where the adoption of new resources, new practices and a reallocation of roles across the network can emerge (Liu et al., 2020). By structuring the process of service innovation on a network level, we investigate how the coordination of resources and interorganizational collaboration lead to new network value propositions.

2.4 Emergence of Service Innovation Networks

In an era of digitization, organizations face the challenge of developing new services in networks (Barrett, Davidson, Prabhu, & Vargo, 2015). This involves management of co-evolving innovation processes at multiple levels (Markand & Truffer, 2008). How levels are conceptualized differs across service management and organization/innovation studies. The former proposes service concepts (macro), service systems (meso), and service encounters (micro) (Baron, Patterson, Maull, & Warnaby, 2018); the latter builds on layers of management which better supports our focus on networks of organizations. We distinguish cooperation and coordination as strategic and tactical-operational management levels (Gulati, Wohlgezogen, & Zhelyazkov, 2012):

Cooperation (strategic management level). Organizations reflect on changes to their strategic role, and they anticipate opportunities stemming from a specific innovation project. Customers are expected to make a shift towards procuring more complex product-service solutions (Caldwell & Howard, 2014), while providers need to extend their capabilities and take on new responsibilities (Holmström & Partanen, 2014). Providers consider how they can leverage these changes beyond the innovation project, e.g. changing their offering to existing or new customers (Dotzel et al., 2013). Within the innovation project, strategic activities include network value management both within and beyond the project (Reypens, Lievens, & Blazevic, 2016), interorganizational politics (Sundström, Karlsson, & Camén, 2017), societal-institutional work (Baron et al., 2018; Koskela-Huotari, Edvardsson, Jonas, Sörhammar, & Witell, 2016), and governance/orchestration (Dhanaraj & Parkhe, 2006; Sjödin, Parida, & Kohtamäki, 2019). The process of cooperation is expected to lead to articulation of network-level value propositions (Ballantyne et al., 2011) as a pivot of a network-level business model. Again, the network could include the innovation project itself, and extra-project opportunities which organizations individually may pursue.

Coordination (tactical-operational management levels). Service innovation in networks entails coordination of operational activities (Gulati et al., 2012). Organizations dedicate resources – commonly used for their routine business – to develop new services. Given the knowledge-intense context we examine, organizational resources need to acquire and collectively develop new knowledge for service concepts, systems, and ultimately encounters (Baron et al., 2018). We are interested in service innovation as interactions organization envision. The sector we examine relies on complex technologies requiring sophisticated and increasingly digitized services. These complement products and are conceptualized as complex product-service systems (Zhang, Ren, Liu, & Si, 2017). Hence, service innovation as journeys or blueprints common in mass B2C literature seems less relevant. Rather, *we seek insight in how organizations explore future coordination in the context of the network value proposition and business model they consider of interest, and specifically how they consider the use of Artificial Intelligence*.

Cooperation and coordination each feature their own dynamics. Their mutually constituting dynamics, however, remain unknown, especially in the context of service innovation. Moreover, our question led us to problematize the process of service innovation. We developed an approach that combines 'weak' (linear) and 'strong' (experiential) process views (Berends & Sydow, 2019) to capture design and 'real life' experiences. We have examined this phenomenon in an emerging service innovation network, being engaged as academics in an open innovation project that functions as an add on to a closed triadic service innovation project. High levels of uncertainty make for an 'extreme' case (Eisenhardt, Graebner, & Sonenshein, 2016): organizations are likely to actively explore how to pursue their own and collective interests. We focused on the early stage of organizations trying to establish new arrangements with potentially sufficient stability for implementation.

3. METHODS

3.1 Empirical Setting

Interest in service innovation on a network level has been increasing across industry sectors. In the Netherlands, the maintenance of maritime equipment for the Royal Dutch Navy is performed by a national network of companies. Investigating the development of service innovation in this context provides us with an ideal setting. First, the network consists of Dutch companies or subsidiaries of multinationals that have a very long history of conducting business. The trust that has been built up over these years contributes to the willingness to collaborate. At present, there have been dialogues with respect to service innovation collaboration and development of capabilities, but there have not yet been significant joint investments (Pikka, Iskanius, & Page, 2011). Even though interpersonal contacts across organizational boundaries tend to be frequent and intense within the network, relationships have been mostly transactional. Second, the vessels that are being maintained by the network can be characterized as having a very high value and a long asset lifecycle – a few decades – and are typically renewed and updated in terms of software and systems during maintenance. Because of the longevity of the underlying assets, network service innovation processes can be established for the long-term and involve intense collaboration among the network partners. For these reasons, a network for maritime service logistics represents an excellent setting to investigate our research question. This research has been conducted as part of a large-scale open innovation project.

3.2 Research Design & Data Collection

Because our research question focuses on how organizations collectively develop service innovations, we chose a qualitative research design for this study. From the outset we as a research team were aware of tensions common to open innovation projects (Reypens et al., 2016). With team members having ample experience at the intersection of business and academia, we paid attention to academic framing as well as practitioners' views and needs. We implemented a nested case study approach (Thomas, 2011), where results that emerge from several networks and participating organizations are integrated and evaluated in a holistic manner. A nested case study differs from a regular multiple case study in that it gains its integrity from the wider case, in this study the maritime service logistics network. Within the open innovation project, our specific case concerns a pilot on Data Science, a domain that extends data storage and analysis towards quantitative business process analysis (Van Der Aalst, 2016). Three organizations participating in that project have been developing their Data Science capabilities in a closed innovation project. The three organizations developing their joint Data Science capabilities are referred to as, first, BuildCo: A global shipbuilding and maritime service company. In accordance with industry dynamics, it invests in digital product development and service capabilities. Second, ShipCo is an organization operating ships and maintaining them in cooperation with industry. And third, ElecCo is an international system integrator, including products and services.

For our nested case study, we were granted access up to a certain level to their closed project to foster learning within the closed and open project spaces. We took a process-oriented perspective (Poole, Van de Ven, Dooley, & Holmes, 2000), as our aim was to analyze how service innovations are developed in networks over time. Our access did not include technical data and models or sensitive public and commercial information of the three organizations involved. We did not experience unusual constraints while conducting our research. Our primary unit of analysis was the Data Science network consisting of the three organizations. We also collected data at the organizational level, their subunits and different management levels. Data was collected via multiple avenues: Roundtable interviews, individual interviews, (validation) workshops, corporate documents, team blogs and impromptu conversations. The entire population is small, so we interacted with the same people multiple times, allowing for cross-verification over time.

3.3 Data Analysis

To obtain an answer to our research question, we have been going through 5 subsequent steps, which have not yet been completed. We do include all steps to provide an overview (Figure 1), and elaborate on our results in the next section.

In the first step, we developed practice scripts based on generic dimensions of practices, such as goal setting and instrumentality (how to achieve goals). An example of such a script is shown below. Such scripts were used to elicit practitioners' thoughts on service innovation in their network:

1. The network around the […] aims to serve [...].
2. The network does this by achieving [...] through [...], performed by [...].
3. The collaboration is supported informally by [...] and formally by [...].
4. A win-win-win situation is created and maintained if [...], and in 5 years the network will [...].

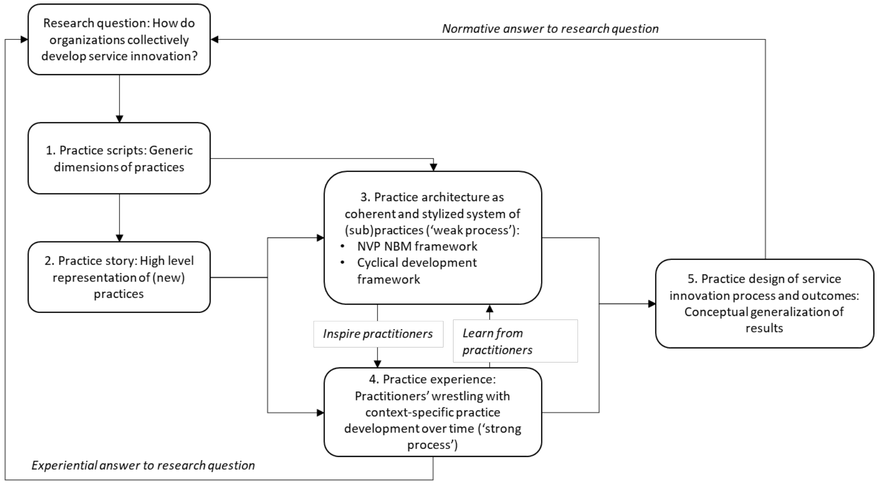

Figure 1. Research Approach

During the second step (Figure 1), we provided these scripts to company representatives during a workshop and invited them to reflect on their current practices and fill in the blanks in the scripts. Their responses formed the basis for practice stories, a high-level representation of practices relating to network-level service innovation. In the third step, we analyzed these practices and ultimately visualized them into an architecture consisting of a coherent and stylized system of practices. Our analysis resulted in two frameworks:

- A process model encompassing the network value proposition and network operations (static) as well as an integrative network business model (dynamic), depicted in Figure 2, and
- A cyclical development practices framework (currently developed).

These frameworks were validated by the company representatives during follow-up meetings: we inspired practitioners and learned from them. We are elaborating steps 4 and 5 as represented in Figure 1.

In line with Kowalkowski et al. (2013) we employed an abductive approach, and went back and forth between theoretical insights and empirical observations (Dubois & Gibbert, 2010). Abduction covers the middle ground between induction and deduction, allowing for the acceptance of both existing theory and empirical observations (Järvensivu & Törnroos, 2010; Kowalkowski, Witell, & Gustafsson, 2013). Similar to Kowalkowski et al. (2013) we relied mostly on induction in the first phase and deduction in later phases. This implies that we let the data guide the analysis in the first phase, and thereafter increasingly turn to existing theory to position our research. Our data analysis led to reflection on the process of service innovation in a network, engaging both academic and practitioner approaches.

4. FINDINGS

4.1 Process Framework for Service Innovation on a Network-level

Based on the input gathered from the scripts, we visualized the process model for service innovation on a network level. We could distinguish activities related to the process of service innovation in a network on 4 different levels. On one hand the collective – or network – and individual partner level, i.e. cooperation (Gulati et al., 2012). On the other hand, the interaction and data & AI levels, i.e. coordination (Gulati et al., 2012). These levels constitute the basis for the network, and have a static nature. Activities on the interaction and data & AI level establish the network operations. Based on the interests on the collective and individual partner level, the network value proposition is formulated. This starts the dynamic part of the model and delineates how value is created by and for the network (Figure 2).

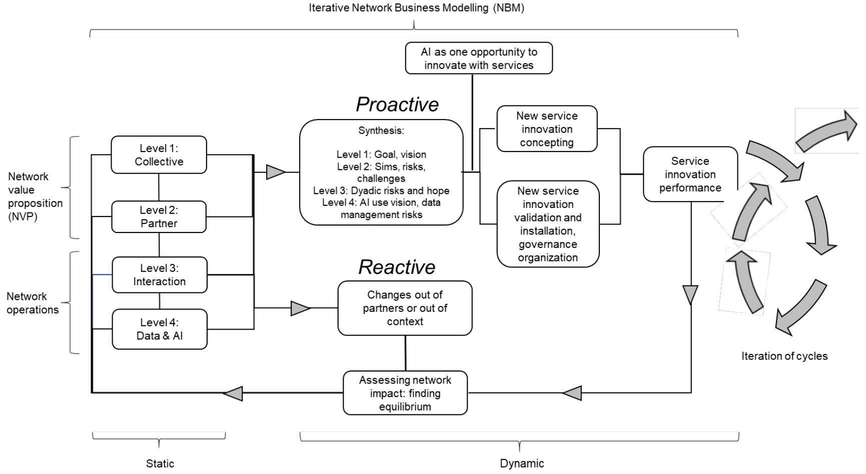

Figure 2. Process model for service innovation on a network level

In the data science use case, the network value proposition entailed *improved performance of the Royal Dutch Navy's assets at the lowest total cost of ownership*. Service innovations can either be introduced reactively, in response to contextual factors, or proactively. In order to deliver the network value proposition, the network-level goal was established to proactively develop new service innovations within the network enabled through new technology. On the individual partner level this resulted in firm-level anticipated benefits, such as being able to better satisfy the customer firm within the network. However, this also led to individual partner risks and challenges, such as IP or data protection. On the interaction level, the goal of achieving improved performance at lowest total cost of ownership through network service innovation generated dyadic risks and hope, such as managing interorganizational processes despite differences in organizational agility or bringing in specific skills and expertise, respectively. At the Data & AI level, aiming to deliver network value proposition resulted in a shared AI use vision and a common vision on data management risks.

Subsequently, the partners in the network identified AI-based services as a fruitful innovation pathway. Making use of Artificial Intelligence algorithms for analyzing maintenance and asset breakdown patterns was seen as an opportunity to move towards more advanced and efficient predictive maintenance services. In the next phase, the network partners started both with concepting the new service and validating the service, discussing governance aspects such as data ownership iteratively. One of the main challenges during this phase was formalizing the collaboration through a contractual agreement. After successful installation of the new service, the performance of the new service impacts the network, such as through an alleged improved relationship between the network partners, which will then find a new equilibrium. This new equilibrium potentially affects the network value proposition and network operations, thereby starting a new iteration of the process.

4.2 Practices Framework for Service Innovation on a Network-level

We are currently developing a framework of practices associated with service innovation for the different levels. We find that on the network level, strategic dialogues between the partners are initiated, resulting in a kick-off of the service innovation process. Subsequently, capability development is managed within the network, leading to progress management. In parallel, there are activities related to the formalization of the strategic network agreement, ultimately generating a contract for the network collaboration. Thereafter, the strategic value of the service innovation for the network is managed, and potential effects on the network equilibrium are evaluated and mitigated, resulting in strategic viability of network service innovation. At the individual partner level, the network vision and value proposition are aligned with the organizational ambitions, leading to participation in the network if these can be matched. Thereafter the balance between the organizational and network goal is guaranteed by constantly managing the individual organizational contribution and network value extraction. In addition, internal horizontal (interdepartmental) and vertical (top-down) alignment is ensured through support for the formal agreement and business case. Ultimately, the individual partners start to either procure or deliver the service innovation and, if possible, leverage the service innovation to customers outside of the network. At the interaction and AI operational levels, the service innovation capabilities, specifically the AI capabilities, are developed, embedded and ultimately servitized. Our process and practices models represent a weak process view which is still incomplete in the sense of analyzing the evolving service innovation experience of participating organizations (step 4 in Figure 1) and generalizable design (step 5 in the same Figure).

5. DISCUSSION

Organizations increasingly engage in service innovation collectively, in a network (Raddats et al., 2019). Current research predominantly focuses on their drivers or analyzes them from socio-cognitive and co-creation angles (Crossan & Apaydin, 2010; Hansen, 2017). We observe a paucity of research structuring the process of service innovation in networks and acknowledging the evolving experience of participants. In this study we set out to answer the question *how organizations can structure the process of service innovation in a network*. Through a qualitative research approach based on scripts, workshops and interviews we structured the process and practices of service innovations emerging from networks. We detail four levels to structure the process and practices of service innovation in networks, namely: The network, partner, interaction, and data/AI level. The process and practices frameworks facilitate the iterative development of new network value propositions and network business models through service innovation, inspiring and leveraging practitioners' evolving experience. Thereby, we offer both academics and practitioners scripts, a vocabulary and practices to construct and reflect on models for service innovation in networks.

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AUTHORS

Prof. Paul C. van Fenema
Department of Military Business Sciences, Netherlands Defence Academy / Faculty of Military Sciences, Breda, Netherlands, 4818 CR
+31611888375, pc.v.fenema@mindef.nl

Dr. Kars Mennens
Department of Marketing & Supply Chain Management, Maastricht University, Maastricht, The Netherlands, 6211 LM
+31646183147, k.mennens@maastrichtuniversity.nl

Tom Schiefer, MSc.
Department of Marketing & Supply Chain Management, Maastricht University, Maastricht, The Netherlands, 6211 LM
+31610248812, t.schiefer@maastrichtuniversity.nl

Prof. Dominik Mahr
Department of Marketing & Supply Chain Management, Maastricht University, Maastricht, The Netherlands, 6211 LM
+31433883855, d.mahr@maastrichtuniversity.nl

INTERNATIONAL CONFIGURATION OF INDUSTRIAL SERVICE OFFERINGS

Jelena Jovanovic, Dirk Morschett

ABSTRACT

Purpose: Despite the increased focus on services for manufacturing companies and their dependence on international sales, little is known about how they should deliver industrial services across borders. The purpose of this paper is to address this gap by studying the configuration decision of individual industrial service offerings across borders, by considering the impact of the digitalisation.

Design/Methodology/Approach: A online survey with Swiss and German industrial manufacturers will be conducted.

Findings (expected): We expect to find that the resources for services with a high extent of digitalisation tend to be centralised, while they are decentralised for services with a high degree of customer contact, co-creation or relationship intensity.

Originality/Value: This paper complements the knowledge on the provision of individual industrial service offerings by subdividing the service provision into the stages of the FTU framework by Moeller (2010). The focus lies on the configuration of the facilities (resources) necessary to provide a specific service, since many of them can be centralized even if the transformation takes place on site. Furthermore, we study the characteristics of service offerings leading to a specific configuration decision.

KEYWORDS: International Configuration, Industrial Services, Digitalisation

1. INTRODUCTION

Increased competitiveness in developing countries, globalization of markets, higher consumer awareness and changes in customer demand have forced industrial manufacturers, particularly those active in highly industrialized countries and mature product industries (Cusumano et al., 2015), to look for new differentiation strategies (Lay et al., 2010). As a consequence, they are focusing increasingly on selling services and combining their products with services, a strategy known as servitization (Vandermerwe and Rada, 1988). Many of these manufacturers sell internationally. Hence, challenges for manufacturers on how to provide services across borders arise (Oliva and Kallenberg, 2003). Nevertheless, researchers in international management, unlike researchers from other fields, have somewhat neglected it, leaving the cross-border perspective on the service provision of industrial manufacturing firms relatively unexplored (e.g. Vendrell-Herrero et al., 2018a). In this regard, the configuration decision (Porter, 1986), i.e. where to locate specific resources necessary for the service delivery, deserves special attention.

While for manufacturing, the location of the resources and the activity of producing are located at the same place, the decision is more complex for services since a) the resources for service provision do not have to be located where the service provision takes place and b) activities are heterogenous regarding their characteristics. Due to this, the requirements of local and central systems and processes differ notably and require various organisational structures (Kowalkowski et al., 2011). Thus, in order to study the resource configuration decision on the level of a service offering, a more fine-grained characterisation is necessary. To the best of our knowledge, there is no research to date on the resource configuration decision of industrial service offerings. The study of Kowalkowski et al. (2011) is the only one analysing the role of local or central organisations for individual service offerings. We argue that, next to the characteristics customer contact, co-creation, and relationship intensity, as defined by Antioco et al. (2008), the extent of digitalisation is another pertinent characteristic of service offering influencing the configuration decision. Past research has recognized that digital advancement changes the nature of some services as well as the way they are delivered (Sklyar et al., 2019), but academic knowledge on the influence of digital advancement on the international service provision is scarce (Hakanen et al., 2017; Jack et al., 2015; Raddats et al., 2019). By decoupling production and consumption of services, digital advances enable and facilitate the centralization of resources by making a remote delivery of certain services possible (Porter and Heppelmann, 2015; Venkatesh et al., 2009).

However, companies which build a digitalisation capability usually adopt a servitization strategy (Parida et al., 2015). This implies a closer and more personal collaboration with the customer and contradicts the centralisation of digitally centralisable services. To understand this contradiction, the different service characteristics have to be analysed in detail. Furthermore, industrial manufacturing companies are facing two main restrictions in the configuration decision. First, the existing structure respectively the administrative heritage (Sklyar et al., 2019) and second, the digital readiness of the host country may pose a barrier (Yoo et al., 2018).

All this leads to the following research questions: Which characteristics of service offerings lead to which configuration across borders in terms of centralization and decentralization? Do the level of servitization, the digital readiness of the host country and the administrative heritage have an impact on the configuration of industrial service offerings?

2. THEORETICAL FRAMEWORK

2.1 International Configuration

When internationalizing, one decision companies need to take is the location or configuration decision of each activity. It is about deciding to what degree to centralise or decentralise the assets and capabilities to perform a certain activity of the value chain (Porter, 1986). Decentralising means to geographically disperse comparable activities and perform them in parallel to one another, whereas centralising means to carry out comparable activities only at a certain (central) location of the firm (Bartlett and Ghoshal, 1989). In this article, location refers to the country.

The advantages resulting from having only one or few sites are economies of scale, a proprietary learning curve and cost reduction (Porter, 1986). For services, having experts with vast information in a central location facilitates problem solution and can lead to product enhancement trough collected and bundled information (Vendrell-Herrero et al., 2018a). Since industrial manufacturers offer several services which are people-intensive and very costly, they have to be productive in order to profit financially. For this, centralising resources which can be used for different services and locations, can be advantageous (Venkatesh et al., 2009). The main driver of decentralization of activities is proximity to customers (Porter, 1986). Trust and relationship experiences are important for building business relationships, favouring decentralization of service provision (Cusumano et al., 2015).

2.2 Service Provision - FTU Framework

According to Moeller (2010), service provision can be subdivided into three stages (see Table 1): facilities, transformation and usage (FTU) (Moeller, 2010). Furthermore, two types of resources must be considered, namely the providers' and customers' resources. The providers' resources, including employees, know-how and machines, are part of the "facilities". They are the foundation of value creation and make service provision feasible. Data is a further unique provider's resource which is part of the value creation (Ulaga and Reinartz, 2011). The customers' resources, which can be the customers know how, their physical objects (machines) or their data, are part of the "transformation". The transformation of the customers' resources takes place by combining customers' resources with the providers' resources. The last stage "usage" refers to the outcome of the service provision, where the value is created for the customers (Moeller, 2010).

3. INTERNATIONAL CONFIGURATION AND THE FTU FRAMEWORK

While for manufacturing activities, the resource location (i.e. the manufacturing plant) and the production location (i.e. the activity of producing) are the same, it is not always the case for services. According to the FTU framework (Moeller, 2010), for service transformation to happen, the resources of the provider and of the customer must somehow meet. It does however not imply that the location of the provider's resources (the facilities in the FTU framework), which are needed for the transformation, is the same as that of the customer's resources.

In general, the provider is autonomous in the decision where to locate the respective resources needed for a specific service activity (Moeller, 2010). Many services rely on direct interactions with the customers. For the manufacturer, this signifies either sending employees (service technicians or engineers) from a central location to the customers' locations or to have a direct or indirect presence with local service employees in the corresponding market (Kucza and Gebauer, 2011). Other services rely heavily on the manufacturers know how, which can be available predominantly in a central location (e.g. the headquarters) or locally in the foreign target market. For a physical repair on a machine, the provider's resources, which are the service technicians, can either be located in the country of occurrence or in a central location and sent to the host country when necessary. The transformation however has to take place on the same location, namely the location of the machine, i.e. the provider's and customer's resources have to meet in space and time (Song and Liu, 2013).

Digitalisation allows to bundle the human resources at a central location since they do not need to be present locally anymore (Vendrell-Herrero et al., 2018a). This can counter the pressure of scarce skilled labour force in many markets. In the case of remote maintenance for example, the service experts are usually located in a central location and provide the service digitally. The transformation takes place at the customer's location, which can differ from the service provider's location. Thus, the provider's and customer's resources meet in time, but not in space. Table 1 summarizes the above discussion.

Table 1: International configuration and the stages of service provision

Stages of the FTU Framework / **International Configuration**	**Facilities** (Company resources act as a prerequisite to any transformation)	**Transformation** (Transformation is induced by customers integrating their resources in terms of persons, objects, nominal goods and/or data)	**Usage** (Customers benefit from the transformation of provider or customer resources)
Resources	Employees, Know How, Machines, Data	Know How, Machines, Data	
Configuration Decision	Where are the respective resources located? local (in the host country) or central (outside of the host country and used for different countries)	Where does the transformation take place? local (provider's resources at customer's site) or central (customers resources at providers site)	
whereas **decentralisation**	local (in the host country)	local (provider's resources at customer's site)	
and **centralisation**	central (outside of the host country and used for different countries)	local (provider's resources at customer's site) or central (customer's resources at provider's site)	

In this vein, the providers' resources are value-adding and the configuration decision must be taken on the level of the available resources, which is why this study focuses on examining the international configuration of the providers' resources. This decision is of high importance for industrial manufacturers for different reasons. According to the resource-based view (RBV), resources are generating the desired competitive advantage, thus, they should be located in the way that their value is optimally exploited (Sharma and Erramilli, 2004).

4. CHARACTERISING INDUSTRIAL SERVICES

Researchers from different fields categorize services in manufacturing differently. In the operations literature, Baines and Lightfoot (2013) categorize the services offered by manufacturing firms into base (e.g. goods and spare parts), intermediate (e.g. helpdesks, maintenance or repairs) and advanced services (e.g. customer support agreements and outcome contracts). Mathieu (2001) divides them in services supporting the supplier's product (SSP) and services supporting the customer's actions (SSC). SSP support the use of the products and ensure a well-functioning and comprise services such as repair or maintenance. SSC are process-oriented and do not have to be product-specific. They include service activities such as consulting and training (Antioco et al., 2008).

Even though the different literature streams have different conceptualizations, many of these taxonomies are related to the SSP versus SSC dichotomy (Raddats et al., 2019). The SSP versus SSC classification is the most commonly used taxonomy to classify services. The distinction helps explain differences in antecedents and outcomes of industrial service strategies (Eggert et al., 2014). Industrial services offerings are very heterogeneous regarding their characteristics. The distinction between SSP and SSC is based on the inherent characteristics of these two groups. We argue that the service focus (product versus customer's action) does not have a direct impact on the international configuration, but that specific characteristics of the individual service offerings are key and should be analysed.

According to Antioco et al. (2008), the characteristics leading to the separation into SSP and SSC are tangibility of the recipient, co-creation and relationship intensity. These characteristics have a substantial influence on the configuration decision (Kowalkowski et al., 2011). Additionally, Raddats et al. (2019) propose that service offerings should be characterized depending on their extent of digitalisation, ranging from non-digital over digitally-enabled to digital services. Different to non-digital services, the marginal cost of producing additional units of digital services is practically zero. Also, digital services, such as self-service touch points, are non-excludable, i.e. providing them to one customer does not importantly reduce the availability for another customer (Vendrell-Herrero et al., 2018b). Digitally-enabled services are changing the customer processes and are impacting the provider-customer relationship. Those offerings are combining physical and digital offerings, such as adding online monitoring to a product (Coreynen et al., 2017).

4.1 Degree of Required Customer Contact

According to Antioco et al. (2008), services differ according to the tangibility of the recipient, whereas the recipient is either the tangible product or the intangible customer's processes. The tangibility of the recipient is highly related to the degree of required customer contact (Raja et al., 2018). Hereby, services supporting the product, such as installation, repair or maintenance, require low customer interactions, whereas services having people or processes as recipients, e.g. process optimization or consultancy, demand strong interactions with customers (Antioco et al., 2008). The degree of required customer contact concerns mainly the configuration decision of the resource "employees". For the provider, it signifies sending employees from a central location to the customers' locations or having a presence with local service employees in the corresponding market (Kucza and Gebauer, 2011).

Low or non-contact activities are primarily delivered to support the tangible product and do not provide a sustainable source of competitive advantage (Eggert et al., 2014). Put differently, they are preventing product failures rather than being sources of differentiation (Antioco et al., 2008). Since these act activities require higher technical skills, they may be separated for greater efficiency gains (Raja et al., 2018). Furthermore, they are rather standardized and centralising can help to reach global synergies (e.g. Venkatesh et al., 2009).

According to Zomerdijk and Vries (2007), activities with high customer contact require different organisational designs to maximise efficiency. High contact activities mainly aim at bringing knowledge to the customers or managing it for them (Antioco et al., 2008). For cross-cultural dealings in services, responsiveness is even more important because it implies dealing with different cultures and expectations (Van Birgelen et al., 2002). By committing to the host country through local employees, local customers are more likely to accept a firm with a foreign background (Grönroos, 1999). This is why the resources of high contact activities tend to be decentralised (Raja et al., 2018). Thus:

H1a: The higher the degree of required customer contact, the less are resources centralised.

4.2 Co-Creation

According to Vargo and Lusch (2008), the term co-creation refers to the co-creation of value and comprises co-production of the service. Furthermore, they argue that "the customer is always co-creator of value". Following the argumentation of Antioco et al. (2008), this can also be interpreted as the customer having a very active or passive role during the service performance.

Co-creation is related to the level of service customization. Standard services usually require no or low co-creation, while delivering customised services requires customer engagement in co-creation. Co-creation is demanded for SSC as they encompass customised services (Antioco et al., 2008).

For co-created services, the customers' resources typically include the customers' employees. Since the provider has several customers in different countries, the approach has to be adapted to the foreign market's acceptance of foreign firms (Grönroos, 1999). Thus, for services which are co-created by the customer, the approach needs to be adapted to the customer's expectations, needs and processes (Hakanen et al., 2017), i.e. being close to customers is crucial (Porter, 1986). Typically, process-oriented services are customised and need co-creation, which is why those services require local responsiveness and problem solving (Cusumano et al., 2015; Kowalkowski et al., 2011). Thus:

H1b: The higher the co-creation, the less are resources centralised.

4.3 Relationship Intensity

Industrial services can be classified as transaction-based versus relationship-based services (Oliva and Kallenberg, 2003). Services emphasizing on the people rather than the product as recipients of the services rely on an intense relationship to the customer. Typically, services aiming at the customer's processes are relationship-intense. By going further than only ensuring the functioning of the product, those services create a more intense relationship to the customer (Antioco et al., 2008).

Trust and relationship are important for building long-lasting business relationships. Being close to the customer is beneficial for building a deep relationship (Cusumano et al., 2015). The empirical results of Gattiker et al. (2007) show that no computer-mediated interaction can replace traditional relationship and trust building. Companies profit from tacit and explicit knowledge spillover by being close to customers. This creates relational, capital and social embeddedness (Gomes et al., 2019).

Product-centred services do not really help to build a strong business relationship to the customer. Usually, those services are standard services, such as repair or maintenance, which require a less intense relationship to the recipient (Antioco et al., 2008). Because the relationship is not a focus, centralization is favoured in order to reach global synergies (Venkatesh et al., 2009). Thus, we posit:

H1c: The higher the relationship intensity, the less are resources centralised.

4.4 Extent of Digitalisation

Dunning (1989) concluded that the configuration decision of services was restricted, inter alia, by the service nature which enabled only centralising, services embodied in goods or people. The digital development has however changed the nature of some services and the way they are delivered (Sklyar et al., 2019). It changes the customer contact to less physical as well as the customer being less present in the delivery system (Zomerdijk and Vries, 2007). Consequently, it makes some services at least partially separable and enables centralization (Vendrell-Herrero et al., 2018a).

So-called digital services decouple production from consumption and substitute traditional offerings, which demand a local presence as well as a high degree of interaction (Kowalkowski et al., 2011; Sklyar et al., 2019). Thus, for services, for which the provision can be spatially decoupled, the provider's resources and the customer's resources do not have to meet in space (Song and Liu, 2013). Consequently, the provider's resources are centralisable and exportable (Jack et al., 2015). Furthermore, digitalisation lowers the total unit cost of a service offering or components of the service by making the service scalable and able to be performed at the same location (Venkatesh et al., 2009). Digital services, such as remote monitoring, lead to a better planning and scheduling of service tasks and improved engineer efficiency (Deloitte, 2013). Besides, technology-based services are based on data and rely mainly on highly skilled employees. Since they are scarce worldwide (Sklyar et al., 2019), centralization of the service provision can help to reduce the bottleneck. Thus, we posit:

H1d: The higher the extent of digitalisation, the more are resources centralised.

5. SERVITIZATION

According to Vandermerwe and Rada (1988), servitization is an organisational change process which denotes that companies add more and more value to their core offering through services and thus experience a shift in their core business towards services. They define three stages: (1) the company is either in goods or services business, (2) goods and services are combined in offerings and (3) offerings are complex bundles of goods, services, information, support and self-service elements.

Oliva and Kallenberg (2003) refer to it as changing the focus of customer interactions from transaction-based services, such as installation or repair, to relationship-based services, such as preventive or full maintenance contracts. Baines et al. (2017, p. 257) conclude that the various definitions consolidate to "servitization being a process of building revenue streams for manufacturers from services".

It has been found that servitization impacts the organisation of global sales and distribution, mainly because the offering becomes more intangible. This again increases the relevance of business relationships (Hakanen et al., 2017) because servitization implies offering more customised solutions (Ulaga and Reinartz, 2011). Customised solutions not only need digital technologies that enable them, but more employees which deal with and support the customer. Furthermore, manufacturers which change the focus from selling solely a product to selling a service, inherently have a higher demand for services. When a manufacturer guarantees the availability and reliability of a certain product (e.g. engine), the entire responsibility to deliver all the products and services needed to guarantee product availability and reliability passes to the manufacturer (Visnjic et al., 2017). The manufacturer will not only coordinate all the activities but may also need to adapt the way to ensure the promised outcome. This might require adapting some activities, or the responsibility for delivering them, to local requirements and expectations since they differ across countries (Hakanen et al., 2017). To understand the customer's expectations and allow for adaptation, resources need to be locally responsive, i.e. decentral (Wilson et al., 1999). Besides, servitization implies having generally a stronger customer focus and building a deeper relationship with the customer (Oliva and Kallenberg, 2003). Thus:

H2a: Servitization strengthens the negative relationship between i) the degree of required customer contact and centralisation, ii) co-creation and centralisation, iii) relationship intensity and centralisation.

Servitization includes offering digital services instead of, or as a complement of, other services. According to Porter and Heppelmann (2015), smart and connected products create new services. These new services rely heavily on data and expert knowledge. Since data about the product use and performance is a valuable resource, it can be seen as a unique asset of the firm (Ulaga and Reinartz, 2011). Centralising data enables collecting information about worldwide product usage and customer processes. This "big" data helps to improve products and services and enhance their overall offerings (Ulaga and Reinartz, 2011). Besides, because related human resources in this field are scarce (e.g. data scientists), companies tend to centralise the resources associated with providing digital services (Sklyar et al., 2019). Servitization transfers the responsibility and risks from the customer to the manufacturer (Visnjic et al., 2017). Non-availability and suboptimal product performance are among the biggest risks. Real-time information about the current and future health of the product enabled by remote monitoring technology allows to mitigate some of those risks (Grubic, 2014). Because data and know how tend to be centralised, we hypothesize:

H2b: Servitization strengthens the positive relationship between the extent of digitalisation and centralisation of resources.

6. IMPACT OF THE EXISTING STRUCTURE AND HOST COUNTRY

6.1 Administrative Heritage

Even though companies need to align the organisation appropriately with strategy to profit from the advantages of offering services (Sklyar et al., 2019), the organisational structure is mostly given and cannot always be easily changed, due to the so-called administrative heritage. The administrative heritage is defined as "the existing configuration of assets, distribution of responsibility, historical norms, values, and management style" (Bartlett and Ghoshal, 1988, p. 56). These elements can hinder the company to adapt as quickly as desired to the changing environment and strategy. Thus, companies depend largely on previous organisation decisions. Based on this, we posit:

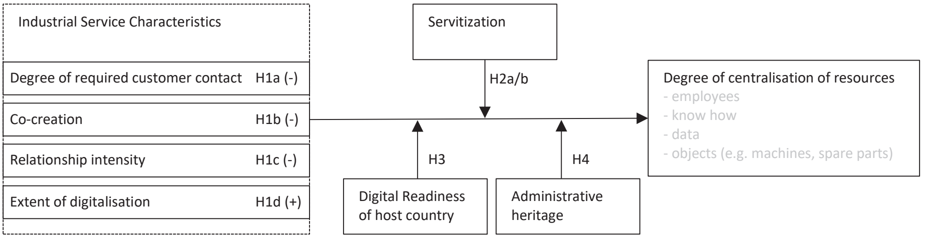
H3: Administrative heritage influences the relationship between the different industrial services characteristics and centralisation of resources.

6.2 Digital Readiness of the Host Country

Despite the numerous opportunities of technology for centralisation, barriers are posed by the acceptance of foreign customers and the ability of the foreign country to receive them (Wünderlich et al., 2013). Van Birgelen et al. (2002) conclude that country-level variables, such as the degree of internet penetration and acceptance, should be included in the context of technologically-based services. The digital readiness of a host country (Yoo et al., 2018) summarizes these issues, which make remote delivery, and therefore centralisation of some resources, possible. Concretely, for a successful remote delivery, the customer in the host country must be able and willing to receive digitally-enabled services (Javalgi, 2004). The ability to receive such services also depends on structural factors, such as technical infrastructure, governmental regulations and economic issues. Having a good infrastructure alone has a little value if the population cannot take advantage of it (Yoo et al., 2018). Thus, availability of educated, skilled workforce to help deploy and maintain technology is crucial (Javalgi, 2004). Furthermore, the willingness to accept digitally-enabled services is highly influenced by cultural characteristics. They have a great influence on the effectiveness of service delivery in foreign countries (Van Birgelen et al., 2002) since customers have not only expectations towards the service activities itself, but also on the way they are provided. Digitally provided services might make service provision more efficient, but also create a distance between the customer and the service personnel. Furthermore, imposing complex technologies that do not, from the customer's view, enhance the service process, might create hostile customers (Walker et al., 2002). Thus, we posit:

H4: Digital readiness of the host country positively influences the relationship between the extent of digitalisation and the centralisation of resources.

Figure 1: Conceptual Model



7. CONCLUSION

This article focuses on the international configuration of service provision. The goal of this paper is to shed light on this topic by analysing the configuration decision of individual service offerings.

The FTU framework explaining the stages of service provision (Moeller, 2010) helps to understand the international configuration decision for service offerings. Concretely, while transformation mostly happens at the customer's location, the location of the provider's resources prior to the transformation is not obvious. Since resources are generating the desired competitive advantage, they should be located in the way that their value is not affected (Sharma and Erramilli, 2004).

Although digital advancement changes the nature of some industrial services and the extent of digitalisation influences the way they are delivered, this paper argues that services with a high degree of customer contact, co-creation and high relationship intensity are decentralised. The main reason is that many industrial services do not only ensure a well-functioning, but strengthen the relationship to the customer, which is crucial because it ensures future product and service sales (Cusumano et al., 2015). This is even more important in the case of servitization. Firms which increase their service focus have a higher need to decentralise services with a high degree of customer contact, co-creation and relationship intensity. However, since this requires a high investment into resources, mainly employees, those service offerings with a high extent of digitalisation are expected to be more centralised, since they have a low unit cost and are can easily be centralised.

The configuration decision faces restrictions from the host country, namely the digital readiness, as well as the administrative heritage. Both are expected to limit the decision-making regarding the configuration. For executives, deciding on the location is a difficult task. One reason is that generally the more centrally the services are provided, the farther they are from the customer.

Even though the argumentation in this article is based on previous articles studying industrial manufacturing companies, the conceptual nature of it is obviously limiting its generalisability. Future research could explore contextual boundaries of the framework, such as differences in industries as well as in company size which can strongly affect the configuration decision. For example, small companies might not have the financial means to invest in local resources even though their services need co-creation. An empirical study should also provide greater insight that underlies the discussed propositions.

8. THEORETICAL AND PRACTICAL IMPLICATIONS

This paper highlights the relevance of studying service provision in stages, mainly distinguishing between the resources necessary for the provision and the transformation itself. Furthermore, it shows that the configuration decision of service offerings can be studied via the service characteristics. These findings are relevant also for practitioners, when deciding where to locate or relocate their resources for service provision. Resources for services which require a high customer contact, involve co-creation or contribute highly to relationships should be located close to the customers, i.e. in the country of the customer. However, since this is very costly, services with a high extent of digitalisation are to be more centralised as they have a low unit cost and are can easily be centralised.

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AUTHORS

Prof. Dirk Morschett
Chair for International Management,
University of Fribourg,
Fribourg, Switzerland, 1700
+41 26 300 84 17, dirk.morschett@unifr.ch

Jelena Jovanovic, M.A.
Chair for International Management,
University of Fribourg,
Fribourg, Switzerland, 1700
+41 26 300 84 59, jelena.jovanovic@unifr.ch

DIGITAL COMPETENCE FOR SELLING ADVANCED SERVICES: AN EXPLORATION OF SUCCESS CRITICAL COMPETENCIES OF SALES PEOPLE

Thomas Süße, Sebastian Kola

ABSTRACT

Purpose: The article seeks to explore specific facets of digital competence among sales people in an advanced services company where digitalization is a key enabler for the business model.
Design/Methodology/Approach: The article follows a single case study approach. The method of semi-structured interviews among five senior sales experts within the advanced services company has been applied for data collection.
Findings: The main finding is a six-dimensional framework of actors' digital competence which is deduced from state-of-the-art literature and further specified with the help of empirical findings from an advanced services company.
Originality/Value: The specific dynamics of advanced services are usually considered as organizational level phenomena. However, due to the further digitalization of advanced services also lower levels in organizations are affected by higher complexity and ambiguity. For that reason, this article puts specific focus on the individual actor's level in order to better understand competence demands in digitalized advanced services business contexts.

KEYWORDS: digital competence, advanced services, sales, solution selling, human actor

1. INTRODUCTION

A key prerequisite for the success of advanced services businesses can be seen in ongoing sensing, seizing and reconfiguring activities within and beyond organizations and enterprises (Teece, 2007; Vendrell-Herrero et al., 2014). In that regard also human actors' competencies of constantly updating, enhancing and integrating widely spread heterogeneous knowledge is of increasing importance for innovative business concepts like advanced services which are based on co-creative value creation processes (Baines et al., 2009). In addition, advanced services as such are increasingly based on, related to or enabled by smart products (Lee, 2010, p. 1163). Thus, digital technology can be considered as a key enabler for further enhancement and prosperity of advanced services businesses and customer specific solution offerings (Coreynen et al., 2017; Lerch and Gotsch, 2015). Digital technologies can also support the ongoing enhancement of integrative knowledge bases which are highly relevant for advanced services offerings as well. This means that digital technologies play a crucial role from at least two perspectives. Firstly, these technologies are an integral element of advanced services offering themselves (e.g. artificial intelligence algorithms within smart sensors) and secondly these technologies enable more effective, efficient as well as enriched information exchange (e.g. communication and collaboration platforms) between a number of heterogeneous stakeholders involved in co-creative value creation processes .

However, in order to explore and exploit the opportunities related to digital technologies human actors like sales people may need a specific set of digital competencies to apply available digital tools and technologies successfully as well as to understand the added value of digital technologies as integral element of advanced services offerings. While recent literature emphasizes that there is a huge demand for understanding more about the specific competencies human actors may need in the context of advanced services (e.g. Baines et al., 2017) an empirical based exploration of human actors' digital competencies that enable individuals to contribute to the success of advanced services business has not been introduced so far. Most contributions remain on a rather conceptual level (Lenka et al., 2018; Süße et al., 2018). In order to address this gap in research this article focusses on individual actor level competencies as the unit of analysis. The main research question of this article is: Which facets of digital competencies are considered as increasingly important by sales people in the processes of solution selling in advanced services business contexts?

2. THEORETICAL BACKGROUND

The article's theoretical framework draws on recent developments and conceptualizations of affordance theory also discussed in organization research, the state-of-the art literature about how digitalization and new technologies enable, support or boost servitization and advanced services as well as recent literature about the conceptualization of digital competencies at an individual actor level. As servitization is more often discussed as organizational level phenomenon or strategy the majority of the literature has no explicit focus on the individual level (e.g. Raddats et al., 2019). Thus, the article also seeks to contribute to this gap in research.

2.1 AFFORDANCE THEORY

Affordance theory which has been introduced by Gibson (1979) is gaining increasing attention by researchers in the field of information systems (IS) (e.g. Bernhard et al., 2013), organization (Zammuto et al., 2007) as well as servitization research (Naik et al., 2017). This theoretical lens has already been related to the digitalization of products as well as digitalization capabilities of human actors in organizations (Strong et al., 2014). In general, the concept of affordance explains how people orient to objects in their environment with respect to the opportunities these objects afford for goal-oriented action. The distinctive affordances of objects are usually related to different people's objectives or competencies (Gibson, 1979; Strong et al., 2014). As such, the affordance perspective considers the functionality of technological objects, but emphasizes that these technological objects need to be recognized as social objects which affect organizational functioning and performance processes, structures and employee's tasks, activities and competence demands (Zammuto et al., 2007, p. 753). Thus, the increasing relevance of digital technology on an organizational level cannot be separated from changes on an individual worker's level (see also Strong et al., 2014). It has been widely discussed that digitalization is considered as a key enabler for servitization and advanced services (Coreynen et al., 2017; Lenka et al., 2017; Lerch and Gotsch, 2015). So, the increasing information content leads to changes in the nature of work. Tasks performed by people at lower organizational levels, including line employees, supervisors, and middle managers, are changed significantly by the increasing creation and usage of information (Zammuto et al., 2007, p. 752). Thus, it can be argued that the increasing usage of technology and the growing amount of information determine and change how work is organized and performed. This means that digitalization can trigger multi-level changes in organizations.

2.2 SERVITIZATION AND ADVANCED SERVICES

While the concept of servitization has inherent processual and transformational facets, this article does not focus on transformational processes in an organization but focusses on an organization that is currently offering advanced services and does not see itself within a servitization journey. Advanced services can be regarded as highly customer-specific solutions based on a complex bundling of product and service offerings (Baines & Lightfoot, 2013; Raddats et al., 2019). Smart products are seen as essential component of advanced services as they can be configured in a customer specific way and are "specialized in a certain type of data processing and functionality" (Lee, 2010, p. 1163). Consequently, digital technologies are an integral part of most advanced services. Baines et al. (2011) argue that advanced services are based on increasingly complex and highly customer-specific contracts that include agreements about performance, availability, reliability and cost (p. 953 f.). They include revenue payments related to the usage of tangible elements, specific performance incentives like penalties for failure as well as long-term contracts (Baines & Lightfoot, 2013; Ziaee Bigdeli et al., 2018). This conceptualization also puts emphasize on the assumption that for offering advanced services it is crucial to fully understand a customer's needs and context by constantly aiming to sense and seize customer related information. In that regard Ziaee Bigdeli (2018, p. 315) point out that relational sales competences are essential for selling advanced services. Thus, the success of highly service-oriented enterprises is also supported by soft factors like human resource management (Homburg et al., 2003). With regards to human resource management Homburg et al. (2003, p. 29) argue that one important aspect of an adequate service-orientation is seen in the way how training and development initiatives equip employees, e.g. sales people, with the appropriate competencies for the interactions with various internal and external stakeholders like customers, engineers, consultants or project managers. However, we argue that effective training and development initiatives demand for a profound understanding about the (digital) competencies employees may need to cope successfully with the specific opportunities and challenges of selling advanced services.

2.3 DIGITAL COMPETENCE

The concept of competence is discussed in various research areas and domains like education, management, psychology information systems and other. One result of this interdisciplinarity of the concept is that competence of human actors is often discussed as a skill, a personality trait or as knowledge (Woodruffe, 1993). In a previous study about information technology competence of business managers Bassellier et al. (2001) argue that competence is "the potential that leads to an effective behaviour" (p. 162). Related to this definition digital competence can then be defined as an individual actor's set of distinct competencies that refer to the effective usage of latest information and communication technology (ICT) in order to solve problems in non-work or work-related contexts (Aznar and González, 2010). A more comprehensive and detailed conceptualization of digital competence has been introduced by Ferrari et al. (2012) who refer to it as a specific "set of knowledge, skills, attitudes […] that are required when using ICT […] to perform tasks; solve problems; communicate; manage information; collaborate; create and share context and build knowledge" (pp. 3–4). These definitions emphasize that digital competence can be considered as a complex and multidimensional construct consisting of several sub-dimensions. In recent empirical and conceptual contributions various models of digital competence consisting of specific sub-dimensions have been proposed. Based on a preliminary empirical investigation in the context of advanced services business Süße et al. (2018) argue that digital competence of individual actors can be related to the three sub-components technical handling, critical evaluation and problem-oriented usage of ICT (p. 200). Ilomäki et al. (2016) suggest that digital competence rather consists of the four dimensions technical competence; the ability to use digital technologies in a meaningful way, e.g. for working; the ability to evaluate digital technologies critically; and the motivation to participate and commit in the digital culture. Thus, recent research introduced different conceptualizations and operationalizations of the construct of digital competence. A summary of these conceptualizations of digital competence with the help of various sub-dimensions is illustrated by table 1.

Table 1: Conceptualizations of digital competence

Author(s)	Publication	Dimensions / operationalization
Calvani et al. (2008)	Journal of E-learning and Knowledge Society	A1. Technological: competence to cope with technical problems and understand the technical interrelationships A2. Cognitive: competence of analyzing and interpreting data and information based on their relevance and reliability A3. Ethical: competence of using technology to interact with others constructively and conscientious A4. Integrated: understand about the potentials and opportunities of technology for collaborative knowledge generation
Ferrari (2013)	Joint Research Centre	B1. Information management: identify, localize, organize, store B2. Communication in digital environments with the help of digital tools B3. Content-creation: generate new knowledge and integrate existing knowledge or content B4. Safety: respect privacy and data security guidelines, ensure secure and sustainable usage of data and information B5. Problem-solving: identification of digital requirements and resources, selection of digital tools for effective problem-solving
Fraillon et al. (2014)	International Computer and	C1. Knowing about and understanding computer use C2. Accessing and evaluating information

	Information Literacy Study	C3. Managing information C4. Transforming information C5. Creating information C6. Sharing information C7. Using information safely and securely
Hatlevik (2017)	Scandinavian Journal of Educational Research	D1. Search and process digital information D2. Produce, e.g. convert, reuse, or create digital elements D3. Digital responsibility, e.g. knowledge about data security and privacy D4. Communication, e.g. present and publish collective results and cooperate effectively
Ilomäki et al. (2016)	Education and Information Technologies	E1. Technical competence, e.g. be able to use appropriate tools correctly E2. Ability of meaningful usage in work, studying or everyday life E3. Ability of critical evaluation of digital information from various sources or platforms E4. Motivation for participation and commitment in the digital culture
Süße et al. (2018) Süße (2020)	Procedia CIRP Proceedings Springer International	F1. Technical handling: ability of using tools or digital platforms to collect relevant information F2. Critical evaluation of information from digital sources F3. Problem-oriented usage of digital resources for own and collective problem-solving processes F4. Digital citizenship behavior: contribution to the social system with the help of digital tools, e.g. sharing and supporting

The overview of table 1 shows that most contributions enhancing the further understanding about digital competence stem from the field of education and learning, except the research conducted by Süße et al. (2018) and Süße (2020) where empirical data has been collected in work-oriented contexts dominated by product and service integration, a context that strongly relates to advanced services businesses (Raddats et al., 2019).

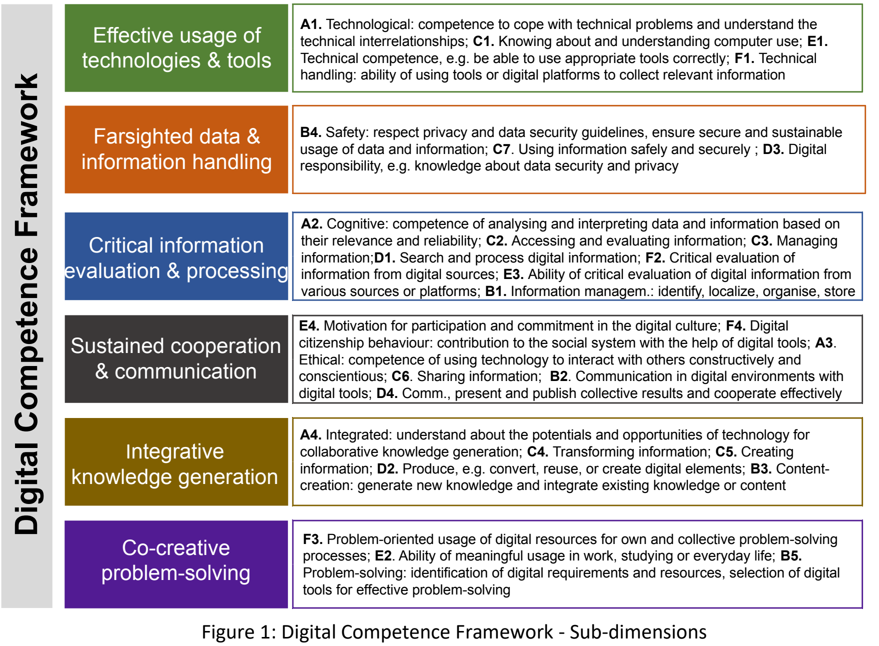

Figure 1: Digital Competence Framework - Sub-dimensions

In order to build on a rather broad perspective for this article's exploratory research approach an integrated conceptualization that provides a more comprehensive picture of all operationalizations mentioned above seems to be fruitful. The result of a number of iterative steps of consolidating and integrating the conceptualizations of digital competence presented by table 1 lead to a framework for digital competence that holds six sub-dimensions. The iterative process has been conducted among a group of researchers and experts in the field of digitalization in organization. Figure 1 illustrates the six sub-dimensions of digital competence deduced from the literature overview summarized by table 1. The first sub-dimension is *effective usage of technologies & tools*. This facet of digital competence refers to an individual's competence of accessing the functionalities of technologies and tools effectively, having a basic understanding about the interrelationships or interfaces between various tools and recognize or deal with upcoming problems. The second component deduced is *farsighted data & information handling*. This sub-dimension of digital competence includes an individual's awareness of potential security and privacy risks while working with sensitive data and information from people as well as organizations. A third element is *critical information evaluation & handling*. It mirrors the discussions in recent literature about individuals' competence of reflecting about the quality of information, evaluating various sources of information, e. g. based on their reliability, as well as identifying appropriate information. The fourth sub-dimension deduced from literature is *sustained cooperation & communication*. It emphasizes on the competence of providing mutual support, communicating constructively and effectively, sharing expertise and innovative knowledge as well as acting cooperatively. The essential facets of the fifth sub-dimension *integrative knowledge generation* can be summarized as the competence of integrating knowledge from various sources during a collective and discursive process in order to contribute to knowledge innovation. Finally, the sixth sub-dimension *co-creative problem-solving* refers to the development of solutions in work-related settings with the help of applying digital tools, digitalized knowledge and other digital resources in an effective manner in closed interaction with other actors.

3. RESEARCH METHODOLOGY

The empirical study is based on a single case company acting in a B2B environment. The case study design has been selected as the appropriate research method as it allows to study specific phenomena in real world contexts. As Yin (2009) argues the single case study analysis can be considered as a research approach which aims to support the researcher in understanding a clearly defined context more deeply and comprehensively.

3.1 Case Company

While the case company agreed to the publication of the research results it also asked for anonymity of the company name. Despite this limitation, the company confirmed that we could provide some general information about the company so that the research context can be better understood. The case company was founded in 1992 in Germany. The company offers advanced services supporting the digitalization of manufacturing businesses. Based on highly integrated product and service elements the case company offers advanced services in the areas of computer aided design (CAD), product data management (PDM) and product lifecycle management (PLM) for small and medium-sized manufacturing businesses. More specifically the researched company offers the availability of high-performance environments for the creation of digital product models, solutions for the protection of the related company-specific knowledge as well as accompanying process optimization solutions based on an integration of hard- and software components. More recently, the case company also offers advanced services in the areas of augmented reality, virtual reality, 3D scan as well as 3D printing. Overall the company had 125 employees in 2019.

3.2 Data collection

Empirical data has been gathered with the help of semi-structured in-depth interviews among sales experts during the second half of 2019. An interview guideline based on the theoretical framework introduced above has been developed and a pre-test has been conducted in advance. Interviews have exclusively been conducted within the sales department of the case company. After the identification of suitable interview partners five interviewees have been selected. The five interviewees were all employees with long and outstanding experience in the company's sales department and in addition all had responsibility for the digitalization of the company's own business as well as for various customers' businesses. Each interview took between thirty and forty-five minutes. Interviews have been recorded and transcribed.

3.3 Data analysis

We applied a content analysis on the basis of approximately seventy pages of transcribed interview material. In our data analysis we followed an iterative two-steps approach. First, we did the coding based on the digital competence framework deduced from the state-of-the art research (see figure 1). In a second step we looked at the material again more inductively in order to grasp additional insights. Overall we followed an iterative process based on directed content analysis (Hsieh and Shannon, 2005).

4. FINDINGS

Figure 2 provides a consolidated overview of the empirical results as a systematization which relates to the six dimensions of digital competence deduced from state-of-the-art literature (see section 2.3). While the interviewees were not explicitly asked for these dimensions it is interesting that we could find great support for our framework by analyzing the transcribed data. For the first dimension *effective usage* it shows that for sales the competence of using a distinct set of tools and combine appropriately seems to be important. The second dimension of *farsighted data & information handling* reveals that balancing data protection demands and ease of use or effectivity might be a challenge while people seem to be aware of the high relevance of the company's digital footprint. For the third dimension named *critical information evaluation & processing* we found that the competence of applying digital tools to cope with the massive amount of information and data is seen as highly important. In addition, the competence of storing information in a way that it is available and readable by other stakeholders is seen as particularly success critical in sales.

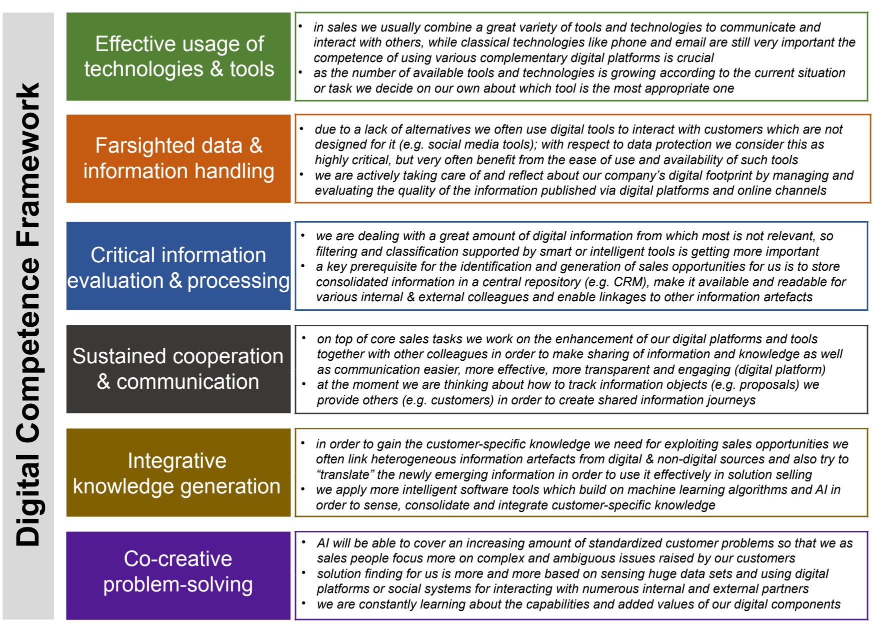

Figure 2: Empirical findings (consolidated)

Within the fourth dimension we refer to as *sustained cooperation & communication* the competence of improving the collaborative work with the help of digital tools in general, e.g. by introducing more open platforms and shared information journeys, seems to be highly relevant in sales. The fifth dimension of *integrative knowledge generation* gives emphasize to the competence of connecting formerly unconnected information artefacts in a meaningful and innovative way so that new knowledge can be deduced and added value is generated. In that regard the competence of applying AI tools is also considered as increasingly relevant, especially for generating a better understanding about the customer. Finally, the sixth dimension of *co-creative problem-solving* reveals that sales people competence of dealing with higher complexity of tasks becomes increasingly relevant as standardized and routine tasks are more often done by smart digital tools. In addition, sales people also gave emphasize to the competence of understanding the critical role of digital technologies as integral components of advanced services offerings.

5. DISCUSSION

This article seeks to explore key facets of digital competence of sales people in an advanced services company. While most of the literature in the field of servitization and advanced services discusses organizational level phenomena, the unit of analysis in this article is the level of the individual actor. We argue that understanding more about the competence demands at an individual actor level is of increasing importance as digitalization also affects the lower levels of the organization, e.g. by change of work processes. Our findings may have a couple of academic as well as practical contributions.

5.1 Academic contributions

With our findings we contribute to the further understanding about the important role of the human actor in advanced services business contexts in the digital age. More specifically the research results about digital competencies among sales people in an advanced services company contribute to further knowledge about “soft factors” regarded as relevant for implementing service-oriented strategies (Homburg et al., 2003). The introduced six-dimensional framework of digital competence deduced from state-of-the-art literature and its empirical support within a case company provide a more comprehensive set of key facets that make up digital competence of individual actors. Thus, with our framework we contribute to the further systematization, conceptualization and operationalization of digital competence of human actors in servitizing as well as advanced services businesses (Süße, 2020; Süße et al., 2018). This means that the research results can also be highly relevant for multi-level investigations about success critical variables of advanced services businesses and for better understanding the driving forces of digitalization in servitizing organizations (Coreynen et al., 2017). Finally, it seems to be fruitful to put our findings in relation to the state-of-the-art knowledge about digitalization capabilities on an organizational level (see e.g. Lenka et al., 2017) and conduct further research among other groups of human actors, e.g. project managers, engineers and others.

5.2 Practical contributions

We argue that our results also have a couple of practical contributions. The six-dimensional framework of digital competence of sales people may provide practical guidance for designing training and development programs for sales staff as well as other staff. In addition, our results may support HR departments as well as manager to better understand the demands and challenges sales people have to cope with when selling advanced services.

6. LIMITATIONS

We are fully aware that this article’s research approach has some limitations. It is case study research within one company with only a few interviewees. Thus, one should be careful when generalizing the empirical results of this article.

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AUTHORS

Prof. Dr. Thomas Süße
Bielefeld University of Applied Science
Faculty of Engineering and Mathematics
Langer Weg 9a
33332 Gütersloh
Germany
+49 5241 21143 43
thomas.suesse@fh-bielefeld.de

Sebastian Kola
Goodea - NRW
Ringstraße 120
44627 Herne
Germany
sebastian.kola@goodea.de

CHANGING THE MANAGERIAL MINDSET FOR SERVITIZATION

Anna van der Togt, Jürgen Tanghe, Quiel Beekman & Sylvia Mooij

ABSTRACT
This paper examines whether the knowledge and tools, present in the field of Service Design, can be applied to evoke a mindset shift in the management of manufacturing companies adopting a servitization strategy. The product and (tangible) feature focus traditionally present in the management of manufacturing companies, hinders the ability to become a successful service provider. An essential step to overcome this, is to shift the mindset to a client-oriented focus on solutions. This paper decomposes the mindset shift and proposes a method based on Service Design tools and methods to evoke this change.

KEYWORDS: Servitization, Managerial Mindset, Service Design, Service-dominant logic, Jobs-to-be-done.

1. INTRODUCTION

Many manufacturers adopting servitization fail to translate their new service strategy into profitable service offerings that match their client's needs (Gebauer et al., 2005; Neely, 2009). One of the main hurdles is the lack of management confidence in the new service strategy (Gebauer et al., 2005; Oliva and Kallenberg, 2003). The product and feature focus traditionally present in the management of manufacturing companies combined with risk aversion and scepticism of the economic potential of services, leads to underinvesting in the new service business and a preference to deliver and sell more well-known (and thus perceived as less risky) value propositions. Hence, the servitization strategy fails to realize returns (Gebauer et al., 2005;).

An essential step to overcome this lack of managerial trust, is to shift the mindset from a product and (tangible) feature focus to a client-oriented focus on solutions (Mathieu, 2001; Oliva and Kallenberg, 2003). This mindset shift should be pursued in concert with the adoption of a service strategy. Literature has described this problem but is sparse in the provision of models and tools that translate the concepts to practice (Baines et al., 2017).

To overcome this gap, this paper engages inter- and transdisciplinary knowledge, by decomposing what this managerial mindset shift should entail and linking these conditions to the premises of the Service-Dominant logic and Service Design methodology to evoke the mindset shift in practice.

2. THEORETICAL BACKGROUND

This paper explores two concepts, both framed based on literature: 1.) Understanding the shift needed among management from a product- to a service mindset, and 2.) Understanding whether the methods and tools in the field of Service Design can be leveraged to translate this to practice.

2.1 The shift from a product- to a service mindset needed among management

This paper attempts to get a better understanding of what the shift in managerial mindset should entail. The research to explore this shift is structured around Tukker's (2004) model. This model contains a classification distinguishing business models between pure products, three types of integrated product-service offerings and pure services. These categories can be plotted on a five-phase continuum from pure-product to pure-service business models. Whereas at the start of the continuum the business model revolves around a product and its features, at the other extreme, the focus is shifted to a service and its role in the processes of the client.

The premise of this paper is that a manufacturer moving (parts of) its portfolio along this continuum eventually will be in need of managers with a service orientation or mindset. This premise was based on previous publications (Gebauer et al., 2005; Martinez et al., 2010; Mathieu, 2001; Oliva and Kallenberg, 2003) which suggest that a managerial mindset geared towards services is essential for a successful shift towards services.

Other models and continua where considered but the continuum in Tukker's model was found to be most useful because it describes the role of the product and the service in the business model. This links the shift in portfolio to the shift in focus and thus in mindset. Accordingly, the research was designed to explore the evolution in mindset along this line (see Figure 1).

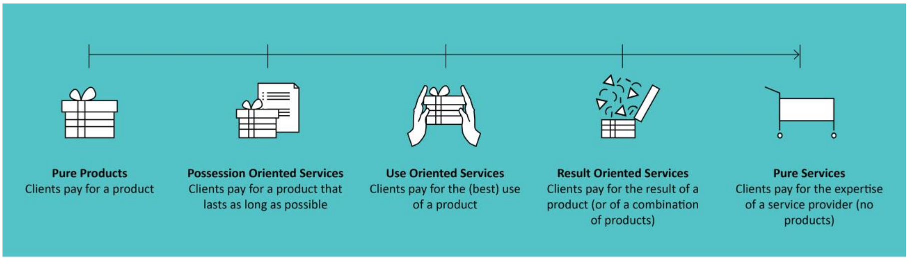

Figure 1: The servitization continuum: from pure-product to pure service business models. *An interpretation of model describing main and subcategories of PSS (Tukker, 2004)*

2.2 The usefulness of the methods and tools from the field of Service Design

This paper proposes the use of theory and tools from the field of Service Design as enablers to translate the knowledge from research and literature to practice. This has been proposed before but is relatively new and marginally studied (Calabretta et al., 2016; Lammi, 2017; Prendeville and Bocken, 2017). However, the arguments of drawing from this field are threefold. First, the business success from servitization depends largely on the ability to design and develop solutions that provide meaningful interactions and relationships with clients (Reason, Løvlie, & Flu, 2015). This means the value of the hands-on knowledge of (service) designers to design these integrated product-service solutions is convincing. Second, the default mindset in the field of Service Design could potentially be the mindset to which the management should shift: the service mindset (Sleeswijk Visser; 2013). And finally, the field has a wealth of tools that help practitioners to refrain from taking another perspective than the client's and to translate this to the design of integrated product-service solutions (Reason, Løvlie, & Flu, 2016; Stickdorn & Schneider, 2015). Applying these tools potentially fills the gap that currently exist between servitization literature and practice (Baines et al., 2017).

3. METHODOLOGY

The paper uses two streams of research: one studying and decomposing the managerial mindset shift needed and one analysing the approach and tools from the field of Service Design. It then appraises these methods and tools for their applicability to facilitate the decomposed mindset shift. These findings were used to develop and test a method and toolkit facilitating the mindset shift.

3.1 First stream of research: the managerial mindset shift needed

The aim of the first stream of research was to gain a thorough understanding of what the managerial shift from a product- to a service mindset should entail. To avoid one-sided views on proceedings, there was a preference for analysing various conceptions of the mindset shift. A multi case study approach with multiple interviewees per case study was therefore chosen.

The cases where recruited in collaboration with a Service Design consultancy. The consultancy is one of the first Service Design companies and has offices in London, Rotterdam and São Paulo. It has a wide range of clients among which several OEM's which were approached to participate. A purposeful sampling technique was used since there were limited cases going through a comparable shift on the continuum which were also information rich (Patton, 2002). Four cases from different industries were selected according to their perceived shift, along Tukker's (2004) continuum. The sampled cases all moved (parts of) their portfolio from the product-oriented category to the use-oriented category.

The cases were constructed using data collected through semi-structured interviews combined with public documents as recommended by Glaser and Strauss (1967). For each case study there were at least three interviewees since Yin (2003) suggest that multiple sources should be consulted for multiple perspectives on the case. Data analysis and confirmation was done inductive and unconstrained to allow findings to emerge freely. Once immersed in the wealth of data, the most promising lines of findings were followed by performing multiple manual data clusterings with so called "statement cards" (Sanders & Stappers, 2008). It was these clusterings that provided the rough set-up of the sub-shifts of the mindset shift (as described in "4. FINDINGS"). As four case studies is not enough to regard their findings as truths, only the insights confirmed by more than one case were included and only the insights that matched with the findings from additional desk research into the multiple streams of literature addressing servitization (Lightfoot et al., 2013), made it into the results.

3.2 Second stream of research: Service Design methods and tools analysed

The second stream of research was designed to find methods and tools from the field of Service Design that could help practitioners to actually make the mindset shift. Field research was done at the consultancy mentioned before. The goal was to understand their methods, tools and way of working: Why, when and how are which methods and tools applied? This was done using methodological triangulation (Patton, 2002; Yin, 2009). This means the topic was analysed in three ways to cross validate the data collected:

1. **Observations of the designers in action.** This allowed a natural inquiry of information and it allowed for contextual sensitivity (e.g. different cases require different approaches). A semi-structured observation guide was used to make notes during the observations. These notes were combined with recordings (audio), photos and obtained props.
2. **Interviews with eight designers.** The interviews were used to address topics driven by analyses interest and to overcome a personal bias in evaluating the observations. The interviews were conducted with a semi-structured interview guide including premeditated probes and were recorded(audio) and roughly transcribed.
3. **Documentation of Service Design knowledge and tools.** Several books written by practitioners and recommended by experts were analysed (Reason, Løvlie, & Brand Flu, 2015; Sanders & Stappers, 2008; Sleeswijk Visser, 2013; Stickdorn & Schneider, 2015).

The data of both the observations, the interviews and the documentation were analysed and consolidated into:

- An overview of methods and tools potentially (in adopted format) suited to bring about the sub-shifts of the mindset-shift discovered in the first stream of research.
- A set of guidelines derived from the Service Design way of working that facilitate implementation into the practical reality of new product or service development.

3.3 Method and toolkit development

The results of the two streams of research were used as a starting point for the development of the method and toolkit. This was developed through a series of brainstorm and validation workshops with Service Design professionals and academics.

A first series of brainstorms was done for a method and toolkit design that could embody the sub-shifts. The resulting toolkit prototypes have been iterated progressively through multiple sessions with Service Designers, interviewees from the case studies and experts and integrated into one overarching prototype. This prototype was further developed into a complete tool, with a detailed user manual and a prototype of a PowerPoint presentation to use alongside the application of the tool. This was tested in a workshop setting with managers from a large international power tool manufacturer. After a thorough evaluation with the participants, co-facilitators and experts, the method and tool were iterated into the final design.

4. FINDINGS

The results of the first stream of research show that the managerial mindset needed comprises of at least 5 sub-shifts (displayed in Figure 2). The second stream of research, addressing the Service Design way of working, suggest that drawing theory, methods, and tools from the field of Service Design to move managers into the new service paradigm could help managers make the mindset shift as long as the application adheres to 5 guidelines. The methods and tools found suitable for bringing about the sub-shifts of the mindset-shift are not presented in this section. These are included in the description of the methodology designed to bring about the mindset shift (in "5. RESULT").

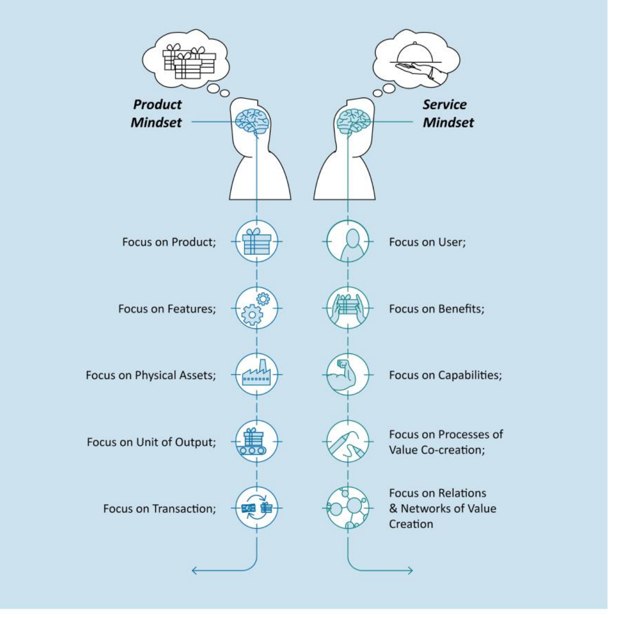

Figure 2: The product- and the service mindset. *Five fundamental differences.*

4.1 The managerial mindset shift needed

The case studies in the first stream of research showed that there are five fundamental differences between the product- and the service mindset (as shown in Figure 2). These translate to five sub-shifts which should be included in the intended managerial mindset shift:

1. A shift in focus from the product and its performance, to the client and its level of satisfaction.
2. A tendency to look for what clients get out of a product (value in use) instead of searching for additional/enhanced features.
3. An emphasis on finding new product-service solutions based on capabilities and values rather than assets available.
4. A focus on creating processes of value co-creation instead of provisioning units of output.
5. An activation to look for partners to create value with and focus on building relations and networks of value creation rather than making transactions.

This strongly corresponds to the differences described in literature and in particular to Vargo and Lusch's (2016) theory of "Good-" and "Service-dominant logic". Accordingly, the S-D logic is the used as the overarching philosophy that is the foundation of the intended mindset shift. The theory, models and tools found to be used in the field of Service Design, are used to make this theory actionable with.

4.2 Guidelines for the method and toolkit

The insights from the second stream of research addressing the Service Design way of working were translated to design guidelines for the (embodiment of the) method and toolkit. To facilitate the implementation of the method and toolkit into the practical reality of new service development and organisational change it should fit the following criteria:

- *The method and toolkit should be suitable for a workshop setting.* To ensure dedicated time/attention and to allow an orchestrated series of activities helping the management to slowly emerge in the content and make it their own.
- *The method and toolkit should facilitate co-creation*. To stimulate a feeling of ownership among management which increases the adoption of the newly gained perspectives.
- *The method and toolkit should create curiosity towards customers.* According to Service Designers, companies often have a faulty perspective on what their customers want and need. The only way to capitalise the customer focus is by combining it with an insatiable motivation to truly understand the customer and its context through qualitative research.
- *The method and toolkit should use "storytelling".* To facilitate the description of the flow of multiple interactions between service provider, client and technology through time).
- *The method and toolkit should be flexible in application.* To adjust to different companies and different shifts.

5. RESULT: A METHOD & TOOLKIT FACILITATING A MANAGERIAL MINDSET SHIFT

The following method and toolkit are a synthesis of the results from the two streams of research. The method consists of nine steps each accompanied by an exercise. These exercises are all set up around models or tools from the field of Service Design that force their users to look from a different perspective. A large canvas integrates all these exercises in one big capture sheet. This embodiment is designed for use in a workshop-like setting or in multiple workshops. It is set up to guide its users through the nine steps, gradually bringing about the desired mindset shift.

5.1 The toolkit: A map, instruction sheet and presentation

The toolkit consists of a canvas, a detailed user manual and a (PowerPoint) presentation guiding the workshop. The canvas is A0 format and is folded like a map. Each time the map is unfolded a bit more, the participants are guided to another step in the mindset shift through a new exercise. The map itself does not contain instructions but only provides space to capture the work. The instructions are explained by facilitating Service Designers or can be handed out as a user manual on a mini version of the map (A3). Unfolding this map, the participants get to see more and more context of use. The perfect metaphor: when one unfolds a real map, gradually more of the surroundings is shown. The blue line, that whirls over the map like a river, subtly shows in which order each box should be filled out. Figure 3 shows the map in unfolded state. Below the rationale of the exercises is explained, in the order at which these are presented to the participants.

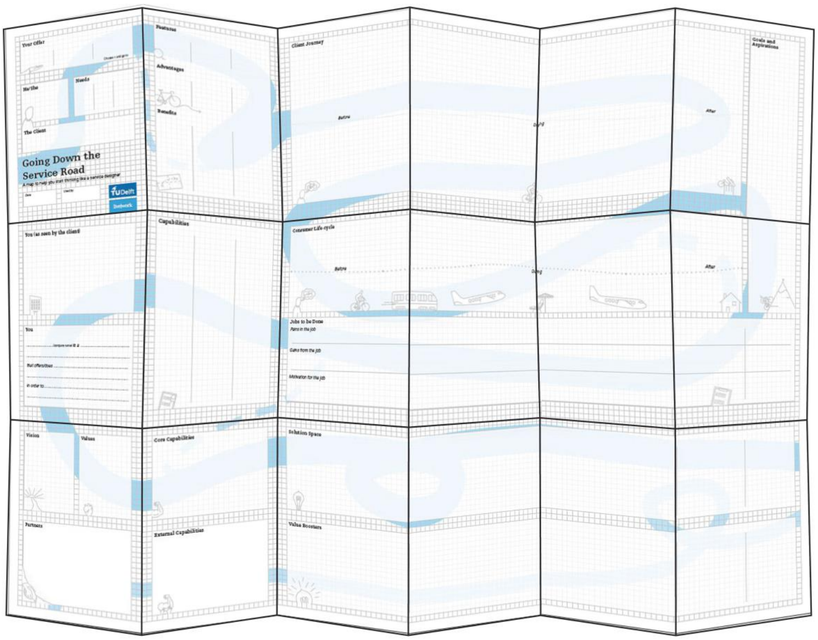

Figure 3: The canvas/map. *Visualized with folding lines*

5.2 The method: Nine steps with an exercise each
The methodology to use the toolkit introduces a more service-oriented way of thinking step-by-step. By changing the focus from product to user and zooming out on the context of use, the product focused management gets a new framework of thought which helps them to explore possible future services and makes them understand the implications for their organisation.

Step 1: Focus on the client
The managers get to know the person that is the client of their products. They have to create a basic persona out of some characteristics of a client segment (e.g. name, age and basic needs) and link this persona to current offerings.
By far the most important mindset change, is the shift in focus from the functioning and performance of a product to pursuing positive impact on the client's processes and results (Martinez et al., 2010). The trick is to stop seeing the product as the solution and start understanding value through the eyes of the client (Brady, Davies and Gann, 2005). This means the first step towards a service mindset is empathizing with the client. In the field of Service Design, a popular method to evoke client empathy is encouraging the creation of a mental picture of the client. By creating a very

basic persona (a format used to create a characterization of a particular type of user) this mental picture is established.

Step 2: Shift focus from product features to client benefits

The managers have to think of the advantages that the features of their products offer, to translate these to benefits for their persona.

The guiding mentality that is the bedrock of the S-D logic, is the idea of "value in use". Once one starts recognizing that solving the client's struggles is the goal, it becomes evident that a product in itself is not embedded with value. "Value" is purely the client's appreciation of the effectiveness and applicability of a certain offering in the client's processes (Vargo et al., 2008). No longer should value be seen from the manufacturers perspective but rather it should be evaluated from the perspective of the client (Slywotzky and Morrison, 1997). To shift focus from the performance of features towards this "value in use", the features are translated to advantages and these are translated to benefits. This is a method the Service Design field adopted from the practice of sales (Finn, 2017).

Step 3: Recognize the context of use

The managers are encouraged to think about the use of their product and the context in which their persona uses it. They have to describe the complete use from start to finish (becoming a client, first interaction, regular use and the end of use).

If value lies in use, a product or service is only "valued" if it fits the context of the client. This means value depends on the (unique) client (its unique combination of knowledge, skills, network, values and experiences), on its context (it's processes, systems or access to resources) and on how this client uses an offering in its context (Bettencourt et al., 2014; Vargo, Maglio and Akaka, 2008). The context of use can only be understood if the product and its use can be seen through time, through the client's eyes. A Service Design theory often used to understand the context of a client is the set of lenses: human, consumer, customer and user. This set of lenses fits the purpose of this step. In particular the "Customer's lens" made actionable with the customer lifecycle-tool. A phase-by-phase description of the client's interactions with the product and the company through time is imagined. This results in a complete overview of both the full use and the factors that influence the effectiveness of the product.

Step 4: Zoom out to see more context of use

The managers zoom out to see the interactions with the product in the context of a larger activity. They are asked to describe this larger activity from start to end (planning, starting, undertaking the activity, incidents and ending the activity).

Looking for the value in use, also means seeing use in a larger context. Not only should the actual interactions with the product be examined but also the larger activity of which this interaction is a component. The "Consumer's lens" (again made actionable with the lifecycle tool) facilitates this angle. The power of describing the consumer lifecycle appears in a detailed understanding of what other factors, systems, products or services effect the client's processes.

Step 5: Identify the goals of use

The managers have to think of the underlying motivation explaining the behaviour of their persona. They are encouraged to analyse and distinguish the probable goals of the persona (i.e. the client segment) or of its boss.

It is relatively "easy" to plot on a timeline what a client does. However, Service Designers recognise that, to truly understand these activities, the underlying motivations need to be recognised. Especially in a business to business setting, the client is more than just one person. He/she has colleagues, and more importantly a boss that has a certain set of priorities. By exploring the aspirations and goals of the client, the critical factors reveal, on which value is evaluated by the client.

Step 6: Pinpoint the client's jobs to be done

Based on the previous activity, the managers have to describe the jobs their client is trying to get done. They have to identify for which job the client purchases the product and what jobs are still unmet.

Empathizing with the client is a vehicle to understand and help getting their "jobs done" (i.e. fulfilling a function in their process, solving a problem or helping accomplish a goal) (Christensen et al., 2016). The "jobs to be done" (JtbD) theory has been adopted by the field of Service Design and is used as a framing to understand the outcomes clients want to achieve. Rather than considering which features to improve or add to the product, a more fundamental question should be asked: What jobs is our client struggling to get done and what value propositions could help them achieve that (better) (Christensen et al., 2016)? This new focus enables companies to extend their R&D efforts beyond product improvement and search for the truly relevant client issues. It is only if the client's obstacles, frustrations and problems in achieving their "Jobs to be Done" are understood, that they can be addressed with holistic and grounded solutions (Bettencourt et al., 2014).

Step 7: Shift focus from assets to capabilities

The managers learn to value their knowledge and capabilities as the source of competitive advantage rather than then their products and assets. They have to explain the knowledge and skills that enabled the development of the products and relate to the qualities and aspirations of their organization.

Traditionally, manufacturers are used to see value in "things" rather than in knowledge or skill. But sustainable advantage through providing solutions is not about the exact products or services, it is about applying knowledge and skill for the benefit of the client (Bettencourt et al., 2014; Vargo & Lusch, 2008; Vargo et al., 2008). This is easy to recognize in maintenance or repair services but applies to the entire composition of the solution: How can the in-house knowledge and skills be applied, to facilitate the client's Jobs to be Done"? The first step to answering this question is recognizing the unique capabilities of the company. Both by exploring the capabilities as recognized by the organization and by discovering the client's perception of the company's strengths.

Step 8: Stop considering units of output as the answer

The managers learn to see the in-house knowledge and capabilities as the lens through which they should seek new value propositions. By combining these capabilities with the identified JtbD's they discover new starting points for ideation.

Thinking about how to help clients get their jobs done more effectively or reliably through applying organizational capabilities provides a fixed focal point of attention to the entire organization. No longer is the focus on the assets or the provision of units of output, but it is on utilizing the organization's knowledge and unique skills to act upon the assets available for the benefit of the client (Sharma and Molloy, 1999). This shifts the focus away from products towards integrated product-service solutions. The challenge is to find the unique blind spot: the extraordinary, valuable and worthwhile link between the knowledge and skills of a solution provider and a client with jobs-to-be-done, that would benefit from these capabilities. The theory on brand driven innovation (Abbing, 2010), used in the field of Service Design, provides the perfect guiding principles to do so. The client's perception of the company's strengths is connected with its internal recognition of capabilities. These two combined, create a lens through which the company can decide which JtbD's can and should be solved with their capabilities (based on Abbing, 2010).

Step 9: Get activated to look for partners

The managers are encouraged to take the ideas to the next level by adding capabilities the organization currently doesn't possess. They have to think of potential partners that do possess these.

When a company starts focusing on helping its clients getting their jobs done, it seems only natural to find partners with supplementary capabilities for delivering these solutions. These external capabilities are needed for two reasons:

- A higher degree of insight in the processes of the clients is needed, for which a higher cooperation between the new solution provider and the client's supporting network is vital (Martinez et al., 2010).
- Though the company should build on its capabilities, the development of these new product-service solutions also needs knowledge and skills which product-focused manufacturers typically do not possess (Reinartz and Ulaga, 2008). Building or acquiring these new skills, knowledge or technologies takes a lot of time and is riskier than partnering.

The service mindset shifts the role of the firm from one that makes transactions to one that enables value creation through networks of relations. Successfully getting the client's jobs done, depends on the ability to successfully match and integrate the capabilities and resources of the client, the firm and all other stakeholders in the "service network" (e.g. suppliers, employees, institutions etc.). Ideally, the firm builds relationships with all these stakeholders and invites them to be part of the service development or operation based on their expertise, access to resources and the relative priority the job to be done has to them (Bettencourt et al., 2014). By envisioning which capabilities could take ideas for value propositions to the next level, the step to finding partners is easily made.

After going to these 9 steps, the management has had a first taste of the service mindset.

6. EVALUATION OF THE METHOD AND TOOLKIT

The test workshops with the international power tool manufacturer resulted in general improvements to the wording, instructions and layout of the canvas to make them sharper, simpler and accessible. Generally, the method and toolkit were perceived as being useful. They offered a complete journey towards a new frame of thinking without enforcing points of view upon the participants. The participating managers expressed that it was very insightful to zoom out on the context of the client and realise just how small the role of the company was in its client's processes. Moreover, they were pleasantly surprised to have started ideating during the workshop and expressed that this solidified their learnings as they started to understand what it could potentially mean for their business. Finally, the participating managers expressed that they liked the holistic view of the method and saw more purposes for it than "just" the sake of shifting their mindset. They evaluated the method as a fruitful and solid starting point for new service ideation and also wanted to use it for evaluation purposes during new service development.

7. THE ACADEMIC AND PRACTICAL IMPLICATIONS

This section addresses the academic and practical implication of the positive evaluation of this method and toolset. Although the method is only tested once and needs more testing before it can be regarded a success, it is a first step in bridging the gap between theory and the everyday challenges servitization raises for practitioners. The need for a mindset shift among the managers of a servitizing company has been identified in papers over a decade ago (Gebauer et al., 2005; Mathieu, 2001; Oliva and Kallenberg, 2003) but up until now it remained relatively little addressed. Building on this paper it might be worthwhile to look at other challenges identified in research through the lens of Service Dominant logic and Service Design. Take for example the need for a clear servitization strategy (Auguste et al., 2006; Gebauer et al., 2005; Mathieu, 2001) or the need for more innovative business models that enable new services to be profitable (Auguste et al., 2006; Mont et al., 2006; Neely, 2009). Building on the insights from this paper, these challenges might also be suited to be explored from this angle. The development of a toolset, helping practitioners throughout their servitization efforts, could potentially help them to approach the shift towards services more holistically. Only then, they are enabled to come up with new iconic services like Rolls Royce's Power-by-the-hour (Smith, 2013) or Xerox's Pay-per-click (The manufacturer, 2017). Finally, it could assist them in future transitions to more environmentally friendly product-service portfolios. The toolset of the future might enable them to create a holistic view including their clients, the environment, their integrated product-service solutions, production and material in overlapping lifecycles of value creation.

8.CONCLUSION

The goal of this paper is to facilitate servitizing practitioners in adopting a managerial mindset fitting a servitization strategy. For a servitization strategy to succeed, it is key that the managers in charge of executing this change shift their mindset from a product and (tangible) feature focus to a client-oriented focus on solutions. Based on multiple case studies of manufacturers, this paper presents a step by step method to evoke a change in managerial mindset. The method integrates complementary perspectives on value creation like Vargo and Lusch's (2004, 2008) Service-dominant logic and Christensen's (2016) Jobs-to-be-Done (JtbD). Furthermore, it is supported by a Service Design toolkit to enable manufacturers to embed the method into their strategic effort and planning. The method and toolkit facilitate management to become aware that the true value to the client lies in the efficiency and effectiveness of an offered solution to its problem rather than excellent product features. Step by step the method invites managers to view through their client's eyes, to understand client problems and needs as well as the context in which these should be addressed. Finally, it kick-starts the ideation for integrated product-service solutions that meet these needs through applying the capabilities and resources of the manufacturer.

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AUTHORS

Anna van der Togt
Former graduate student at the faculty of Industrial Design Engineering, Delft university of Technology.
Service designer
Livework studio Rotterdam
Hofplein 20, 3032 AC Rotterdam, NL
Anna@liveworkstudio.com
https://www.liveworkstudio.com/

Jürgen Tanghe
Lecturer
Industrial Design Engineering (building 32)
Delft university of Technology
Landbergstraat 15, 2628 CE Delft, NL
http://www.io.tudelft.nl/

Quiel Beekman
Lecturer at Product Innovation Management
Industrial Design Engineering (building 32)
Delft university of Technology
Landbergstraat 15, 2628 CE Delft, NL
http://www.io.tudelft.nl/

Sylvia Mooij
Lecturer at Product Innovation Management
Industrial Design Engineering (building 32)
Delft university of Technology
Landbergstraat 15, 2628 CE Delft, NL
http://www.io.tudelft.nl/

SO YOU WANT TO SERVITIZE; BUT ARE YOU READY TO "FINANCIALISE"?

Ibon Gil de San Vicente & Bart Kamp

ABSTRACT

Purpose: to introduce outcome-oriented charging modalities as a form of advanced services has financial implications for the firms implementing them.

Design & Methodology: we conceive a framework to assess the applicability of outcome-oriented charging modalities from a financial perspective and apply it in a multiple case study setting.

Findings: we identify a series of financial aspects - related to the servitizing firm, the business potential of outcome-oriented charging modalities for a specific value proposition and/or product/service financing risk - that help predict the likeliness for adopting such modalities.

Originality: the paper uncovers the role of finance on the road to advanced services insightful, both from a conceptual and business perspective.

KEYWORDS: Advanced service business models, Financialisation, Financial service providers.

1. INTRODUCTION

Servitization can take on many forms. One of them is applying servitized payment models or outcome-oriented charging modalities, often referred to as advanced services (Baines et al. 2009a). While this may be an attractive kind of value proposition from a demand side perspective (particularly due to its payment-friendliness), it may not be the easiest form of servitization from a supply side implementation standpoint.

Many studies have pointed out that companies with an interest in servitization are confronted with cultural and structural barriers (Baines and Lightfoot 2013; Gaiardelli et al. 2014). In addition, outcome-oriented charging modalities brings about considerable financial implications for companies adopting them (Huikkola et al. 2018; Kamp 2020).

Against this backdrop, our paper explores a series of financial factors -internal and external to firms that consider implementing outcome-oriented charging modalities- to assess both the readiness of firms to manage such modalities as well as the value proposition for which they want to charge on an outcome-oriented basis.

Thereafter it depicts the readiness of a series of manufacturing companies that are in the process of implementing such modalities and the suitability of their value propositions for outcome-oriented charging modalities.

2. THEORETICAL BACKGROUND

Competitive pressure drives companies towards a stronger orientation on customer needs, moving from product-oriented services to "services oriented on user's processes" (Baines et al. 2009b). Altogether, this process of servitization allows companies to differentiate themselves better from market rivals and bond more intimately with customers (Lay 2014).

Interest in financial aspects to servitization goes back more than a decade, and started off by focusing on the question whether servitization pays off financially. Seminal studies in this regard come from Gebauer et al. (2005) on the service paradox and Neely (2008) with regard to the profitability of servitizing companies.

Until now, only very few publications have focused on the role of financial skills and resources for firms to servitise (Gebauer et al. 2017, Perona et al. 2017 and de Oliveira et al. 2018) are among the few publications that actually address financial question in relation to advanced services. Hence, there is an interest in extending the current knowledge base on the financial implications of advanced services delivery, also since Huikkola et al. (2018) indicate that an advanced service business model bears features of a financial product in it. Relevant issues in this regard are, for example, the complexity of the financial management and risks around advanced services, and the internal and external resources needed for their implementation.

In the rest of this paper, we refer to "outcome-oriented charging modalities" as a financialised form of an advanced services earnings model that allows customers to pay only for outcomes of a service, rather than paying for the underlying assets, activities or tasks (Ng et at 2009). By "financialised" we mean that it requires some kind of financial engineering or funding construction that is new for the firm and which is implemented specifically for the advanced services in question.

When offering outcome-oriented charging modalities - where revenue generation is directly linked to asset availability, reliability and performance (Baines and Lightfoot 2013)- the payment modalities are typically framed on a pay-per-outcome basis, and in many cases this goes together with the launching of leasing schemes and a pre-financing of the goods concerned. On the one hand, this changes the financial operations and roles of companies on the supply side, which translates into their cash flow and treasury management (Toxopeus et al. 2018). On the other hand, it increases the importance of financial management skills to pay-back the investments needed to deliver services (Perona 2017). In addition, it can strengthen the need for capacities to manage investor relations and/or to obtain external funding.

In our view, there is currently a gap in the servitization literature as regards these financial aspects related to implementing advanced service business models, or "outcome-oriented charging modalities" as we chose to call them. Hence, we set out to explore ways to cover this void.

3. Framework For Analysis

This section outlines our conceptual framework and reviews its key constructs. It departs from a previous framework to analyse industrial firms' financial aptitude to implement servitized earnings models (Kamp, 2020). We fine-tune and extend this model by operationalising several of its building blocks and by incorporating new ones. As such, the framework [as shown in Figure 1] forms a tool to enable firms to prepare for adopting outcome-oriented charging modalities.

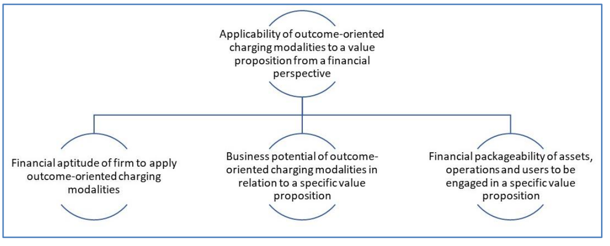

Figure 1: Counting in Bulgarian

3.1 Financial aptitude

Financial aptitude is defined as the readiness of a company to develop/adopt outcome-oriented charging modalities that include services. As indicated above, adopting servitization implies that firms are confronted with cultural and structural barriers. In our case, the financial innovation that come along with outcome-oriented charging modalities typically require a new mindset in companies to assess and deal with the financial consequences they generate (de Oliveira et al. 2018; Fosfuri and Rønde 2009). Likewise, it may put a firm's ability to provide the right skills set for the new situation to the test, as well as it know-how to deal with novel financing arrangements (Kamp, 2020).

To understand the financial aptitude of a company we propose to assess two dimensions (i) the status of the Financial Department inside a company's organisation and (ii) the capabilities of a company to innovate financially. We argue that in order to implement new value propositions entailing an important financial innovation, the role of the Financial Department may have to expand and increase its influence in the definition and feasibility checking of such value propositions. Therefore, the role of the Financial Department must become one of an "strategic business partner" rather than an "accounting controller" (Goretzki et al. 2013). The former also helps dealing with the structural complexities that the launch of a new innovative business brings along (Benedettini et al. 2017) and facilitates better decision making. For measuring the internal position of the Financial Department we use two indicators:

- Proxy 1.1: Hierarchical position of the Financial Department in the organisation.
- Proxy 1.2: Role of the Financial Department in defining the company's strategy.

From a financial capabilities perspective, the company should possess the skills and know-how allowing it to financialise its activity and hence requires appropriately trained human resources for that. Consequently, we propose the following indicator:

- Proxy 1.3: Availability of financial engineering skills/profiles inside the company.

3.2 Market potential

Whatever business or market a company is devoted to, alongside the option of selling a product and getting paid for it at the time of delivery, it is possible that part of the market becomes interested in servitized payment models. This may particularly be the case in mature industries with declining product sales (Cusumano et al. 2015). As such, market potential for the former models is a matter of market segmentation and assessing the (potential) amount of customers that would be interested in outcome-oriented charging modalities amidst the total sales volume for a business.

In function of the former, a market player will have to decide whether it makes sense to offer servitized payment models and back them up -if need be- through dedicated financial arrangements. This leads us to propose the following indicator:

- Proxy 2.1: By splitting the business of a company into a segment where “clients want to own the asset in question” and a segment where “clients want to pay on an outcome-oriented basis”, it is possible to assess the relative size and outlook of the latter segment.

3.3 Financial packageability

Companies that offer outcome-oriented charging modalities must make the transition from transaction-based business with their users to managing the value proposition as a financial product or service. This typically implies involving an economically separate capital investment project in which the providers of the funding look primarily to the cash flow from the project as the source to provide a return on their equity invested in the project (Finnerty 2013). In a similar vein, they would engage in risk ratings of clients as a basis for go/no go decisions. We reason that the degree with which a company is able to visualise the risks and returns involved (and to present them as “packages”) will determine its ability to attract external funds to implement outcome-oriented models.

This “financial packageability” can thus be characterised through:

- Proxy 3.1: The degree to which the company can package or propose its outcome-based charging model under a project financing scheme. The main characteristics of financial packageability are that (3.1.1) the sum of transactions to be considered can be treated financially as an independent economic unit; (3.1.2) that they can be financed by some kind of debt; (3.1.3) that their risk can be measured; and (3.1.4) that the focal company maintains the control over the client relationship, while incurring in a form of project financing with a different third party (Finnerty 2013).

4. Research methodology

Our research aims to explore insights into how and in which forms manufacturing firms make financial arrangements to implement outcome-oriented charging modalities. For that we recurred to a cross-case study methodology. This kind of case studying is pertinent for research that attempts fostering theory development. Firstly, because it allows an in-depth analysis of a real context (Eisenhardt 1989) and, secondly, since it allows furthering novel research questions (Yin 2017).

4.1 Selected cases and information sources

The cases in question were chosen on the basis of purposeful sampling: selecting firms that were either trying to implement outcome-oriented charging modalities for services or who had already adopted such modalities for part of their business. Table 1 synthesizes the cases selected.

	Company A	Company B	Company C	Company D
Main activity	Collective ground mobility solutions	Automotive	Utility vehicles	Packaging machinery
Juridical person	Limited Company	Cooperative	Cooperative	Cooperative
Employees / turnover	+ 10,000 +- 1 billion €	2,500 – 5,000 +- 750 million €	50 - 250 31-40 million €	50 - 250 5-10 million €
Income from service activities	Approx. 25%	5%	65%	16-20%
Experience with financialiation	Financed project mobility solutions (including product and services)	Direct financing to customers	Outcome-oriented charging pilots	Financed project packing solutions

Table 1: Cases selected

With each company we organised two rounds of semi-structured 60-90 minutes interviews. At each of the companies we interviewed persons with responsibility for service business or for financial management. In addition, we held follow-up correspondence with interviewees to raise our understanding of their situations and to clarify further issues than those discussed during the interviews. In addition, we considered a variety of additional public like web pages, reports, and annual accounts that include financial information.

5.FINDINGS

5.1 Company A

This company has evolved over the years from manufacturing mobility products to becoming a mobility operator. Consequently, it has been very active in differentiating the traditional industrial activity from services. To support this transition, it has been highly active in creating/buying companies that have allowed the company to incorporate new activities to its portfolio of market offerings. The company has a growth dynamic (in the 2018-2011 period, sales have grown by 20% and assets by 61%). Thus, in 2018 it has 87 financial stakes (47 in 2008), of which 16 are services (11 in 2008) that are not manufacturing and maintenance, and 11 (5 in 2008) have to do with financial activities such as holding participations. This growth has been financed through debt (it represents 34% in 2018 compared to 18% in 2011) which has increased the company's financial burdens (37% of EBITDA in 2018). The findings of outcome-oriented charging modalities to a value proposition from a financial perspective of Company A is shown in Table 2.

Proxy 1.1	The company has an autonomous unit for the definition and launching of project financing. This unit is separated from the Financial Department that is responsible for traditional business.
Proxy 1.2	The autonomous unit for project financing has expanded the relations of the company towards new types of finance providers, such as pension funds and insurance companies. They lead all tenders based on outcome-oriented charging modalities inside the group.
Proxy 1.3	Initially, Company A included mainly pure engineering profiles. The company has attracted people with hybrid profiles (engineering + finance) and experience in project financing. Today they have multidisciplinary work teams and, depending on the importance/complexity of a project, it recurs to personnel with a more specialised financial background.

Proxy 2.1	The market can be segmented into two parts, one where clients prefer a "traditional" purchase and another where clients request outcome-oriented payment projects (still a minority). Each operation is different, so they are used to delivering customised solutions. It is precisely this adaptability that made them propose innovative financing solutions, allowing them also to enter and compete in new geographic markets. Clients seeking outcome-oriented payment modalities do so to raise project efficiency, to share risks (Anglo-Saxon market) or due to financing or deficit limitations (developing countries).
Proxy 3.1	(3.1.1) While asset financing companies helped with its first operations, the use of project financing increased later on. They distinguish projects between greenfield (little prior knowledge and high uncertainty) and brownfield (with certain experience allowing for better risk assessment). (3.1.2) The company has increased the weight of capital financing by structuring its operations financially. Regarding the financing partners they turn to, these are diverse (mainly investors seeking to diversify their portfolio and to achieve a higher return). The role of banks is also worth highlighting, as they evolve to financial consulting, offering finance for the first steps of the operation, helping to structure and attract partners (for which they charge a fee). (3.1.3) The understanding and measuring of (technical and financial) risks per operation is critical as it impacts on cash flow predictions. The pricing model for outcomes generated is based on a capacity payment that incorporates price reductions due to incidents: quality of services, compliance with travel frequency, maintenance, deadlines, etc. Risk sharing is a key element as well, both among consortium members and with the client. (3.1.4) Agreements are complex and include covenant clauses, coverage ratios, and guarantees as entry rights. Some investors may transfer their rights in the operation to third parties, so that the project can be converted into a financial derivative.

Table 2: Findings of Company A

5.2 Company B

Company B has managed to be very successful in recent years through organic growth. They went from being on-demand assemblers to developing their own product (turning themselves into an OEM) and are now betting heavily on the electric vehicle market. In the latter they have quickly built up a strong market and technology position. Their service activities are chiefly linked to their product sales. As part of their service business development, they have created service companies in the field of data analysis and electronics. Since 2010 they have had a strong increase in activity (Income + 62%) which has meant an increase in its Current Assets (+ 83%), but not in its Fixed Assets (+ 2%). This growth has not created liquidity stress; the Acid Liquidity ratio remains in 2.25. On the other hand, it has generated higher financial expenses, but are still relatively low (financial expenses / EBITDA: 0.22). The findings of outcome-oriented charging modalities to a value proposition from a financial perspective of Company B is shown in Table 3.

Proxy 1.1	The Financial Department reports directly to the CEO of the company. It has a seat on the company's corporate board. The company has foreign subsidiaries and has financial units in those subsidiaries with a limited level of autonomy since they depend on the parent company (for example, for treasury management and relationship with financial providers).
Proxy 1.2	The Financial Department fulfils a traditional (accounting) role in the company and is in contact with other departments to support their activity, but each maintain their own sovereignty. The Financial Department is aware that financialising the company's offer further would imply that it should adopt a different role.
Proxy 1.3	The company has advanced skills for the management and planning of conventional charging and invoicing methods. Its financial experts have a traditional profile and the company has not incorporated hybrid profiles or persons with experience in project financing.

Proxy 2.1	They segment their markets per geographic area and product types. Electrification can open new market possibilities for the company (also in terms of charging modalities), although this demand is incipient with an unclear potential. At present, the demand for financial solutions is residual (only some public contracts). In the electric vehicle segment, the company offers on a limited scale leasing schemes for batteries.
Proxy 3.1	(3.1.1) Only on very few occasions Company B itself assumes the financing of outcome-oriented charging solutions to clients. In those cases it is treated as a regular sale. (3.1.2) The company is used to work with traditional banks who offer finance to their clients. It reaches agreements with them to offer clients special conditions. As long as the demand of this kind of solution does not take off, they do not foresee making big changes in the financing strategy. Despite this, they have explored new formulas such as bond issuance. They have also explored the possibility of project financing, which would allow them to attract additional types of investors. (3.1.3) The risks they run are predictable (they control technology and the product) and they have developed monitoring solutions that would allow them to establish the residual value. (3.1.4) They have agreements with asset financing companies.

Table 3: Findings of Company B

5.3 Company C

Company C provides logistics solutions and sells and rents forklifts mainly on the national -Spanish- market. Their forklifts are not own manufactured, but the main product bases come from two foreign OEMs. The sector has low commercial margins (in 2017 the EBITDA on sales was 3%) and during the 2008 crisis had difficult years. Today it is in a better situation and wants to develop solutions that improve its positioning in the market; this would help reduce the financial needs of its activity that generate working capital tensions (its Acid Liquidity was 0.47 in 2017, and has deteriorated in recent years). Despite these working capital needs, the company maintains a contained financial expense (Financial Expenses / EBITDA: 0.12) and has significantly improved its situation in recent years. It has limitations to finance the necessary investments for its differentiation just with own funds, which represent 23% of the total balance. The finding of outcome-oriented charging modalities to a value proposition from a financial perspective of Company C is shown in Table 4.

Proxy 1.1	The Financial Department reports directly to the CEO of the company. It has a seat on the company's corporate board. It belongs to a group of cooperative companies that jointly manages its affiliates' financing needs, which has allowed them to issue bonds, access loans from the European Investment Bank, and improve relationships with banks.
Proxy 1.2	The Financial Department has a traditional role in the company, managing the relationships with providers of credit and capital, and is in contact with other departments to support their activity, while each one remains accountable for its respective responsibilities. The Governing Council of the cooperative is the one that pushed the implementation of outcome-oriented charging modalities. The company has started to interact with alternative financial suppliers (asset financers and insurance companies).
Proxy 1.3	Company C believes that its technical capabilities and knowledge on the product (specifically about its amortisation) are stronger than their financial knowledge and ditto resources. As such, cooperation with external partners seems necessary to adopt outcome-oriented charging modalities.

Proxy 2.1	They have a wide portfolio of clients. A large percentage of the product is standard although they also adapt their products in function of client needs. Their clients are used to working with leasing and renting, but the company is preparing to take these payment solutions a step further in the form or pay-per-use. At present, though, the demand for this solution is timid. But since competitors do not offer it as yet, Company C argues this can give it a first mover advantage. Another reason to promote outcome-based charging modalities is to reduce its financial burden (seeking new forms of financing).
Proxy 3.1	(3.1.1) They perceive outcome-based charging modalities as a distinct line of business, separate from selling or remanufacturing. (3.1.2) They aspire to mobilise external finance to offer a comprehensive outcome-based charging solution (financing, maintenance, insurance, etc.). (3.1.3) They control the residual value of the product, which for them is the main issue in this solution; they have developed monitoring solutions allowing to measure the use. Once the contract finishes they can remanufacture the product quite easily and put it on the market again. (3.1.4) They would have to adapt the legal part from the actual rental contract models.

Table 4: Findings of Company C

5.4 Company D

This company is devoted to blow moulding solutions and largely sells production lines to FMCG companies that package or bottle their products in plastic containers. It also has a subsidiary that creates packaging material. This double activity differentiates them from a lot of their competitors. A big share of their production lines are destined for export market, some in very exotic places: Russia, Arab Mediterranean countries, South Africa, Zimbabwe, and Latin America. The fact that their order book relies on project-based contracts implies that their balance sheet and income statement is rather volatile. The company had profitability difficulties at the end of the crisis, which it has been able to overcome in recent years. Despite having relatively high financial autonomy (Own Funds represent 45% of the balance), they need resources to finance the projects they are running, which generates significant financial costs (Financial expenses / EBITDA: 0.44). Despite having to finance a significant level of working capital (stocks and debtors), they have no tension to finance it (its Acid Liquidity was 1.41 in 2017). The findings of outcome-oriented charging modalities to a value proposition from a financial perspective of Company D is shown in Table 5.

Proxy 1.1	The Financial Department reports directly to the CEO of the company.
Proxy 1.2	The Financial Department has a traditional role in the company, managing the relationships with external providers of finance and is in contact with other departments to support its activity, but each maintaining different roles. The move towards adopting outcome-based charging modalities is seconded by all departments. It is the result of a cultural change promoted by an executive that came from another sector. Consequently, the vision on these modalities are well aligned between the Commercial and the Financial Department.
Proxy 1.3	The company has advanced financial capabilities as it has engaged in sizeable projects, with clients larger than themselves, and in complex geographic markets. Operating in this high variety context has also brought them into contact with very diverse types of financial service providers.

Proxy 2.1	The company is highly active and dynamic when it comes to looking for new (niche) opportunities. They work mainly for large companies that demand solutions to package their products. Clients are increasingly asking for turnkey solutions. Company D has developed several turnkey projects where they even provide the workers who operate the machines (Build-Operate). In these cases, the project was financed through its own funds (which posed a heavy burden to the company). While the turnkey market is a promising growth option, it would cause financial stress such projects were financed through own resources.
Proxy 3.1	(3.1.1) Since they work on a project basis the transition to project financing comes naturally to them. (3.1.2) They work mainly with traditional entities and leasing companies, due to the market they work with. They have difficulties to find alternative finance providers for outcome-oriented charging modalities. At the same time, the size of their operations greatly limits the type of finance providers they can go to. In this regard, they entered into contact with investment funds who showed little interest. (3.1.3) Still, they are also aware that a turnkey operation implies substantial risk for the involved material, and uncertainties on overall profitability of operations. (3.1.4) Towards the market, the company is promoting a culture of service orientation proposing turnkey projects with complex contractual agreements.

Table 5: Findings of Company D

6. IMPLICATIONS

Our case analyses help to make the role of finance on the road to advanced services insightful, both from a conceptual and business perspective.

In addition, the conceptual framework we introduced can serve as a tool for analysts and managers to assess the applicability of outcome-oriented charging modalities in different contexts where advanced services can be envisaged. Similarly, it helps to understand when a company and its value propositions are ready for adopting such modalities. Accordingly, it reveals how the risks of project financing for outcome-oriented charging modalities can be dealt with.

I.e., if a company can offer a quasi-standardised product to a group of clients that will make use of the product in a comparable manner, the risks of applying outcome-oriented charging modalities reduce as, for example, depreciation rates become more foreseeable. This means that contracts can become rather uniform and thus function as a kind of standard package. Moreover, if the number of clients that will make use of an asset according to outcome-oriented charging modalities is substantial, the rating of these clients can lead to their packaging into sub-groups with similar financial risk profiles. These packages can then be managed under project finance arrangements.

Our analyses also indicate that companies that assign a more important role to their Financial Department, perhaps even creating dedicated project finance units, advance their financial aptitude further, also as regards dealing with progressive external finance suppliers.

From a market potential perspective, uncertain or low demand for outcome-oriented charging modalities obviously complicates the adoption of such solutions. Finally, the initial financial situation of companies seems to be a determining factor for the implementation of outcome-oriented charging modalities. It is also reasonable to think that smaller firms are more constrained in their plans to launch outcome-oriented charging modalities through their limited financial capacity (Carpenter and Petersen, 2002) and the fact that they face difficulties in obtaining outside funds from financial suppliers (Gupta, 1969).

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AUTHORS

Dr Ibon Gil de San Vicente
Orkestra-Basque Institute of Competitivenes
San Sebastian, Spain, E-20012
943- 297 327
igil@orkestra.deusto.es

Dr Bart Kamp
Orkestra-Basque Institute of Competitiveness
San Sebastian, Spain, E-20012
943- 297 327
bart.kamp@orkestra.deusto.es

SERVITIZATION 2.0: THE SIGNIFICANCE OF PRODUCT AND SERVICE DOMINANT LOGICS FOR PUBLIC SERVICE ORGANISATIONS

Caroline Ennis & Nicholas Barnett

ABSTRACT

Purpose: This conceptual paper explores servitization as significant to public service organisations (PSOs) within which there is a requirement to administer lean and sustainable provision. It specifically appreciates that the digital transformation of services has embraced customer processing machine technologies that facilitate volume growth. Notably, the efficient operating model runs alongside the process of information sharing; thus, fostering co-operation within collaborative network systems whilst pro-actively operating as elements of the product-service system (PSS).

Design/Methodology/Approach: We attempt to evaluate and progress servitization research for novel and conceptual purposes by exploring the critical realities of its application as we enter the Servitization 2.0 era. We seek to determine from the academic literature the contextual issues and tensions experienced by PSOs at a point in time when they are rapidly digitally transforming their operational activities. With this comes the appreciation that organisations are therefore increasingly operating within interorganisational networks, requiring a more transparent, accountable measurement of their performance outcome. Therefore, since public transport systems are heavily reliant on information collected from their processing machines, to efficiently and effectively execute their service, they provide an ideal field of study. We seek out credible research literature in this field to determine the logic applied within the business ecosystem; and to understand the roles of service-dominant (S-D) and information-dominant (I-D) logic.

Findings: Many arguments in the literature demonstrate that it is not necessarily the goods or service element that dominate the business model in the era of Industry 4.0. Pertinently, there is a growing body of empirical studies enabling us to explore business models in this specific field of PSOs, to understand servitization in the context of public transport systems and the future developments of information driven business models. We find that there is a shifting dominance towards information logic and explain how this is evident in the context of public transport services.

Originality/Value: We demonstrate the significance of the S-D logic perspective when considering servitization within specific PSOs. Ultimately, we seek to better understand the strategic and operational realities for the era of Servitization 2.0, wherein the business operates within an ecosystem dominated and critically influenced by *information***.** This is pertinent, in that we ultimately seek to understand more deeply the impact of servitization principles within PSOs, and particularly to explore the critical realities within public transport systems that rely heavily on service equipment for their customer processing and service quality and the information generated from its deployment.

KEYWORDS: Servitization 2.0, Service-Dominant (S-D) logic, Public Service Management, Information-Dominant (I-D) logic, Public Transport Systems

1. INTRODUCTION

Servitization now enters an era of critical development (Baines, Bigdeli, Bustinza, Shi, Baldwin, & Ridgway, 2017; Bigdeli, Baines, Bustinza, & Shi, 2017), having evolved from the perspective of goods-dominant (G-D) logic (Smith, Maull, & Ng, 2014), wherein the emphasis tended to be placed with the original equipment [product] manufacturer (OEM), or equipment provider. Businesses have identified the respective roles of products and services, within their PSS business model, wherein products and services are critically interrelated. As such operations strategy would need to be reconsidered to cope with this perspective where they cooperate with each other within this system (Spring & Araujo, 2009). Kans & Ingwald (2016) offer a business model framework, for the 4.0 era of service management, that explores the opportunity for producing companies and service providers to establish value, wherein information and communications technology (ICT) is an enabler. This offers an understanding of the change that Industry 4.0 has brought to the strategy and operations within organisations and how it fosters collaboration within the business ecosystem, which therefore brings product manufacturers and service providers into increasingly dependent systems of cooperation. We believe that the PSS perspective is particularly relevant to public transport services. This is because organisations will go beyond the maintenance option as add-on service perspective of Servitization 1.0 era, to the Servitization 2.0 era; and that this perspective has a much broader value system which is dominated and led by the information collected from products in service use (Advanced Services Group, 2019;Ennis & Barnett, 2019).

Generally, the implementation of servitization has meant the resultant transformation of *product-centric* businesses; wherein there is a shifting of the business model logic towards service provision (Baines & Lightfoot, 2013). This tended to foster the claim of viability of servitization strategy across the broad range of industries and sectors. Paradoxically, the actual reality is that servitization takes differing paths, and brings about differing trajectories depending on the environment in which it is applied (Turunen & Finne, 2014). It is only by undertaking in-depth theoretical and empirical observations that the implications of the efficient and effective digital transformation of goods and services can be able to be realized, and further developed in the era of Servitization 2.0.

We are particularly interested in digital transformations' impact within public transport systems relying on the servitization of their products for efficient and effective service delivery. With this comes the appreciation that organisations are therefore increasingly operating within interorganisational networks, requiring a more transparent, accountable measurement of their performance outcome.

2. RESEARCH METHODOLOGY/APPROACH

A conceptual consideration is posited that the deeper understanding of the dominant logic applied in servitized sectors, which are operating in a system where products and services are interdependent, adds to the knowledge in the field of business strategy and business models (Vargo & Akaka, 2009). We aim to add to the understanding of the business logic applied in executing information dependent public transport services in the Industrial era 4.0, and its associated Servitization era 2.0. This is pertinent since organisations are not explicitly aware of the concept of servitization (Crowley, Burton, & Zolkiewski, 2018). Very often, organisations assume that they can follow a prescribed process towards performance improvement with the 'silver bullet' of digital transformation (Curtis, 2019). This transformation process, with its operation's strategy, and its lean and efficiency objectives, is based historically on manufacturing models (Barnes, 2018) and the production of goods; which tended to foster the G-D logic (Baines & Lightfoot, 2013). From the perspective of the broader operating environment, Paton, Clegg, Hsuan, & Pilkington, (2011) define the operations production, with its associated processes as a *system* of complex interactions; which for us is an important aspect for the way in which we explore the concepts of business models and logics.

In contrast to the G-D logic, Wieland, Hartmann, & Vargo, (2017) offer a conceptualisation of the application of business models as an element of service strategy. Therefore, we express, that using a S-D logic lens allows consideration of the importance of the interoperable and dynamic network perspective, with its systems orientation emphasis on service outcome (Gaiardelli, Martinez, & Cavalieri, 2015). Turunen & Finne (2014) determine the intentions for service provision in manufacturing organisations and encourage comparative research on servitization in differing manufacturing contexts, so we would like to go beyond that and explore service organisations. Notably, Ostrom, Parasuraman, Bowen, Patricio, & Voss (2015) state that research from the service innovation perspective requires more understanding of servitization. Therefore, critical arguments are determined from the S-D logic and servitization literature (see also the work of Ordanini & Parasuraman, 2011; Karpen, Bove, & Lukas, 2012; Kohtamaki, Parida, Oghazi, Gebauer, & Baines, 2019). We wish to clarify the more recent characteristics in relation to the organisational and operational strategy as relevant and significant, to goods, service and information logic, within PSOs Since public transport systems are heavily reliant on information collected from their processing machines, to efficiently and effectively execute their service, they provide an ideal field of study from which to view the business model and logic framework.

3. SERVITIZATION AND THE SERVICE-DOMINANT PERSPECTIVE

Digital capability and its transformational powers can be applied to goods production, machine maintenance, service processing, and *information management* and the associated system within which they co-operate (Jovanovic, Engwall, & Jerbrant, 2016; Huikkola & Kohtamaki, 2017). Hence it becomes pertinent that we ultimately seek to understand more deeply the impact of servitization principles in an era when organisations have gone beyond the initial framework of creating mutual value through a shift from selling products, to selling PSS, with their added benefits and value (Baines, Lightfoot, Evans., Neely, Greenough, Peppard,… Wilson, 2007). Historically, PSS is considered as complimentary service which is offered and bundled with the product to include warranties, maintenance and revenue-through-use contracts (Baines & Lightfoot, 2013), which is dependent on the information generated in the use of the products. Notably, organisations have evolved, in the digital era, to an approach which adopts data-driven decision making (Bigdeli, Baines, Bustinza, & Shi, 2017; Brynjolfsson & McElheran, 2016); and towards strategies and business models, that exploit the usefulness of this data in managing individual operations and supply network members (Ennis & Barnett, 2019). We have now gone beyond the first phase of servitization (Baines, et al., 2017), to an era wherein the developments of digital transformation, and information, bring critical opportunities in terms of the value within the business ecosystem (Dinges, V; Urmetzer, F; Martinez, V; Zaki, M; Neely, A, 2015). This is the case particularly where the products deployed in *service*-dominant contexts involves capturing information that brings the loop back round to the product designer. The strategic intention here is to capture the value that this offers in relation to product efficiency, effectiveness; and its associated quality performance for members of the business ecosystem (Gaiardelli, Martinez, & Cavalieri, 2015). As we consider in more depth, the deployment of manufactured goods when directly applied within *service provision* we seek to be able to identify the logic being applied in terms of goods, services and now information. Moreover, where we experience *information as the logic* that drives business decisions, Parnell, Stone, & Aravopoulou (2018) see this as a critical aspect of how we manage our businesses with futureproofed strategic orientation. The perspective of information is critical to our academic framing in this field, since we seek to understand the implications of the logic deployed by business in the execution of their organisational strategy related to digital transformation.

Vargo, one of the highly regarded theorists of S-D logic, along with colleagues, identified that more needs to be understood about the framing and revised conceptualisation of business models in this era of *service revolution* (Wieland, Hartmann, & Vargo, 2017). It is our intention to bring a greater understanding of servitization and the business logic within PSOs (Luftenegger, Comuzzi, & Grefen, 2013; Smith, Maull, & Ng, 2014; Virtanen, Stenvall, Kinder, & Hatam, 2018), and particularly to explore the critical realities within public transport systems, particularly where the service must be configured around specific customer needs (Raja, Chakkol, Johnson, & Beltagui, 2018). This is significant since this category of public service relies heavily on service process machines, with their *associated operating information* indicating its use, performance, and customer service quality (Hartmann, Roehrich, Frederiksen, & Davies, 2014; Raja, Bourne, Goffin, Cakkol, & Martinez, 2013). In more recent work on S-D logic, Lusch & Nambisan (2015:160), state that "the emergence of computers enabled the digitization of information and the associated capability to decouple the information from the technologies (or devices) that store, transmit, or process it". Pertinently, their paper indicates the current key themes of service-dominant logic and service innovation; with the central themes being that of *service ecosystem, service platform and value cocreation*; (for more on this supply chain and business network ecosystem perspective see Ennis, Barnett, de Cesare, Lander, & Pilkington, 2018). Other academics determine that S-D logic can function as a *strategic business logic*, particularly where organisations are able to facilitate long-term improvement from the mutual value cocreation (Karpen, Bove, & Lukas, 2012).

Going beneath the business logic, and more deeply into the operational aspects, Ordanini and Parasuraman (2011) consider that service innovation operates within a service network involving collaboration and capability. They understand the complexity of service operations, wherein there is an emphasis on S-D logic; but as the study was in the case of a luxury hotel, their work is therefore not generalizable. However, (Ng & Vargo, 2018) justify the framing and perspective of S-D logic, defining it as operating within service ecosystems and institutions, with interrelationships; also indicating the growing recognition that S-D logic is experiencing. Deriving from the S-D logic, Fehrer, Woratschek, & Brodie (2018) state the need to consider the business ecosystem where there is a reliance on engagement within [information] platforms; and Wieland, Hartmann, & Vargo (2017) provide perspectives that challenge the previous norms and advocate business models informed by S-D logic.

3.1 Public Services and business logic

Public services differ in funding models between fully funded, and partially funded with the service user paying for use of the service, to hopefully make up the extent of the operating cost; and sometimes creating excess for reinvestment (Hartley, 2005). Since the UK model funding for public transport is by the charging fares for most users, the day-to-day transport service user experience is likely to be at the forefront of the value proposition (Burnham, 2006). Therefore the approach towards production is driven by the customer service need, for which the business decisions are made with service value as a dominant factor (Lusch & Nambisan, 2015).

Since some argue that there are flaws emanating from the dominance of product and manufacturing based business model logic, alternative conceptualisations espouse identifying and activating service-based dominance pertinent to specific organisation types (Fehrer, Woratschek, & Brodie, 2018); for example, the *public* service-dominant logic. This very specific conceptualisation states that services are evolving and are being transformed into service ecosystems (Vargo & Lusch, 2017), and within public services, leading to the changing nature of their management towards the new model of networked governance (Osborne, Radnor, & Nasi, 2012) and accountability (Virtanen, *et al.,,* 2018). As such, the associated business models require inter-firm operational capabilities (Spring & Araujo, 2009) and business logic that addresses the challenges of survival (Osborne, Radnor, Kinder, & Vidal, 2014; Osborne, 2018). We can draw again on the work of Parnell, Stone, & Aravopoulou (2018), who within their research on the service sectors, determine that within the public sector there is a role that *information* plays in the business model choice; which is particularly critical if the organisation intends to be able to sustain itself in an era of enhanced efficiency. As such, the service should be able to fully exploit the information to make decisions that enhance service performance, customer quality and product design; and then ultimately the information becomes a dominant factor in the business strategy and operations. Notably, this approach requires dynamic capabilities within the organisations (for more on this see (Teece, 2010; Teece, 2018).

4. FINDINGS

It is stated that the explicit understanding of the public transport service needs will be embedded within the core principals of the service delivery for this sector (Lyons & Harman, 2002; Parnell, Stone, & Aravopoulou, 2018; Ennis & Barnett, 2019). Generally, meeting the critical customer needs involves carefully planned cooperation and business process systems integration, which draws from data collected from registration and service use (Brynjolfsson & McElheran, 2016). Where data is collected from profiled registered service users it provides much more critical and individualist information, and knowledge about users and therefore supports tailored service delivery (Karpen, Bove, & Lukas, 2012). The associated knowledge that arises from the collected data, and thereafter the refined information, provide insight that allows an organisation to improve performance and public service quality (Hartmann, *et al.,* 2014; Lariviere, Bowen, Andreassen, Kunz, Sirianni, Voss, . . . De Keyser, 2017; Kohtamaki, *et al.,* 2019). Camacho, Foth, & Rakotonirainy (2013) find this to be particularly pertinent in public transport systems since it is the information aspect that brings value for the customer. This indicates a business model, which whilst relying on products for the service process, is dominated by the *service standard* requirement. Drawing and exploiting knowledge from service use information, machine maintenance information, and customer registration information, therefore dominates the philosophy and logic of the business approach, particularly in public transport systems. This enables the organisation to be able to make strategic business decisions for service delivery directly and indirectly within its networked ecosystem; albeit constrained by some members of the service supply network (Ennis & Barnett, 2019). The interoperations of the network members of the business ecosystem (Ennis, Barnett, *et al.,* 2018) will contribute information and then exploit it for efficiency and effectiveness of the products and services within the system.

Although not explicitly identified, servitization is practiced within organisations (Crowley, Burton, & Zolkiewski, 2018), since the service provision involves a broad range of machine products that are deployed and that are closely associated with the original equipment manufacturer (OEM). This is significant as customer processing machines are able to provide critical information about required product use, maintenance needs and product design improvement (Huikkola & Kohtamaki, 2017); thus supporting service quality. In this era of progressive digital transformation service provision is discussed in relation to the *digital servitization* of products which is experiencing evolvement into the Servitization 2.0 era, relying on a collaborative, interdependent, networked business ecosystem (Ostrom, Parasuraman, Bowen, Patricio, & Voss, 2015; Raja, *et al.,* 2013; Tossi, Lockett, Raja, & Martinez, 2013). Recently the use of digital information platforms has been encapsulated as the *platform provider business model* (Kohtamaki, *et al.,* 2019); and is identified as a model where the organisation is a fully digital business ecosystem. It is reasonable to argue then that fully functioning, cooperative and networked digital operations are the ideal, not the norm (Osborne, 2018; Curtis, 2019). Therefore, in order to understand the issues of digital information, and the servitization of products, more specific empirical studies are needed to explore the critical realities and learn the lessons of the revision of business models (Wieland, Hartmann, & Vargo, 2017; Ennis, *et al.,* 2018). Then we will have the opportunity to establish an enhanced understanding of the shift towards an I-D logic perspective; and then how the ecosystem operates in the collaboration and exploitation of the value of the information it has gathered.

When applied to public services, this *ecosystem* perspective can be explored in terms of the dynamic capabilities involved within the network members of the system which are fostering the requirement for co-creative endeavour, and this revised collaborative business model logic (Osborne, 2018). Where the service proposition is the indicator of expected service quality, and its associated performance of the operation, we can draw upon Ng & Vargo (2018:519) who determine the narrative and process of S-D logic as having the characteristics of nesting, interlocking and coordination through service exchange. This is an increasingly significant issue, in terms of the role that the service system contributes to the value chain and firm performance. Further revisions of business model logic indicate an identification of the link between [information] platform business models, and S-D logic; although these are subject to empirical investigation (Fehrer, Woratschek, & Brodie, 2018). However, we are still in the early years of research into Industry 4.0, and therefore have yet to develop a deeper understanding and knowledge of the operating awareness of digital PSS, specifically where business logic is dominated by information, and the move into the era of Servitization 2.0. Pertinently, we believe that this establishes a business model approach that fosters the perspective of *I-D logic.*

4.1 Public Transport Services

Parnell, Stone, & Aravopoulou (2018:160) argue that within public sector organisations, the use of information presents an appropriate approach to the decision making, logic and business model applied by management and that most managers understand “the need for and significance of information” which goes beyond the scope of the direct service provider (Karpen, Bove, & Lukas, 2012; Kohtamaki, *et al.,* 2019). An international range of academics have explored the use of data for public transport delivery and improvement (Pelletier, Trepanier, & Morency, 2011; Watkins, Ferris, Borning, Rutherford, & Layton, 2011; Tang & Thakuriah, 2012; Camacho, Foth, & Rakotonirainy, 2013; Dragoicea, Borangiu, & Voinescu, 2016; Mehmood, *et al.,* 2016), demonstrating the critical realities about the day-to-day gathering of data and information, from the overall business ecosystem; and the contributions that this has for efficient and effective service provision.

Public transport, as a PSS, is increasingly digitalized and interoperable within its business ecosystem (Ennis & Barnett, 2019). Notably, not all regions of the world have identified the significance of this within their public transport provision; about which Leviakangas (2016) determines that the governement agenda is where this would be strongly represented. Geographical context, and society norms will obviously determine the strategic approach that is adopted towards public transport services and systems in different geographical locations. For example, the US government strategy is related to the value proposition that public transport is provided for users with no alternative option of transportation (Polzin, 2018). This is in stark contrast to the UK government agenda which advocates transport investment that fosters a stronger, fairer country; pertinent to a post-Brexit Britain (Department for Transport, 2017).

Lyons and Harman (2002) had talked about how infrastructure improvements to UK public transport alone would not necessarily persuade people to forgo their cars and make use of public transport modes, since intending travellers needed to be informed of what was available, and to appreciate the value proposition of public transport services as a viable alternative to car use. Notably, at a time when information dominance within the business strategy was in its early days, they stated that enhanced public transport information systems assisted the efficient and effective operation of transport services. Pertinently, the main national initiatives for UK public transport services are now advocating integrated information provision (Department for Transport, 2017). Public transport services require efficient and effective customer processing, dependent on a fully integrated and interoperable information system, and as such there is a critical role for the information as a dominant element of the logic being applied in public transport networks; and pertinently, other public services too. City authorities and communities are using ever-growing bodies of data to improve their understanding of citizen behaviour and service usage, in which case, future city operations managers need strategic tools to help them realize a vision of an efficient and effective urban transportation network (Mehmood, Meriton, Graham, Hennelly, & Kumar, 2016:76).

City based public transport strategies are refined from the overall national agenda, and in London the responsiblitiy for the implemenation of the agenda and government policy is underataken by Transport for London (TfL), within The Mayor's Transport Stategy (Transport for London (TfL), 2018a). Related to her role as Head of Analytics, Sager Weinstein, (2016) considers the collection of data from TfL transport use, and the value that it has exploited which act to support service prediction, planning and improvement. Interestingly, Sager Weinstein (*ibid.,)* mentions the valuable [broader] *open use* of this data as it extends beyond direct use of the transport service; pertinently it offers chances for transport safety planning. This data subsequently now contributes categorically into the broader aspects of the TfL Strategy, such as the Vision Zero for London action plan (Transport for London (TfL), 2018b). From the data collected from TfL's service information, it seeks to have an acute understanding of issues such as crowding, conjestion and delays, in order to be able to provide safer streets and efficient and effective use of transport routes. TfL is one of the worlds largest public transport systems and research conducted by Stone & Aravopoulou, (2018:12) determined that within TfL, their *live* open data platform operates with, "information [which] continues to be used to make improvements for travellers". TfL state that the role of big data is critical in the development and improvement of the service, however, they are aware of the difficulties presented by the differing trajectories within the functions of the interoperating systems that demonstrate the critical realities of business strategy and operations (Ennis & Barnett, 2019).

When considering the value proposition of public transport services, Turetken, *et al.,* (2018), highlight that this is a business domain where digital innovation has great potential. This is particularly pertinent since it offers heightened opportunities wherein open and networked service use information can offer critical enhancement for public transport services and smart mobility. Urban public transport systems are designed with the aim of moving large sets of people in a specific geographic setting, in an efficient and effective way; and this strategy relies very heavily on the information relating to the operating activities (Camacho, Foth, & Rakotonirainy, 2013; Camacho, Foth, Rakotonirainy, Rittenbruch, & Bunker, 2016; Dragoicea, Borangiu, & Voinescu, 2016; Mehmood, *et al.,* 2016).

Turetken, Grefen, Gilsing, & Adali, (2019) determine that in moving large groups of people around a city that the stakeholder collaboration requires a service-dominant business logic to be applied and that digital technology enables the complexity to be more easily managed. Improving journeys is a critical aspect of transport service developments and utilising the information that is captured from the service use, gives rise to value capture and exploitation (Dinges, Urmetzer, Martinez, Zaki, Neely, 2015; (Ennis & Barnett, 2019; Stone & Aravopoulou, 2018). Hence, we can determine examples of the dominance of *service and information logic* in the business model and philosophy, particularly within an organisation that relies heavily on the use of information gathered from its customer service and processing machines [products]. Where there is enhanced deployment of processing machines, collecting live and ongoing data within their PSS, which involves ticketing processes, entry barriers, escalator and transport hub usage, this demonstrates that these organisations are operating with the dominance of business strategy eminating from information. See Ennis & Barnett, 2019 for an example of how this supports use of escalators in TfL. Organisations are often operating within a PSS, where the dominance of business strategy emanates from push-based emphasis on assumed product capabilities, as opposed to pull-based appreciation of the service system information. This is pertinent to recognise, because we advocate that high performing interoperable service system networks, that draw critically from information logic, address the broader scope of the service provision and performance beyond that of the G-D logic. Hence, the business model and logic should be addressed more critically as we evolve into Servitization 2.0 and into collaborative, interdependent, interoperable business networks and ecosystems (Smith, Maull, & Ng, 2014; Ennis, *et al.,* 2018), wherein manufactured products are not the dominant aspect of what we offer and how we consider strategy and operations.

4.3 Theoretical and practical contribution

Whilst the digital transformation of organisations has given rise to a reconsideration of the dominant logic (Gaiardelli, Martinez, & Cavalieri, 2015) there are difficulties in translating the principles of S-D logic at the strategic level (Luftenegger, Comuzzi, & Grefen, 2013). Business strategies and models should be considering competitive capabilities of efficiency and effectiveness with much more attention given to the design and value of interoperable business information. Moreover, there needs be more empirical observation of the associated dominant model of business logic and decision making that this I-D logic necessitates (Parnell, Stone, & Aravopoulou, 2018). It is pertinent to seek to understand how the *holistic* perspective of the S-D ecosystem (Luftenegger *et al.,* 2013) enables collaboration and value, and what this business model looks like in specific services operating within the PSS contexts. Bigdeli *et al.,* 2017:15, determine that we should seek to understand more deeply the process of cooperating within the business ecosystem, and how this applies in relation to PSS for the next servitization era. In doing so, they state that prescriptive research should be “principally concerned with questions on how the reality should be”. We strongly suggest that in PSOs the role and significant value of information may foster a dominance of information logic within the strategy and business model.

We believe we have drawn from an extensive and credible range of literature to further explore and conceptualise the dominant logics in PSOs; and specifically within public transport services. Our previous papers within the servitization academic community have enabled us to develop further the initial consideration of competitive strategy and business ecosystems (Ennis, *et al.,* 2018; Ennis & Barnett, 2019); although we appreciate there is still much to explore about business strategy, models and logics that supports the operational efficiency and effectiveness of organisations. In an era when products and services are critically interdependent, organisations will be able to advance their offering to be strategically and operationally sustainable for the digital era and Industry 4.0 (Jovanovic, Engwall, & Jerbrant, 2016; Sousa & da Silveira, 2017 Kohtamaki, *et al.,* 2019). We advocate that information dominates how the PSS operates in transport systems. Deploying the business model and dominant logic lens in research offers a perspective from which further research can be framed in order to view organisational practice of PSS in other service contexts as we forge ahead into the Servitization 2.0 era.

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We use the spelling *organisation* for our own writing; where it is spelt *organization,* this is in line with the title of the article of publication.

AUTHORS

Mrs Caroline Ennis (Visiting Researcher)
Westminster Business School,
University of Westminster, NW1 5LS
caroline_ennis@msn.com

Mr Nicholas Barnett (Senior Lecturer)
Westminster Business School,
University of Westminster, NW1 5LS
n.barnett@westminster.ac.uk

EXPLORING OVERARCHING PSS DESIGN IN B2B INDUSTRIAL MANUFACTURING

Bart Bluemink, Lianne Simonse, Sicco Santema, Odeke Lenior

ABSTRACT

Purpose: The objective of this study is to explore PSS design approaches for product-service innovation in the B2B manufacturing industry. This paper builds on current research within the Delft University of Technology, researching the role of design as a driver for change and servitization.
Design/Methods/Approach: We studied 13 product-service design cases of ten weeks, carried out by students industrial design engineering. We collected the case data, observed their process and analysed the outcome of the project. We mapped the product-service proposals and built frameworks categorising levels of innovation and the applied strategic design elements and methods.
Findings: Taking an overarching innovation approach, creating a broader perspective on the value chain, exploring new business contexts without being hindered by conventions and limitations and using state-of-art design methods, increase the innovation level of product-service propositions.
Originality/Value: This study draws attention to the importance of strategic design processes in PSS innovation.

KEYWORDS: client-of-the-customer, overarching servitization, strategic design, value proposition.

1. INTRODUCTION

Servitization research has so far mainly focused on its effects In terms of benefits for the companies. For example, Baines & Lightfoot (2014) and Visnjic et al. (2013) have shown in their surveys that industrial companies are more successful when they add services to their products. In the long run, these companies show growth in their turnover and profits (Baines & Lightfoot, 2014). Moreover, they know better how to arm themselves against disrupters. In fact, by going through a servitization process, they discovered that they show more resilience and better prepared for drastic changes in their market. They learned that servitization could be an excellent strategy to respond proactively on new market circumstances (Visnjic et al., 2013). Some industrial companies even learned to develop disruptive services complementary to their products (Visnjic et al., 2013). However, considering the process of servitization, we see industrial companies struggling with the transition from product-oriented into service-oriented value propositions. They find it difficult to change the related business model, and they tend to get stuck in their known way of working. They often lack the right capabilities and experience to implement such a strategic change (Tongur & Engwall, 2014). Their organizational structure is also usually not fit to design services added to physical products (Baines et al., 2007). To address such strategic elements, several scholars took the initiatives to increase knowledge in the manufacturing industry in this regard by studying servitization practices and reflecting on implementation processes. For example, Grubic & Jennions (2018) analysed multiple out-come-base product-service solutions (PSS) cases and a framework for service development. Adrodegari et al. (2017) discussed a process framework for PSS business model design. Concerning organisational aspects, Burton et al. (2017) explained the challenges companies face during a servitization journey. Reim et al. (2015) carried out an extensive literature review of papers that discuss business models and tactics in servitization.

Overall, in these efforts for a better understanding of servitization, the design-driven approaches for successful service development (Dong, 2015) have been largely overlooked. Therefore, this paper studies the design of PSS within the business-to-business (B2B) manufacturing industry, addressing end-user needs and behaviour. This paper builds on recent efforts within the Delft University of Technology in which we study design as a means for strategic innovation in the industry, where we see a growing interest in the role of design as a driver for change and service innovation. In a recent study, Price et al. (2019) captured how companies can use design as a means for strategic innovation and provided a framework to identify the different levels of innovation.

In this paper, we used this framework (Price et al., 2019) first to categorise 13 design project cases that student groups carried out, developing product-service solutions for an industrial company. Then, we analysed the strategic elements of PSS design in relation to servitization and uncovered an *overarching servitization* approach.

In the next section, the theoretical background is addressed. Then the method is described, followed by our findings in the result section, ending up with the discussion of the findings and an outline of further research avenues.

2. THEORETICAL BACKGROUND

2.1. Servitization in B2B industrial manufacturing

From a recently carried out literature scoping study concerning the state of servitization knowledge in the B2B manufacturing industry, we concluded that this research concentrates in Europe, mainly in the UK and the Scandinavian countries (Bluemink et al., 2020). In these studies, we found that moving into service-oriented products requires a servitization strategy, which inevitably entails a change in how companies create value for end-users and consequently impact the company's business model (Baines et al., 2009; Reim et al., 2015). Product-service design affects the internal organisational structure of design processes and triggers design collaboration with partners in the company's network (Ziaee Bigdeli et al., 2017). However, the design-driven approaches for successful service development (Dong, 2015) have not been practised widely within the B2B manufacturing industry. Only a few papers study the design of product-service solutions addressing end-user needs and behaviour. Although Ryu et al. (2018) recognised a growing interest in UX-design as a servitization strategy, overall, the servitization literature focused on the B2B manufacturing industry lacks product-service design approaches.

2.2. Servitization and PSS Design

Servitization is a useful strategy for technology-intensive manufacturers to extend their current product portfolio with linked services. In essence, servitization is defined as a transition process from selling products to selling product-service systems (Kohtamäki et al. 2018). Along with the increasing use of data platform technologies, many opportunities have arisen for differentiation in service propositions. Based on which also newcomers got a chance to disrupt industrial manufacturing markets. In considering competitive advantage, technology-intensive manufacturers in the capital goods industry have shown a growing interest in servitization. Previous studies learned that manufacturers that adopted servitization were able to increase their business profitability (Baines et al., 2010; Reim et al., 2013; Story et al. 2017). In the literature stream of design, similar studies argued that a design-driven approach is a useful strategy to achieve successful PSS results (Price et al.,2019; Dong, 2015). However, a combined approach of PSS Design in the manufacturing industry has not been found. In the Aerospace industry, Price et al. (2019) conducted research that was triggered by earlier research initiatives by Dong (2015), showing that design-driven innovation leads to successful results for organizations and industries. She evaluated 82 master and doctoral theses conducted in the Dutch aviation industry and captured how companies can use design as a means for strategic innovation. Based on this case evidence, she has built a framework to identify the different levels of innovation. In this study, we extend this framework to the B2B manufacturing industry.

2.3. Strategic Design and PSS Design

In addition to PSS design-driven approaches to achieve successful PSS results Table 1 shows the thematic results of our scoping review study (Bluemink et al., 2020). We found that the five strategic design elements *business models, organisational capabilities, value creation, collaborative networks* and *servitization strategies* are helpful to take into account in PSS design. Moreover, we argued that to better understand PSS design as a strategic approach to increase the competitiveness and resilience of the company in a future context, we currently have insufficient knowledge of *overarching servitization*, about how to create PSS that serve customers throughout the value network. Both findings led to our research question: how to design strategic elements in PSS in B2B industrial manufacturing.

Table 1: Number of Studies per Main Strategic Element Addressed

Strategic Element	***Number of Studies***	***Short Description of Topic***
Business Models	*17*	*Discussing Business Models in Servitization*
Organizational Capabilities	*10*	*Discussing Organizational Capabilities to execute Servitization*
Value Creation	*9*	*About Value Creation through Servitization*
Collaborative Networks	*6*	*Discussing Providing PSS's through Cooperation in a Network*
Servitization Strategies	*8*	*Discussing Strategic Frameworks and practices for Servitization*

In previous studies, Price (2019) and Dong (Dong, 2015) argued that a design-driven approach is a useful strategy to achieve successful PSS results. Bluemink et al. (2020) found that the five strategic design elements of our scoping study *business models, organisational aspects, value creation, collaborative networks* and *servitization strategies* are helpful to take into account in PSS design. Moreover, he argued that to better understand PSS design as a strategic tool to increase the competitiveness and resilience of the company in a future context, we currently have insufficient knowledge of *overarching servitization*, about how to create PSS that serve customers throughout the value network. Both findings led to our research question: how to design strategic elements in PSS in B2B industrial manufacturing.

3. METHOD

3.1. Data Collection

In total, we selected a sample of 13 design cases of a strategic design course provided at the Delft University of Technology, as part of the International Strategic Product Design master program. We used three selection criteria. First, the company operates in a B2B market. Second, it manufactures and supplies mainly physical products. And third, it has strong R&D-capabilities and in-house knowledge of advanced technology. Five groups carried out the course assignment for ten weeks in the autumn of 2018 for an industrial company that produces baggage handling systems for the aviation industry. In the fall of 2019, eight groups took the same course for a manufacturer of commercial vehicles. In all cases, the students drew up a strategic plan for the company and to propose a new integrated product-service. At the end of the project, we gathered the data the students delivered, consisting of a poster presentation, a minimum viable product (prototype) and an end report explaining the proposed product-service solution.

3.2. Data Analysis

We analysed this data according to the classification model of Price et al. (2019) to determine the level of innovation. We first classified the innovation level of the expected outcome as defined in the initial design brief. Both companies asked the students to propose an integrated product-service solution as part of a strategic plan. Based on this, we classified the expected solutions as Integrated Products. We then mapped out the design case results by the level of innovation to understand to what degree the students elaborated their product-service solutions. After analysing the collected data, we were able to sort all projects according to the innovation level and mapped them the out on the framework of innovation level (Price et al., 2019). The course coordinator who also was involved in the study of Price (2019) contributed to the aerospace and manufacturing comparison. The second author secured the objective stance to the data analysis. In the second phase, we classified to what extend the students covered the strategic design elements of Bluemink et al. (2020). We analysed the deliverables of each case and extracted, clustered and mapped out additional strategic design elements. We then determined the extend of element coverage in the particular case by using three categories: fully, partly, or not covered in the case.

4. FINDINGS

Two out of 13 cases created a product-service solution on the same level of innovation level compared to the initial brief (Table 2). Four groups were able to design solutions as classified in the second level of innovation, *Services, Processes and Interactions,* creating user experiences and services for end-users. With their answers, they 'jumped over' the B2B-customer of the company, direct addressing end-users in the next step of the value chain. Seven groups, however, added complexity to their proposed value proposition by involving other stakeholders in a joint product-service network solution. We categorised their solutions in *Systems and Organizations*. 12 out of 13 groups made use of digital data platform as part of their solution to manage the end-user interactions and value transactions.

Table 2: Levels of Innovation at the begin and end of the project

				Innovation Levels according Price et al. (2019)		
Year	**Team**	**1st Coach / Principal Researcher**	**2nd Coach**	**Integrated Products**	**Services, Processes and Interactions**	**Systems and Organizations**
2018	Group 6 Pick&Go	1	2	● →	→	→ ▲
	Group 11 PickUp	1	2	● →	→ ▲	
	Group 12 GiftDrop	1	2	● →	→ ▲	
	Group 20 Baggage Hotel	1	2	● →	→	→ ▲
	Group 29 UX	1	2	●▲		
2019	Group 12 Vita	1	3	● →	→	→ ▲
	Group 14 Unboxing	1	3	●▲		
	Group15 Quook	1	3	● →	→ ▲	
	Group 21 Incubator	1	3	● →	→	→ ▲
	Group 22 Craft	1	3	● →	→	→ ▲
	Group 26 Switch	1	3	● →	→ ▲	
	Group 28 MedX	1	3	● →	→	→ ▲
	Group 29 Delivery	1	3	● →	→	→ ▲

● = Innovation level asked in the brief of the project

▲ = Innovation level result at the end of the project

→ = Increase of innovation level during the project

← = Decrease of innovation level during the project

During the coaching sessions, we observed that all groups show a more or less standard approach in the way they carry out their project. In most cases, they used one or two of the following design methods and techniques that we teach as part of the Strategic Product Design master program of the Delft University of Technology Faculty of Industrial Design Engineering: the Vision-in-Product Design method by Hekkert (2014) and the Design Roadmapping method by Simonse (2017). Both approaches, each from another angle, focus on the future perspective and make a PSS design strategy more tangible and explicit, by creating a future vision, exploring a new business development strategy and designing a roadmap to deploy the new strategy (see Table 3).

Table 3: Strategic Design Elements Covered in the PSS Design Cases

Five out of 13 cases covered all strategic elements in their deliverables. All cases delivered PSS design that focused on a future business context by delivering a future vision, a new business strategy, accompanied with a design roadmap for deployment. Ten out of 13 cases applied an overarching servitization strategy, bypassing the company's direct customer, addressing the end-user in the value network. As Table 3 shows, the students encountered most problems with setting up business models throughout the value network and determining the capabilities that an organization must deploy to introduce the PSS.

5. DISCUSSION

Generally spoken, manufacturing industries usually operate in a B2B market, with a strong focus on the needs of their direct customers. The two companies involved in our cases also focused mainly on this one-to-one relationship with their customers, creating PSS within their current B2B context. However, in most cases, we saw the student-designers looking beyond the current B2B context and shifting to the next levels of innovation of Price' framework (Price et al., 2019). By creating solutions that entail an extended supply chain, we unravelled strategic design elements. First, as the designers built a business-to-business-customer value chain (B2B2C), they were overarching current company's customers. Second, at the end of the strategic design project case, both company representatives showed surprised by the quality of the strategic design process and the completeness of the final PSS design results.

5.1. Limitations and further research

Although the students lack the expertise and knowledge of experienced R&D-engineers, they are unbiased; they have a fresh look at the business and can open up a broader perspective, exploring new business contexts without being hindered by conventions and limitations of their context. Further, they bring skills, toolboxes and up-to-date knowledge into the project, using proven design methods and techniques as described in the Delft Design Guide (van Boeijen et al., 2014; 2019).

5.2. Contribution to the field

The majority, 11 out of 13 design cases resulted in an increased level of innovation, leading to outcomes that were above expectations of the representatives of both companies. We may, therefore, conclude that it makes sense to set up and implement future projects according to this approach and to advise companies to develop and nurture these capabilities in-house.

In our introduction, we showed that the existing servitization research focuses strongly on creating or redesigning business models (Adrodegari & Saccani, 2017; Tongur & Engwall, 2014). This finding, we justified with our study on strategic design elements, as business models are, in most cases, an indirect result of a designed value proposition. After all, both are closely linked and cannot exist without each other. However, we argue that the focus should be on the design of the value proposition itself, not the other way around. Therefore, we promote to start the design process at the end of the value chain and create product-service solutions that bring value upstream into the supply network, then design the related business models.

6. CONCLUSIONS

We examined 13 cases of strategic design carried out by students. We found that using strategic design methods and in particular, taking an overarching servitization approach, enable designers to increase the level of innovation of PSS design results.

Regarding practical implications, we conclude that by creating a mind-set and conditions as present in the student design cases, industrial manufacturers operating in B2B environments can increase the innovation level of their service innovation projects. Moreover, user-centred design, creating product-services and user experiences, improve the outcome of the innovation process. We, therefore, advise focusing on the design of the value proposition itself, rather than on its related business model.

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AUTHORS

Bart Bluemink, MSc.
r.g.h.bluemink@tudelft.nl

Dr. Lianne Simonse
L.W.L.Simonse@tudelft.nl
Prod.Mr.Dr.Ir Sicco Santema
S.C.Santema@tudelft.nl
Faculty of Industrial Design Engineering
Delft University of Technology
Landbergstraat 15
NL-2628 CE Delft

Odeke Lenior, MSc.
Odeke.Lenior@vanderlande.com
Vanderlande Industries
Rooseveltlaan 1
NL-5466 AC Veghel

SME INTERNATIONALIZATION THROUGH DIGITAL SERVITIZATION: DEVELOPMENT OF ECOSYSTEM CAPABILITIES

Milad Kolagar, Wiebke Reim, Vinit Parida & David Sjödin

ABSTRACT
Purpose: Digital servitization has shown to create a competitive advantage for manufacturing companies on the international market. However, companies, specifically SMEs, are struggling to make use of its benefits for their international activity. Therefore, the purpose of this study is to investigate how SMEs utilize digital servitization for their internationalization strategy by developing their ecosystem capabilities.
Design/Methodology/Approach: To achieve this purpose, this study has adopted an exploratory multiple case-study approach and conducted in-depth semi-structured interviews with 21 manufacturing SMEs.
Findings: In this study, a framework has been developed for SMEs to enable their international activities by strengthening their digital servitization capabilities, which include digital awareness, digital service innovation, and digital service customization. Ecosystem capabilities, including ecosystem knowledge synergy, ecosystem innovation appropriability, and ecosystem alignment, have been identified as the deciding factor for the successful adoption of internationalization strategies.
Originality/Value: Despite its potential, the implementation of digital servitization is still challenging for most of the manufacturing companies, especially SMEs that target international markets. These companies are dependent on ecosystems in the international atmosphere, but the capabilities needed to succeed requires further research. In this regard, the framework presented in this study helps SMEs to develop ecosystem capabilities for digital servitization in the international arena.

KEYWORDS: Digital servitization; Internationalization, SMEs; Ecosystem capabilities; Business ecosystems.

1. INTRODUCTION

In recent decades, there have been fundamental changes in the business environment. Different industries are operating in a highly competitive atmosphere and are affected by technological transformations and dynamic changes in response to market needs. These changes have led to a situation in which small and medium-sized enterprises (SMEs) play a large, diverse, and vital role in the industrial production and economic development of countries (Kula and Tatoglu 2003). Developing business boundaries and operating in the international market, is one of the most important ways for businesses to succeed (Kuivalainen et al. 2012). Attending international markets for SMEs offers many opportunities, but SMEs are usually facing internationalization barriers such as a product-centric strategy, limitations on their available resources, inability for networking with other companies, and the traditional mindset of the leaders and entrepreneurs (Roy et al. 2016).
Many SMEs have realized the potential to satisfy customer's needs by providing services and solutions instead of only selling products (Queiroz et al. 2020). This trend has been described as servitization (Reim et al. 2019; Valtakoski and Witell 2018). Servitization helps companies to differentiate themselves, however, the use of new technologies is usually required to succeed (Parida et al. 2016). This transition needs to be accompanied by the development of digitalization capabilities to the current products and services and introducing new digital solutions (Lenka et al. 2017; Reim et al. 2019). By using these technologies, organizations are seeking value creation in their business and making a better experience for their customers. A business can once claim to be transformed from a digital perspective when it gains the ability to redesign its processes, products, and services by using

digital technologies. Only the use of these technologies in different sectors of the organization will not work, but the whole organization should seek to use them with a problem-solving mentality. When an organization realizes the fact that digital transformation is not a technological issue but a cultural and belief change, it would be a key moment for that business. But there are still hidden angles in how to facilitate digital servitization in SMEs and the role that actors and stakeholders play in a business ecosystem and the ecosystem capabilities that need to be developed.

Digital servitization has shown to create a competitive advantage for manufacturing companies on the international market. For example, remote monitoring or up-time contracts give companies opportunities to provide the same service offers all over the world. But, most studies have been conducted with large multinational companies that already have an existing international activity and established distribution channels. However, many SMEs also recognize that digital servitization would allow them to enter international markets (Sklyar et al. 2019). There is a lack of research that specifically targets SMEs and the benefits of digital servitization and ecosystem capabilities for their international activity. Therefore, the purpose of this study is to investigate how ecosystem capabilities affect SMEs' internationalization strategy when offering digital servitization. This is done by developing a contingency framework based on ecosystem capabilities for successful internationalization.

2. THEORETICAL BACKGROUND

2.1 SME Internationalization

Incompatibility with today's highly volatile marketplace will have a very dangerous outcome for organizations and late reactions will sometimes lead to nowhere. One notable feature in the current competitive environment is the growing trend of international competition, which has led companies and businesses to keep in line with the uncertainty and worry about losing their market share. In such circumstances, internationalization is one of the most important tools that help companies survive and succeed. Developing the frontiers of business and operating in the foreign market, referred to as internationalization, is one of the most important ways of achieving business success (Niittymies and Pajunen 2019). Internationalization reflects the interests of the country of origin and the enthusiasm of decision-makers (entrepreneurs) to operate based on opportunities available in foreign markets. It is the process of adapting a company (strategy, structure, resources, etc.) to operate internationally. SMEs play a vital role in industrial innovation and benefit their communities through economic development. Despite the steady role of SMEs in economic development, few studies have been conducted on the internationalization of these companies; and research in this area is still in its infancy.

2.2 Digital Servitization

Digitalization is the most complex business transformation that needs to highlight the strategic role of new technologies and capabilities. This transformation is a process in which organizations use new technologies, expand their communications, and through the transformation of various business dimensions, including business model innovation(Parida et al. 2019), customer experiences *(digital products and services)*, operations *(Processes and decisions)*, impact on individuals *(skills and culture)*, and networks *(total value chain)*(Nambisan et al. 2019) to reach better performance and competitive advantage. This transformation is the ongoing process of adapting to changes or making changes in customers and markets *(external ecosystems)* using digital capabilities (Lenka et al. 2017) to create new business models or new products and services.

Digitalization has led many companies to search for ways to move from product-centric models to providing digital service-oriented offerings (Kohtamäki et al. 2020). This has led to the emergence of a new concept in servitization literature called "digital servitization" (Coreynen et al. 2020; Paschou et al. 2020), and companies have become more inclined to adapt to the existing situation by moving towards offering digitally-enabled advanced services. This transition requires a set of transformations in the firms and their associate ecosystems processes, capabilities, and offerings to create, deliver, and capture increased service value which stems from a broad range of digital technologies that can enable their service offerings (Sjödin et al. 2020). Although this concept is becoming increasingly important for manufacturing companies, there is still much ambiguity about how to develop the capabilities needed to run it in companies, especially SMEs.

2.3 Business Ecosystem

In recent decades, the pace of change in the business world has increased exponentially. In line with these changes, new approaches and methods have been proposed by management thinkers. One of these concepts is the business ecosystem approach, which has emerged due to the changing conditions of the business world. Based on this approach, the business world is like an ecosystem in which different businesses from different industries interact with each other, and their survival is largely interdependent (Adner 2017). With the increasing trend of communication and complex relationships between businesses, and also with the fast-paced technological changes in the business world, the behavior of companies can be compared to the behavior of organisms in an ecosystem (Iansiti and Levien 2004). A business ecosystem is an expanded system of organizations that support each other. In an ecosystem approach, it is believed that each member affects the overall destiny of the business ecosystem (Dedehayir et al. 2018). For example, when the number of customers in an ecosystem decreases, the value of the ecosystem for suppliers and other customers decreases. Also, when a new supplier of a complementary product enters the ecosystem, the ecosystem value for all its members increases. On the other hand, an organization may be a member of several ecosystems at the same time and play a different role in each ecosystem. Although almost all companies have realized to some extent the importance of working in an ecosystem, this concept still needs more research. In this regard, the need to research and assess the capabilities that help companies to strengthen their ecosystem activities is being felt more than ever.

3. METHODOLOGY

The present study is based on an exploratory multiple case study involving 21 manufacturing SMEs. Almost all of these SMEs benefited somewhat from digitalization, but there was a difference in their level of digital maturity. We studied these companies to examine the capabilities needed to successfully internationalize digitally-enabled advanced services in SMEs and analyze the ecosystem capabilities that need to be developed in this regard. This research design was chosen because there is limited knowledge about how ecosystem capabilities affect the internationalization through digital servitization. Information from rich real-life cases can help identify new aspects and phenomena derived from reality (Eisenhardt and Graebner 2007; Yin 2014). This approach is used because it helps to better understand complex social processes and phenomena such as ecosystem capabilities.

The primary sources of data have been in-depth interviews based on face-to-face meetings and calls using a semi-structured questionnaire with 21 respondents, each of whom was one of the executives, central managers, and local managers involved in digital servitization projects. These interviews were based on the respondents' experience with offering digitally-enabled services, their internationalization strategies, and how they are managing their relations with partners and customers in the ecosystem. Each interview lasted about 60 to 90 minutes and has been recorded. The interviewers were also taking notes during the interviews. Then, all the recorded interviews were transcribed and the process of encoding the collected data began.

The coding included comparing and interpreting the interview transcriptions, notes taken during the interviews, and the secondary data collected from companies' documents, websites, and social media. The initial coding process also began with analyzing of the first-order codes of the collected data, which has yielded 25 categories after subsequent re-coding of the data. Then, by identifying the relationships between these codes, 9 second-order themes were identified. Finally, those themes were generalized to 3 aggregate themes at a higher level of abstraction. Also, to ensure the validity of the coding structure, an inter-judge reliability test was performed, and based on all stages of data analysis, coding structures can be displayed as Figure 1.

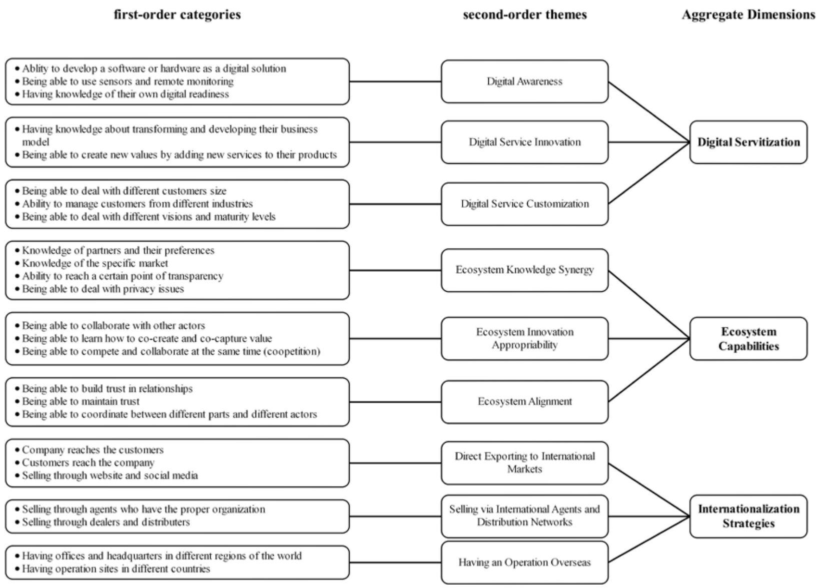

Figure 1: Data structure and coding process

4. RESULTS AND FINDINGS

This study revealed several insights about how digitally-enabled service offerings in an ecosystem of providers, customers, and partners can help SMEs in their internationalization strategies. Following the order of aggregate themes in the coding structure (as shown in Figure 1), the relevant findings of this research are described below.

4.1 Digital Servitization Capabilities

Many SMEs are aiming to create digitally-enabled services for their customers and offer them solutions instead of selling them mere products. In this regard, the three capabilities of digital awareness, digital service innovation, and digital service customization were identified for stepping towards digital servitization for SMEs.

Digital awareness can be considered as a capability that has a decisive role in providing digitally-enabled advanced services. The more companies are aware of the developments in the digital age and their digital readiness, the more accurate and intelligent the answers to existing problems can be. Based on the analysis of research data, it became clear that companies need to develop their communication and technological facilities to provide new types of services to the customers. In fact, in order to meet customer needs, market trends and competition, SMEs should have the ability to develop a digital solution in the form of software, hardware/machine, or a combination of these two. In this regard, many companies are looking to use sensors for optimizing their production and service processes. This technology made it easier to collect large amounts of information and create more organized systems. The more workplaces are equipped with sensor-based IoT technology, the better the analytics tools will be, and companies will find new ways to improve their services. Before embarking on this journey, companies need to measure their digital readiness and enhance their knowledge. Also, the CEO of one company explained how customers knowledge and digital readiness impact their digital service offerings:

" … Again, depending on the customer, their own level of automation knowledge. Typically, we adapt in our end so that it will work in the customer's machine but there is a possibility for the customer to do that as well but quite normally, there is not that high knowledge about safety protocols and communication protocols in the customer… "

The analysis of gathered data has led to a new capability called digital service innovation which can be defined as service system reconfigurations, intending to change the service systems in a way that increases the value for the involved actors. Accordingly, digital service innovation then refers to changes due to digitalization. It focuses on new digital services or new re-combinations in service systems, resulting in new practices that are valuable enough for the involved actors to make it sustainable. The fundamental issue in contemporary management is the creation and architecture of a business model that leads to value creation, makes it possible to achieve stability in a turbulent environment, and contributes to market success. Although new technologies are often the main causes of change, they never change the industry alone. The key to achieving such a transformation is a business model that can link new technology to a new need. One of the factors that play a decisive role in the evolution of businesses for providing digital services is the knowledge of companies on how to innovate their business model.

The digital service customization capability can help SMEs gain insight and become aware of how to differentiate between different customers with different visions and maturity levels from different industry segments to create different types of digital services. One of the most important challenges that companies are facing in their digital servitization journey is how to provide digital services and solutions to different companies with different features. In fact, customer segmentation is one of the first and foremost steps in providing digitally-enabled services. This concept not only helps to find better ways to meet the needs of current customers but is also a desirable approach for identifying unsatisfied customer needs. In companies that offer a variety of digital products and services to the market, customer segmentation is the most effective way to customize digital services based on customer needs and create competitive advantage and profitability. A business development manager from Alpha explained how a project mismatch with a customer can lead to failure:
" … Depending on the customer, we have very different approaches because we, of course, know that we cannot offer a big R&D project to a small customer, it will never be feasible for them to actually do that project …"

4.2 Ecosystem Capabilities

Working in a business ecosystem has helped organizations survive in a rapidly changing business environment. A business ecosystem consists of a network of interconnected organizations that compete dynamically for the survival or growth of a business. Every being in the ecosystem affects and is affected by other components; in this way, connections are created in the ecosystem that are constantly evolving, and entities must be flexible and adaptable to survive. Based on the analysis of the data obtained from this research, it was concluded that SMEs should also develop their ecosystem knowledge synergy, ecosystem innovation appropriability, and ecosystem alignment capabilities to maintain their survival and expand their business boundaries, which are discussed below.

The components of an ecosystem must reach a level of ecosystem knowledge synergy that provides a deeper understanding of the preferences, privacy boundaries, and capabilities of other components. This allows companies to expand their knowledge through the views, opinions and experiences of others. For example, if a company has a plan to export and develop its business, by combining knowledge and building relationships in the ecosystem, it may be able to use the knowledge of more experienced companies in the international arena. Working in an ecosystem can lead companies to identify opportunities for partnerships, conducting joint development operations, or various areas of business development. Companies need to develop their ability to get to know their partners well and gain knowledge about their priorities. Besides, companies need to gain a thorough understanding of their target market, as this will help them to better understand their audience and produce the right services. Also, one of the most important issues that companies are facing is the creation of this ability in themselves and their partners to achieve an acceptable level of transparency while respecting each other's privacy.

Organizations compete to survive in business ecosystems and adapt to it. Ecosystem survival means that participants have developed their patterns of behavior in such a way that a stream of ideas, talents, and capital is created through the ecosystem. Being active in the ecosystem provides mechanisms for the exploitation of technology and the acquisition of competitive advantage for effective competition with other organizations. Innovative businesses cannot grow and develop in a vacuum; they must create a variety of resources including capital, partners, suppliers and customers to create a collaborative network, which is achieved through activity in the ecosystem. Dynamic business ecosystems create an environment in which competitors in the ecosystem collaborate even for a limited amount of time. Companies need to learn how to co-create and co-capture value together and that requires them to strengthen their ecosystem innovation appropriability to learn how to manage the interactions in an ecosystem in a way that balances all the relationships and entities.

One of the most important ecosystem capabilities that this research has achieved is ecosystem alignment. According to the findings of this study, one of the most important factors in establishing this alignment is how to build and maintain trust in the ecosystem. Trust has a decisive role that leads to the creation of new ideas and values in the form of an ecosystem. Also, the R&D and marketing manager of one company mentioned how the lack of trust between different stakeholders in an ecosystem can collapse the collaboration:
" … It's trust. If we don't trust each other and you'll start holding information for yourself, I guess that wouldn't be-- That's not a good collaboration. We have to be open, trust and share information to take it forward. If you start holding information for yourself, it will be hard …"
Besides, how to create harmony and coordination between the various components and actors of an ecosystem to a large extent depends on creating and maintaining that trust and can lead to the ecosystem alignment.

4.3 Internationalization Strategies
Internationalization is a multidimensional process, meaning that SMEs will have to make multiple decisions in various fields to participate in international markets, and these decisions shape the corporate vision of these companies. Based on data collected form SMEs, this study considers three strategies of direct export to international markets, selling via agents and distribution networks, and opening an operation overseas for the internationalization of these companies.

Some of the companies being interviewed in this study directly export their products and services to the international markets. This means that the company offers its services directly to customers without the presence of an intermediary. The way to communicate with the customer is that sometimes the company makes a connection with the customers themselves to sell their products and services and sometimes the customers refer to the company to buy their services. Also, the R&D and marketing manager of Gamma described how they are being contacted by their customers:
" … A new customer always contacts us through email and they would typically want to buy one unit and we have a discussion maybe and sometimes we also make a demonstrator software. If we know that they typically describe that application and then we can make some kind of software maybe to make it easier for them to see the benefits of our products… "
In the meantime, the effective use of online sales websites and social media networks is also a low-cost way to enter global markets.

Another strategy that these companies use to sell via agents and distribution networks who have an organized distribution system and can distribute the goods and services produced by these companies

in an organized manner. Also, a significant percentage of these companies sell their products and services through dealers and distribution networks. The CEO of Beta explained to what extent choosing the right distributer is important for their business:
"… When we look for a distributor, we try to find someone that understand what we are doing and knows the need for this, and then that has an organization of salespeople… "

Some of these companies also pursue the strategy of selling products and services by opening own operations in different regions of the world. In addition, some companies might have operation sites in different regions of the world so that they become closer to their main customers.

4.4 A Framework For Successful Internationalization Of SMEs

As mentioned in the previous sub-sections, SMEs need to develop capabilities in order to be able to strengthen their digital servitization and provide digitally-enabled offerings. These capabilities pave the way for SMEs to expand their business and develop their activities beyond their borders into the international market. In other words, it can be argued that digital servitization capabilities act as the stimuli of internationalization and can empower different strategies in the SMEs. SMEs need to choose the most appropriate internationalization strategy from the existing strategies. One of the factors that help SMEs in making this crucial decision is the development of their ecosystem capabilities. Figure 2 shows the framework that this study has proposed to evaluate the internationalization strategies according to different ecosystem capabilities.

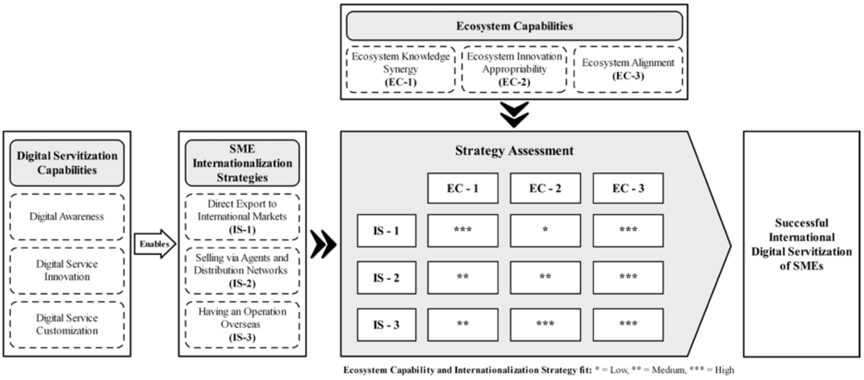

Figure 2: A framework for successful international digital servitization of SMEs

It can be concluded that SMEs need to strengthen their various ecosystem capabilities in order to successfully implement their digital services internationally. It should be noted that each of these capabilities, depending on which internationalization strategy is being used, has different degrees of importance. Regarding the direct export strategy, it can be said that this strategy requires less cooperation between the actors of the ecosystem than other strategies. But instead, SMEs need to have a high level of knowledge of their partners and target market. Also, these companies need to gain a high level of trust in their relationship with customers to increase their loyalty. Sales strategy through dealers and distribution networks also requires a moderate amount of knowledge about the market and competitors. In this type of strategy, sales agents and networks usually have specialized knowledge about the target market and customers, so SMEs can entrust a large part of this responsibility to them. Also, companies need to develop a moderate level of ecosystem innovation appropriability and strengthen the mechanism of how to collaborate and create collective value with sales representatives and distribution networks. In addition, this internationalization strategy also requires SMEs to achieve a high level of trust in their business relationships with distribution agents and networks, and develop their ability to coordinate between different sectors of their business. In connection with having an operation overseas, it should be emphasized that this internationalization strategy requires direct local contact customers and local suppliers and gaining market experience, and therefore requires a moderate level of market knowledge by SMEs. Also, due to the vital need to exercise direct control over the quality of services provided to customers and partners in this strategy, companies are required to develop their ecosystem service innovation and ecosystem alignment capabilities at a relatively high level. As can be seen from the assessment framework presented in this study, the common denominator of all SMEs that intend to internationalize their digitally-enabled advanced services is that the majority of them consider the development of ecosystem coordination as the most important ecosystem capability. In fact, building trust in the form of ecosystem collaboration can be seen as the foundation for the survival of SMEs in the age of digital servitization.

5. CONCLUSION

This study has the purpose to examine how the development of ecosystem capabilities can help SMEs in internationalizing their digitally-enabled advanced services. This research has made several contributions to the field. First, this study specifically considered digital servitization in SMEs, and using the analysis of empirical data, concluded that these companies need to nurture some capabilities in order to facilitate the provision of their digitally-enabled advanced services (Paschou et al. 2020; Coreynen et al. 2020). These capabilities, which include digital awareness, digital service innovation, and digital service customization, can enable the SMEs to compete in the international markets. Second, the results of this study confirmed that SMEs, due to the limitations they have in their resources, usually do not have the ability to adopt different internationalization strategies simultaneously (Roy et al. 2016; Niittymies and Pajunen 2019). So, they must come up with the right strategy based on the constraints they face. Also, direct export, selling via agents and distribution networks, and having an operation overseas were recognized as the dominant internationalization strategies in SMEs. Finally, a key contribution of the present study is defining the ecosystem capabilities (Dedehayir et al. 2018) required for SMEs to create collective value with other actors in an ecosystem. In this regard, ecosystem knowledge synergy, ecosystem innovation appropriability, and ecosystem alignment were identified as the ecosystem capabilities of which the development of each of them plays a key role in choosing the best internationalization strategy in SMEs. In fact, SMEs need to strengthen their digital servitization capabilities in order to secure their presence in international markets, and then develop their ecosystem capabilities to successfully pursue their chosen internationalization strategy.

Although the results of this study can contribute to the emerging literature of digital servitization, ecosystem capabilities, and SME internationalization, it has certain limitations that need to be considered. This research gained insights from 21 SMEs; however, selecting and reviewing more SMEs or even reviewing SMEs operating in other regions of the world may yield different results. This could form the basis for further research in this area and examine whether the capabilities obtained from this research can be generalized to other SMEs operating around the world.

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AUTHORS

Milad Kolagar
Entrepreneurship and Innovation, Luleå University of Technology, Luleå, Sweden, 97187
+46 920 49 2857, milad.kolagar@ltu.se

Dr Wiebke Reim
Entrepreneurship and Innovation, Luleå University of Technology, Luleå, Sweden, 97187
+46 920 49 2079, wiebke.reim@ltu.se

Prof. Vinit Parida
Entrepreneurship and Innovation, Luleå University of Technology, Luleå, Sweden, 97187
+46 920 49 2469, vinit.parida@ltu.se

Dr David Sjödin
Entrepreneurship and Innovation, Luleå University of Technology, Luleå, Sweden, 97187
+46 920 49 1819, david.sjodin@ltu.se

SERVITIZATION IN THE DIGITAL HEALTHCARE INDUSTRY: CREATING VALUE BY LEVERAGING SMART MEDICAL SERVICES

Kira Rambow-Hoeschele, Matthias M. Hampel, David K. Harrison & Bruce M. Wood

ABSTRACT

Purpose: New technologies, digitalisation and trends are changing the healthcare ecosystem. Smart medical services emerge in multiple areas of healthcare, some are researched and under development, while others have already been implemented. The transformation from a traditional to a smart and servitized healthcare ecosystem needs the collaboration of all stakeholders. The purpose of this research is to study the transformation and servitization of healthcare.

Design/Methodology/Approach: A systematic literature review was applied to investigate the change from a traditional to a smart and servitized healthcare ecosystem.

Findings: The healthcare system of the future will be more digital and networked. In addition, current trends create a more patient-centred healthcare system. These changes entail both opportunities and risks for stakeholders. Opportunities include improved servitized medical care and cost savings. Risks concern legal aspects and data protection.

Originality/Value: The future healthcare ecosystem will be patient-centred, thus, the patient will be involved in the formation of the healthcare value chain and smart medical services. The future healthcare ecosystem will be designed to provide an individualised and servitized care for patients. The aim will be to maintain and restore the health of people and actively involve them in care processes. Networking and cooperation between stakeholders will enable enhanced servitized care.

KEYWORDS: digital healthcare, smart medical services, patient centricity, transformation, healthcare ecosystem.

1. INTRODUCTION

With the advancement of technology, the traditional healthcare industry has gradually begun to digitise and to servitize. Smart medical services incorporating a new generation of information and communication technology have emerged. Smart healthcare includes changes from disease-centred to patient-centred care, from general management to individualised management and from a focus on disease treatment to a focus on preventive healthcare. Particularly addressing the personal needs of people, the future healthcare industry enhances the efficiency of medical care as well as the medical and health service experience. Digital health trends across five dimensions are paving the way for improved health outcomes (Figure 1).

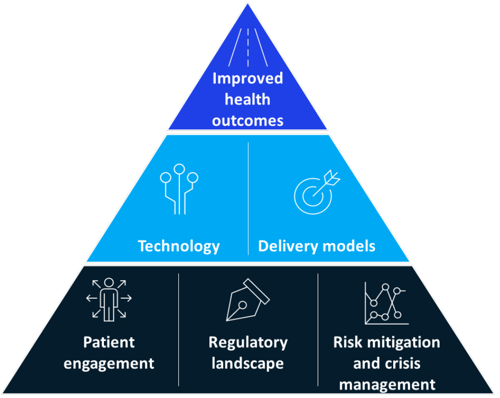

Figure 1: Key global trends influencing digital health innovation

Key global trends are influencing digital health innovation. Shifting patient expectations and evolving regulations, combined with increased demand for crisis management and new technological availability are unlocking improved health outcomes for patients:

- Fragmented experiences are streamlined into seamless journeys yielding patient empowerment, higher efficiency and satisfaction.
- Data flows complement existing health data with patient-generated data.
- Value is attributed creating new forms of business models and spurring innovation and resilience in the health system.

Technological enablement coupled with new delivery models are creating a supply of health innovation to respond to increased demand:

1. *Technology*
   - 1.1 *Automation*: Hardware and software robots transforming care delivery in clinics and hospitals (e.g. surgery) and outside (e.g. companion bots).
   - 1.2 *Data and sensing*: 360° repositories of longitudinal, high "velocity" data for consumers logging data from wearables/implantables, genomics, SDOH, EHR etc.
   - 1.3 *Artificial intelligence*: Meaningful share of current primary care physicians / nurse practitioners duties competently replaced by AI "doctors" available 24x7; artificial intelligence throughout the health journey.
2. *Delivery models*
   - 2.1 *New business models*: New and innovative care and business models, often digitally enabled, evolving across the care continuum (e.g. telehealth, online pharmacies).
   - 2.2 *Ecosystem integration*: Digital ecosystems connecting fragmented health systems into seamless journeys, thereby unlocking new sources of value (e.g. better health outcomes, higher efficiency and satisfaction).

Shifts in demand and regulatory support lay the foundation for innovation in digital health:

3. *Patient engagement*: Tech-savvy population educated on healthcare; knowledgeable and empowered individuals with high expectations.
4. *Regulatory landscape*: Development of the legal basis to implement digital health solutions in national healthcare systems.
5. *Risk mitigation and crisis management*: Comprehensive risk mitigation protocols that leverage data analytics to build and respond to a range of scenarios incl. spread of disease.

2. DEFINITIONS

This section defines the terms relevant in the context of digital healthcare.

Digitalisation describes the automation of processes and business models through networking of information, people and digital technologies (Kruse Brandão & Wolfram, 2018).

Digitalisation in the healthcare system is referred to as *smart health*. Smart health includes all changes and innovations in the field of healthcare and business models as well as increases in efficiency of internal processes and networking of actors by information and communication technology (Bernnat, Blachetta, Greiner & Leppert, 2016, p. 26).

Electronic health (eHealth) is a subfield of smart health. eHealth is a generic term for a broad spectrum of applications supported by information and communication technology. These applications can be used to electronically process information, exchange it via secure data connections as well as support patient care and treatment processes (Federal Ministry of Health, 2020a).

Mobile health (mHealth) is a subfield of eHealth. Wireless and mobile technology such as smartphones and tablets can be used to achieve health objectives (Halber, 2017). In addition, mHealth devices can support the diagnosis and treatment of diseases and perform real-time monitoring (Rossmann & Krömer, 2016).

Information and communication technology (ICT) refers to all technical devices and equipment that can digitally convert, process, store and transmit information (Federal Ministry for Economic Cooperation and Development, 2013).

Big data refers to the processing of large and unstructured amounts of data to gain new insights and connections. Big data exceeds the recording capacities of traditional database systems in terms of data volumes, relationships, processing speed and heterogeneity (Markl et al., 2013).

The *Internet of Things* (IoT) is the combination of increasingly powerful technologies from the fields of communication and information technology as well as microelectronics. This results in a network of connected things (devices). This network creates relationships between people and people, people and things and things among each other. Things, in this context, are physical, electronic and sensory devices as well as other embedded systems (Dodhia, Anudeep, Jain & Shishir, 2018; Kruse Brandão & Wolfram, 2018).

Artificial intelligence (AI) is a branch of computer science and a generic term for methods, algorithms and systems for implementation of intelligent behaviour in a computer system. Artificial intelligence deals with the automation of intelligent behaviour, machine learning and deep learning (Auer, Hollenstein, & Reumann, 2019; Geisberger & Broy, 2012).

Wearables are electronic devices that are attached to the human body and record data such as vital values in real-time via sensors. This data can be sent directly to the smartphone or tablet via Bluetooth (Mischak, 2017; Waldhör, 2018). Examples of wearables are fitness trackers, smart watches, smart headbands, smart glasses, pulse watches, smart tattoos, smart clothes and smart jewellery (Mischak, 2017).

3. GERMAN HEALTHCARE ECOSYSTEM

3.1 Overview

This section introduces the traditional German healthcare system on which the authors focus in this paper. A healthcare system is defined as a system which is responsible for organising, financing and controlling medical healthcare for the population (Schienkiewitz & Walter, 2003, p. 813). The German healthcare system covers the areas of prevention, diagnosis, treatment, rehabilitation and care (Grethler, 2017).

3.2 Structure

The German healthcare system is influenced by the government and market economy. The government provides a legal framework in the form of laws and regulations. The market economy supplies the actors in the healthcare system with healthcare products and services (Grünberg, 2014). In Germany, the healthcare market can be divided into healthcare market I and healthcare market II. Within the framework of traditional healthcare, the healthcare market I comprises products and services that are financed by the social system. Healthcare market II comprises all healthcare-related products and services that are not financed by the social system. Citizens have to pay privately for these products and services (Federal Ministry of Health, 2020b). The traditional healthcare system is located within healthcare market I. For this reason, healthcare market I is the focus of this paper. The structure of the German healthcare system is shown in Figure 2.

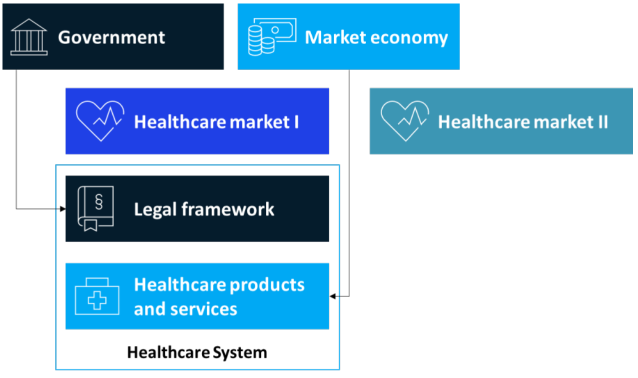

Figure 2: Structure of the German healthcare system

4. TRADITIONAL ECOSYSTEM AND STAKEHOLDERS

The healthcare ecosystem is defined as all actors, their activities and functions, as well as their interactions and interdependencies within the healthcare system. The actors are involved in promoting, maintaining and restoring the health of the population (Nagel, 2007). The healthcare ecosystems consist of different stakeholders. The stakeholders can be divided into four main groups: beneficiaries, healthcare providers, healthcare funders and the government (Penter & Augurzky, 2014).

The German healthcare ecosystem focuses on the beneficiaries. Beneficiaries are primary consumers of health products and services. Healthcare providers supply beneficiaries directly or indirectly with health products and services. The government provides framework conditions and tasks for the healthcare system and the individual actors of the healthcare ecosystem. Healthcare funders assume all or parts of the healthcare costs of the beneficiaries (Federal Ministry of Health, 2020c; Penter & Augurzky, 2014). The four main groups of stakeholders, the subgroups as well as their relationships are shown in Figure 3.

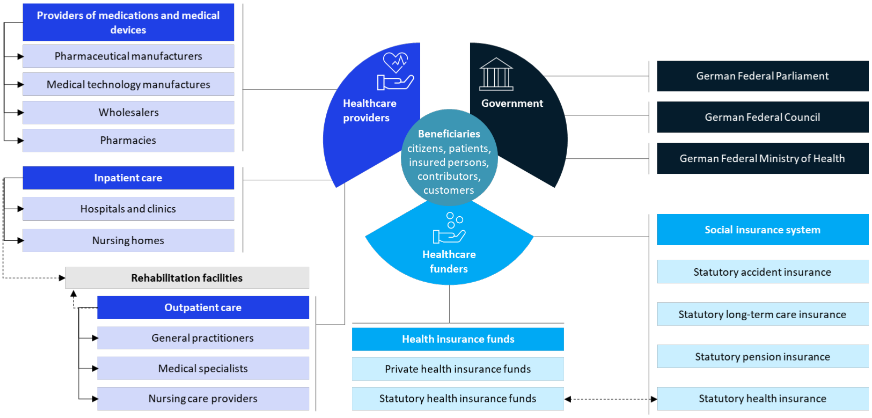

Figure 3: Key stakeholders in the traditional healthcare ecosystem

A beneficiary can be a citizen, patient, insured person, contributor or customer. Citizens are defined as all people who live in Germany with German citizenship. Patients are all persons who receive medical treatment from medical doctors, hospitals or clinics. An insured person can be defined as someone who is insured for social risks by the social insurance system. Contributors are all persons who pay a contribution to health insurance (Penter & Augurzky, 2014). The healthcare system is regulated at federal, state and local levels. The structure and functioning of the healthcare system are determined by legal frameworks. There are also individual legal regulations for the precise control of service offers, demand for services, financial flows and financial resources (Penter & Augurzky, 2014). Based on the supply structure, healthcare providers can be divided into these areas: provider of medication and medical devices, inpatient care and outpatient care (Schwartz et al., 2003). The main funders of the healthcare ecosystem are the social insurance system and health insurance funds.

5. TRENDS AND TECHNOLOGICAL DEVELOPMENTS

5.1 Trends

The observation of trends is important for studying developments of the future healthcare system. The most impactful trends in the healthcare system are the ageing population, individualisation and digitalisation. These trends have an impact on the actions of stakeholder groups and drive changes in the healthcare system (Bernnat et al., 2016).

Due to the constantly ageing population, the requirements in terms of financing and service provision for the German social and health system are increasing (Bernnat et al., 2016). The relative ageing of the German population will continue in the coming years. According to forecasts by the Federal Statistical Office, the proportion of the population over 65 will rise from 21% in 2013 to 33% in 2060 (Pötzsch & Rößger, 2015). This ageing population raises the risk of chronic diseases and multimorbidity, i.e. the simultaneous occurrence of several diseases in one person (Augurzky et al., 2017), and thus health costs. Another point of demographic change is the migration of young and well-educated people from rural areas to conurbations. As a result of this migration, there are fewer patients in rural areas and therefore fewer medical doctors. As a result, the provision of medical care in rural areas is decreasing (Augurzky et al., 2016).

Another trend is the individualisation in the field of healthcare. The involvement of patients in diagnosis, treatment and prevention is increasing. Treatment is created or adapted for the individual person. A trusting and interpersonal relationship between patient and healthcare service providers is becoming increasingly important. Thus, the healthcare system is changing from a traditional system to a joint project involving patients and healthcare service providers (Huber et al., 2015).

Digitalisation is intended to connect actors in the healthcare system (hospitals, doctors' offices, patients' homes etc.) with technical devices (medical devices, medical measuring devices, smartphones etc.) in order to synchronise data. Large amounts of data (big data) can be recorded and analysed by the technical devices. Spatial and temporal separations can also be overcome by digitalisation. This means, for example, that a patient can have a doctor's consultation from home. Processes in healthcare are changing due to digitalisation. As a result, the traditional value chain and business models in the healthcare system are changing (Bernnat et al., 2015 and 2016; Wolff, 2018).

5.2 Technological developments

Technological developments and the application of digitalisation in the healthcare system are ongoing. New technologies and products that change the healthcare system are constantly emerging. Medical and technological innovations in the fields of robotics, sensor technology, nanotechnology and 3D printing are creating new products and processes. Mobile health applications for smartphones and wearables are gaining a foothold in various areas of the healthcare system. Increasing data volumes make evaluations faster and enable vital values in humans to be monitored in real-time (Bernnat et al., 2015 and 2016; Wolff, 2018).

The healthcare system is influenced and changed by IoT. Through IoT, individual areas of the healthcare system are networked with ICT. New technologies and IoT make these areas smarter. Smart health areas include medical technology, pharmaceutics, nanotechnology and biotechnology (Council of Future Bavarian Economy, 2020). New technologies and IoT are changing the way in which patients are diagnosed and treated. Patients are also given the opportunity to participate proactively (Hipp et al., 2017). IoT provides the basis for the development and emergence of smart medical services.

6. FUTURE ECOSYSTEM AND STAKEHOLDERS

The future healthcare ecosystem is characterised by new stakeholders, new technologies, patient centring and greater collaboration between the stakeholders. The traditional healthcare ecosystem must transition to become a smart, servitized and patient-oriented ecosystem. Not all stakeholders in the healthcare ecosystem, however, can adapt immediately to a servitized patient-centred healthcare ecosystem (Hipp et al., 2017; Karpf, 2015).

For this reason, the healthcare ecosystem will transform gradually. The current healthcare ecosystem is changing into a central health platform for digital stakeholder networks. The stakeholders in the current healthcare ecosystem are not effectively connected with each other. The lack of digitalisation leads to less transparency and ambiguous communication and the individual actors thus pursue their own objectives, agendas and perspectives.

A central health platform is being created as an intermediate step for the servitized patient-centred health ecosystem. This platform connects stakeholders digitally via a central point and can reduce health transaction costs as a result (Hipp et al., 2017; Karpf, 2015). An electronic health record (EHR) could function as a digital central point in healthcare.

The next step is the transformation of the central health platform into a patient-centred ecosystem. In a servitized patient-centred ecosystem, not only the patient is connected to the stakeholders, but also the stakeholders with each other. Patients can control the interactions with stakeholders by releasing their own health data. In order to achieve their respective goals, all stakeholders in the healthcare ecosystem need to work actively with patients and other stakeholders. The collaboration of all stakeholders reduces transaction costs in the healthcare system (Hipp et al., 2017; Karpf, 2015). The transformation from the traditional to the future healthcare ecosystem is shown in Figure 4.

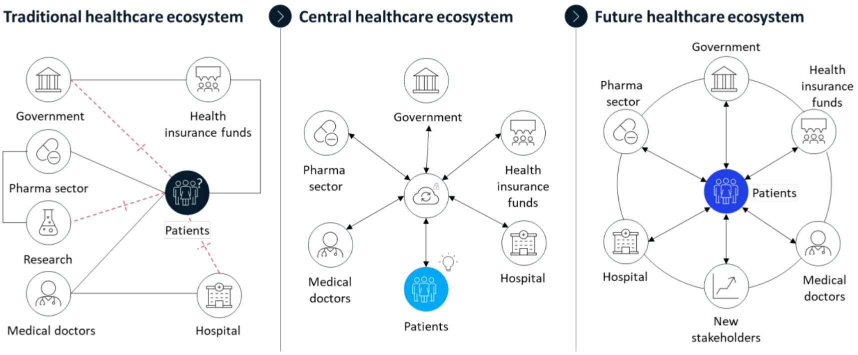

Figure 4: Transformation from the traditional to the future healthcare ecosystem
(similar to Hipp et al. [2017] and Karpf [2015])

In order to apply the benefits of digital medicine and leverage smart care and services efficiently, it is important that all stakeholders take part in the transformation. Rapid transformation is unlikely due to the complexity of the healthcare ecosystem. Long-lasting digitalisation success can only be achieved via the active cooperation of stakeholders as well as the use of new technologies (Hipp et al., 2017).

The transformation from a traditional to a future healthcare ecosystem also changes the roles of traditional stakeholders. Existing stakeholders will concentrate on new patient needs in the future and are currently transforming their old health processes into new and more innovative processes for this reason. By using digital technologies and participating in the cooperation model, stakeholders can develop new servitized business models and growth areas. In addition to the changing roles of traditional stakeholders, new stakeholders could also enter the healthcare ecosystem. They will have the opportunity to develop new servitized offers and business models (Hipp et al., 2017).

Stakeholders in the future healthcare ecosystem include traditional stakeholders such as healthcare providers, government and healthcare funding sources as well as new stakeholders. The integration of biotech and medical technology manufacturers into the healthcare ecosystem is increasing due to research and development with respect to new innovations. Potential new stakeholders in the healthcare ecosystem could include platform and social media providers, smart home providers or providers of hardware and software (Hipp et al., 2017). An overview of the key stakeholders in the future healthcare ecosystem as well as important technologies are shown in Figure 5.

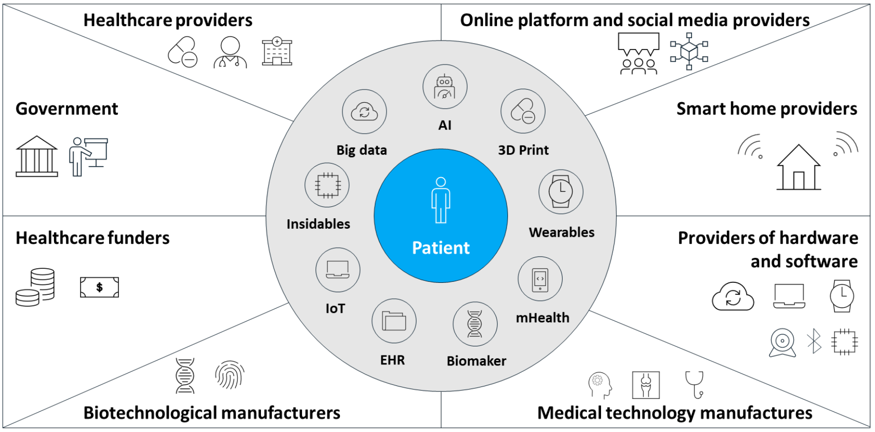

Figure 5: Key stakeholders and technologies in the future healthcare ecosystem (similar to Hipp et al. [2017] and Karpf [2015])

7. IMPLICATIONS TO DRIVE DIGITAL AND SERVITIZED HEALTH

- Top down steering and defining standards by the government accelerates adoption of digital health: Collaboration with the federal government is required to drive a national digital health vision to all states and relevant stakeholders.
- The right regulatory framework supports the adoption and penetration of providers, funders and technology companies: Collaboration with the federal states is needed to build the right mechanisms (e.g. reimbursement processes, incentives and penalties, gamification approach, switch from opt in to opt out system) to encourage adoption.
- A health ecosystem with established standards ensures efficient collaboration of all healthcare stakeholders: Active shaping and management of the digital health ecosystem is vital to address open needs of the national health system, to ensure system interoperability and to provide the foundation for efficient collaboration of all stakeholders.
- An attractive entrepreneurial landscape drives national innovation power: The creation of an attractive environment for healthtech startups (e.g. funding, availability and access of skilled professionals, access to key stakeholders, standardized application programming interfaces) is essential to leverage innovation.

8. CONCLUSION

In summary, the healthcare system of the future becomes more digital and networked. In addition, current trends create a more servitized and patient-centred healthcare system. These changes entail both opportunities and risks for organisations and other stakeholders.

Opportunities exist in terms of improving servitized medical care and cost savings. In addition, personnel can be relieved, and resources saved. Risks are mainly reflected in the legal aspects. There is insufficient data protection and security in many areas of the healthcare system so far. In addition, liability issues relating to damage of people or their possession by new technologies have not been clarified. Furthermore, digitalisation and new technologies may not be accepted by various stakeholders. The acceptance of all stakeholders is important for the implementation of a smart and servitized healthcare ecosystem.

The transformation from a traditional to a smart and servitized health ecosystem can successfully be achieved if stakeholders adapt to new technologies and there is active collaboration. As a result of digitalisation in various sectors of the economy, the healthcare system is forced to adapt to this new world. If the acceptance of all stakeholders is guaranteed and the legal aspects are clarified by the government, a smart and servitized health ecosystem may well emerge in the future.

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AUTHORS

Dr. Kira Rambow-Höschele
School of Computing, Engineering
and Built Environment
Glasgow Caledonian University
Cowcaddens Road, Glasgow G4 0BA, UK
kira.rambow-hoeschele@t-online.de

Dr. Matthias M. Hampel
School of Computing, Engineering
and Built Environment
Glasgow Caledonian University
Cowcaddens Road, Glasgow G4 0BA, UK
matthiasmhampel@gmail.com

Prof. Dr. David K. Harrison
School of Computing, Engineering
and Built Environment
Glasgow Caledonian University
Cowcaddens Road, Glasgow G4 0BA, UK
d.harrison@gcu.ac.uk

Prof. Dr. Bruce M. Wood
School of Computing, Engineering
and Built Environment
Glasgow Caledonian University
Cowcaddens Road, Glasgow G4 0BA, UK
b.wood@gcu.ac.uk

THE EVOGY CASE: ENABLING RESULT-ORIENTED PSS IN THE ENERGY MANAGEMENT OF B2B SMART BUILDING INDUSTRY THROUGH CYBER-PHYSICAL SYSTEMS

Claudio Sassanelli, Tiziano Arriga & Sergio Terzi

ABSTRACT Traditionally, the market of energy in the B2B buildings sector is seen as a 'necessary evil' and not a core activity for building management and maintenance. The state of the art of energy management (EM) using ICT technology in B2B buildings industry is characterized by a traditional monitoring approach which could assess the energy consumption of the building but that cannot manage and act the required action to improve the energy management according to a demand side approach. The aim of this paper is to present an EM model enabling a result-oriented PSS for B2B buildings through Cyber-Physical Systems adoption.

Purpose: The Evogy use case will be presented in this paper. In particular, Simon model will be explained. The idea of Simon is to overcome the traditional monitoring approach, promoting a CPS-based one. Starting from sensors embedded in field and modelling the equipment, this approach is built on a CPS model of equipment useful to simulate and acts in a cyber way to optimize the energy consumption of building. In future researches, its application and testing will be conducted in a residential building.

Design/Methodology/Approach: The research methodology adopted calls out principles from interpretative, interactive and system development traditions, keeping as main reference the design research methodology (DRM) framework. The proposed research methodology is based on three main phases: Observation and conceptualization, Theory Building and Model Development, Validation.

Findings: The Simon model will be defined. First, the main technologies involved in it will be declined. Finally, its orientation to manage systems in multi-site configuration will be shown, with a hierarchical division of the related knowledge into levels.

Originality/Value: Simon model will enable to implement an autonomous control system helping operators in the energy management in a building. Its adoption enables Evogy to aggregate the energy demand coming from the plethora of buildings and, according to CPS and artificial intelligence approach, not only monitoring the consumption but also actuating the equipment. This can be possible thanks to a simulation and an equipment 'cyberization', always considering the constraints from customers such as, for instance, comfort for people in the building. Thanks to this, a result-oriented PSS can be provided thanks to the exploitation of CPS, also avoiding the need of ordinary maintenance on equipment and opening the way to a digital-based predictive maintenance on the real system. Thus, its adoption will bring the company to increase its competitiveness on the national and international market and conquer new customers. Moreover, the company's competence and value will increase on the market due to the increasing competitiveness of Simon. The Simon model can be than expanded and used in other buildings (residentials and tertiary market) and in other industry, creating new business opportunity even on markets which before having difficult to access.

KEYWORDS: Product-Service Systems, Cyber-Physical System, Energy management, result-oriented PSS, Industry 4.0.

1. INTRODUCTION

Nowadays, Product-Service Systems (PSSs) (Goedkoop *et al.*, 1999) and digital technologies, grouped under the umbrella of Industry 4.0 (I4.0) (Roblek, Meško and Krapež, 2016), represent valuable business opportunities to enhance companies' competitiveness (Porter and Heppelmann, 2014; World Economic Forum, 2016; Kowalkowski *et al.*, 2017). From one side, PSSs can enable companies to provide to the customers several types of additional services to be embedded and integrated with the physical product (Tukker, 2004) through a suitable design process (Sassanelli, Pezzotta, *et al.*, 2019). From the other side, digital technologies can play a strategic role in the exploitation of the data and knowledge deriving by the provision of these new services and strengthen the value proposition given by PSSs providers (Coreynen, Matthyssens and Van Bockhaven, 2017; Sassanelli, Rossi, *et al.*, 2019).

However, the employment of such business models and technologies can often meet several hurdles, mainly in the case of SMEs companies (Ambroise *et al.*, 2018). The main barriers against the transition from traditional businesses, based on the design and sale of physical products, to a new business orientation, which comprises an integrated combination of products and services (Neely, 2008; Kowalkowski et al., 2015), were detected in user acceptance and radical shifts in business culture (Schotman, Dina and Ludden, 2014). Financial, organizational and cultural aspects can also contribute to lead companies towards the service paradox (Brax, 2005; Gebauer, Fleisch and Friedli, 2005). Moreover, the lack of adequate technical expertise and specialist knowledge are relevant gaps in the digital technology application domain. Last, a set of boundary issues (e.g. always changing customer expectations, cultural transformation, updated regulations and skills, etc.) contribute to hamper both the servitization and digital transitions (Baines *et al.*, 2007; World Economic Forum, 2016; Pacheco *et al.*, 2019).

Companies managers and government leaders need to manage these challenges to reveal and make exploitable the set of benefits that digital technologies offer to both society and industry. Indeed, to properly support the products upgrade, the processes improvement and the business models adaptation to the digital age, several initiatives have been launched both at Europe and world level. Starting from 2013, have been launched the ICT Innovation for Manufacturing SMEs (I4MS) initiative, followed by the Smart Anything Everywhere (SAE) in 2015 (European Commission, 2018), belonging to the European Commission's Digitising European Industry (DEI) Strategy (European Commission, 2016), and by Digital Transformation of Industries (DTI), a project launched by the World Economic Forum in 2015 (World Economic Forum, 2016). The goal of these actions is to support the growth of Digital Innovation Hubs (DIH) to foster SMEs, start-ups and mid-caps to enhance their products and services through the inclusion of innovative digital technologies: user companies, in particular SMEs and mid-caps, needing both to invest in digital technologies and to include ever more services among their offerings to improve their competitiveness (Davies, 2004), are put in contact with supply companies (owning suitable ICT products helpful to satisfy the needs of the users).

In this context, the adoption of digital technologies fosters the service innovation of manufacturers (Kindström and Kowalkowski, 2009). Through their deployment, companies can easily develop, implement and provide PSSs (especially result-oriented ones), renowned to play a strategic role to strengthen the company competitiveness, prolong the relationship between providers and customers, and shift the owning and operational responsibility of the solution on the provider (Baines *et al.*, 2007; Lerch and Gotsch, 2015).

This paper focuses on a particular industry, the energy management (EM) in B2B smart building, investigating the role of digital technologies in this specific context. Its aim is to present how a new model (named 'Simon The digital energy specialist', developed by an Italian SME, Evogy srl, and facilitated by the Italian Politecnico di Milano DIH) can enable the provision of a result-oriented PSS in the energy and residential sector through the adoption of a set of digital technologies, among which Internet of Things (IoT), Artificial Intelligence (AI) and Cyber-Physical Systems (CPS). The paper is structured as follows. Section 2 introduces the research context, defining the EM industry and declining its application in PSS and I4.0. Section 3 reports a description of the methodology adopted to develop the model, also introducing the use case company. Section 4 explains the main result of the study, i.e. the Simon model, and Section 5 is dedicated to its discussion. Finally, Section 6 concludes the paper, triangulating results with theory and providing further researches and limitations.

2. RESEARCH CONTEXT: ENERGY MANAGEMENT IN PSS AND I4.0 CONTEXTS

In literature, digital technologies' role to ease the service innovation of manufacturers is renowned (Lerch and Gotsch, 2015). In particular, three digital technologies (Internet of things, cloud computing and predictive analytics) have been detected to support knowledge generation, from collection and transmission of data up to storing, aggregation and processing (Ardolino et al., 2016), upon which companies can deploy advanced product-service solutions. Generally, smart technologies enable four different levels of products capabilities (monitoring, control, optimization, autonomy), each one building on the preceding ones (Porter and Heppelmann, 2014), and trigger a wide bundle of services whose delivery is strictly related to the physical products (leading to the provision of new and more efficient result-oriented PSSs) (Gaiardelli *et al.*, 2014).
Traditionally, the market of energy in the buildings and residential sector is seen as a 'necessary evil' and not a core activity for building management and maintenance. The state of the art of EM using ICT technology in the building industry is characterized by a traditional monitoring approach which could assess the energy consumption of the building but that cannot manage and do the required action to improve the EM according to a demand side approach. Therefore, EM context needs a support of digital technologies, especially in residential and B2B civil industry (Francisco, Mohammadi and Taylor, 2020). On one side, the large enterprises are well served since EM is one of the core processes of the company also in terms of cost and criticality on process performances. On the other side, there is a plethora of SMEs in particular in B2B buildings and civil market (real estate, buildings, residential, etc.) in which it is not possible to exploit the competences and the leverage used in the large enterprises. Anyway, due to the high responsibilities of these sectors on the pollution and also to the opportunity to save energy and money optimizing the consumption based on a demand-side management approach, there is the need to optimize the energy consumption in this market (Pierce and Andersson, 2017). Indeed, recent researches demonstrate that relevant energy savings can be registered through the adoption of smart technologies in the B2B buildings and civil industry. It has been proved that energy efficiency from buildings has led to 5-6% reduction of EU energy consumption (European Commission, 2017b, 2017a). The potential of data, made available through I4.0 technologies employment in smart buildings, is strategic to shrink greenhouse gas emission (Zuo *et al.*, 2013). Smart building play a strategic role mainly in energy efficiency improvement (with 60% saving of lighting energy and 5-15% of HVAC energy) (European Commission, 2017b), also contributing to both safety and security efficiency and employee productivity enhancement. In the building industry, an innovative data-driven black box modeling approach (based on a Random Forest model) has been recently proposed to fully exploit smart capabilities (Maccarana et al., 2019): it has been opposed to the standard physical white box modeling approach (relying on the software TERMOLOG).

3. RESEARCH METHODOLOGY AND THE USE CASE

'Simon the digital energy specialist' model is based on the data-driven black box modeling approach (Maccarana et al., 2019). It has been developed by *Evogy srl*, an Italian SME. To boost and accelerate digital technology adoption (of both AI algorithms and the CPS-integrated platform and software), *Evogy srl* collaborates with the Italian *Politecnico di Milano*'s DIH. The research methodology implemented has been structured based on several joint research traditions. Indeed, it calls out principles from interpretative (Williamson, 2002), interactive (Svensson, Ellström and Brulin, 2007) and system development (Nunamaker Jr. and Chen, 1990), keeping as main reference the design research methodology (DRM) framework (Blessing and Chakrabarti, 2009). The proposed research methodology (inspired and based on (Pezzotta et al., 2018; Sassanelli, Pezzotta, et al., 2019)) is based on three main phases: 1. Observation and conceptualization, 2. Theory Building and Model Development, 3. Validation. It guided the authors to conceptualize and develop the SIMON model in order to enable the provision of result-oriented-PSS in the B2B smart building industry through the embedding of digital technologies. In particular, Evogy srl is an Italian SME, specializing in EM. Through the use of an EMS (Energy Management System) platform based on IoT/AI technology, Evogy provides solutions and services aimed at the management and optimization of energy consumption for Customers of the Industry 4.0 market, smart buildings and the multisite Retail market. The customers are different: from large enterprises, who consider EM a core process, up to SMEs that in particular in B2B building civil market (real estate, buildings, residentials, etc.) are not able to exploit the competences and the leverage used in the large enterprises. This issue, especially coming from SMEs belonging to the B2B buildings and civil industry, together with results of both state of the art and practice, pushed *Evogy srl* to the development of SIMON model and the introduction of ICT technologies support. The third phase, validation, has been conducted in a building of a highly specialized hospital group in Milan area. However, so far in this application case, even though the full Simon infrastructure has been installed in the building, only the monitoring and analysis services for efficiency measures have been implemented. The next step will be the switch to the remote control level of the entire building through the centralized EMS platform (that is already enabled through the Simon model thanks to the IoT infrastructure but still not used).

4. RESULTS: THE SIMON MODEL

This section is aimed at presenting 'SIMON The digital energy specialist' (from now on Simon). Its idea is inspired by a butler who helps in the efficient and optimized management of a system (in this specific case, energy management of B2B smart buildings). Within SIMON model, three main technologies (IoT, CPS and AI) have been considered, systematized and embedded (see Figure 1):

1. Simon on the field (IoT systems embedded on the existing devices): a control board gathers data coming from a supporting data metering and transmission infrastructure (i.e. co-generator, sensors and field meters, photovoltaic (PV) systems, PLC, Building Management System). Indeed, it is necessary to equip with sensors and hardware the building plants in order to activate the required action to optimize the global EM portfolio;
2. Simon Lab (directly linked to the CPS of the equipment/buildings controlled): it includes also the simulation of the building, to take into account customer constraints such as people comfort in the environment;
3. AI: algorithms interacting with the Simon Lab to capture and replicate the operators' competence to optimize the EM.

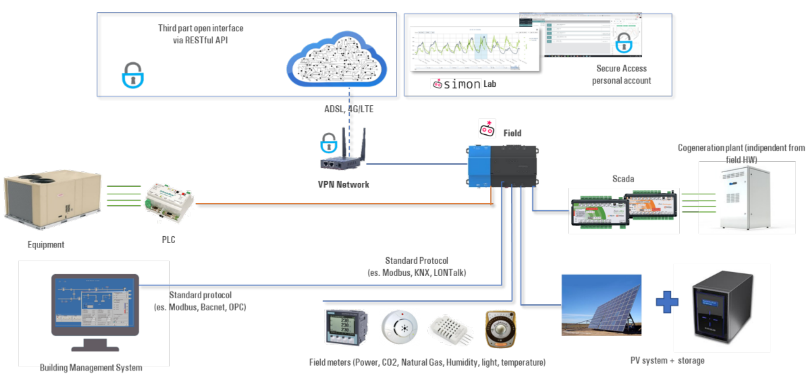

Figure 1: SIMON model, the functional scheme

Simon is organized into hierarchical levels to manage systems in multi-site configuration:

1. "Project" layer: the most aggregate level of information display. The human-machine interface is particularly important since this is the presentation layer of the aggregate consumption;
2. "Plant" layer: individual site or plant level;

3. “Device" layer: in this level it is represented the CPS, being possible to log into a virtual representation of each single component of the system.;
4. “Data-point" layer: single elementary information level (e.g. multi-meter consumption value, set-point, alarm);
5. “Security" layer: this layer is responsible for data security.

Each layer is characterized by specific features and mutually contribute to each of them:

1. the plants geolocation on maps with digitized building planimetry;
2. a customized dashboard with graphic widgets that can display KPIs, Energy Performance Indicators (EnPIs) or other aggregation layers of the obtained information;
3. reports creation (on demand and/or with time planning) based on the user's template;
4. alarm management with trigger and notification rules based on role/user;
5. commands in ON/OFF or set point format, persistent or with duration according to CPS signals;
6. commands in single and aggregate form (per plant areas, areas or floors), with and without time schedules and management of exceptional events;
7. advanced data analysis and model construction (consumption, forecasting based on CPS model) to optimize the plant management and consumption/expense balance by referring to a baseline agreed and loaded on the platform;
8. Demand Response mode for balance grid congestion and electricity network services. It consists in creating real VPPs (Virtual Power Pools) of plants that, individually, could not participate in the electricity services market, but which, aggregated in clusters, can be used to intercept economic advantages both in terms of power (i.e. incentives for the capacity made available) and of energy (i.e. power supplied in the period of time necessary to solve network’s critical issues). The aggregation function takes advantage of the regulatory changes introduced in Italy by the energy authority (*Autorità di Regolazione per Energia Reti e Ambiente- ARERA*) and implemented by the operator of the electricity transmission grid (*Terna spa*).

Table 1 enlightens the connections among Simon’s layers and the features characterizing them:

Table 1. Simon’s layers and related characterizing features

Features / Layer	Plant geolocation	Dashboard with graphic widgets	Reports creation	Alarm management	Sending of commands	Commands in single and aggregate formats	Advanced data analytics and model construction	Grid congestion and electricity network services
Project		X	X	X		X	X	X
Plant	X	X	X	X	X	X	X	X
Device		X	X	X	X	X	X	X
Data-point		X	X	X	X			
Security		X		X				

Moreover, in Table 2 each service provided through the Simon solution, enabled by the functionalities detected above, has been declined and linked to:

- the type of I4.0 technology (Rüßmann et al., 2015) used (IoT, AI, CPS);
- the smart capability enabled (monitoring, control, optimization, autonomy) (Porter and Heppelmann, 2014);
- to the type of PSS enabled (product-, use-, result-oriented) (Tukker, 2004);

  the benefits obtained through the specific service provided per each stakeholder (customer, PSS provider, TSO).

Indeed, Simon includes several services, e.g. the modelling and design of the building technological infrastructure, the installation of the required technologies up to the pro-active management of the building based on the data gathered and processed.

Table 2. Digital technologies-based services: benefits for customer, service provider and TSO

Service delivered	Digital technology used			Smart capability enabled	Type of PSS enabled	Benefits for customer	Benefit for service provider	Benefits for Transmission System Operator (TSO)
	IoT	AI	CPS					
Consultancy on the modelling and design of the building infrastructure	-	-	-	-	Product-oriented	- Customized design of the system - Digitized building planimetry (CAD).	Complete knowledge of the building and of the system to be installed (BIM).	-
Installation/start-up and commissioning of the required technologies	X	-	X	-	Product-oriented	System installed and kick-off.	- Complete understanding of plants' issues; - Virtualization of the physical plants and and virtual test of different models; - Availability of data for simulation analysis.	-
Plant geolocation	X	-	-	Monitoring	Product-oriented	Ease of geolocation in particular for multi-site plants.	Database of both projects and plants for remote monitoring of internal and external conditions.	Detection and mapping of existing plant for VPP definition and creation.
Diagnosis & reporting: dashboard and graphic features	X	X	X	Monitoring	Product-oriented	Customized KPIs, EnPIs and reports.	Continuous monitoring of the systems.	-
Help desk for product, process and business	X	-	X	Monitoring	Product-oriented	Remote and/or on-site assistance based on the gathered data.	Possibility to optimize assistance based on data gathered.	-
Updates/upgrades of HW and SW	X	X	-	Control	- Product-oriented - Result-oriented	Always updated EM system.	Possibility to upgrade the system based on the system monitoring leading to an easier achievement of target consumption results on contracts.	Possibility to activate Demand Response mode of plants thanks to updated/upgraded HW and SW.
Remote control from centralized platform	X	-	X	Control	- Product-oriented - Result-oriented	- Personalization of the user experience and of the comfort level; - Plants control.	- Remote control of system functions and reduced on-site interventions; - Plant dynamic set-up.	-
Alarm management and sending of commands in single and aggregate formats	X	X	X	Control	- Product-oriented - Result-oriented	- Enabling of predictive diagnostics, service and repair; - System performances enhancement; - Plants shut-down avoidance; - Building environment discomfort avoidance.	- Reduced maintenance/control interventions on-site; - Preventive maintenance.	-
Advanced data analytics and model construction and autonomous remote control of the entire building	X	X	X	Autonomy	Result-oriented	- Autonomous improvement of consumption and of the performance of energy systems; - Autonomous system personalization.	- Ordinary maintenance avoidance; - Knowledge of the entire operative life of the system; - Self-diagnosis and service; - Autonomous product operation; - Self-coordination of operation with other products and systems.	Real-time monitoring and possibility to activate Demand Response mode: dynamic plant management as a function of the electric grid balancing needs.
Demand Response mode for balanced grid congestion and electricity network services	X	X	X	Autonomy	Result-oriented	- Effective/efficient EM. - Possibility of creating real VPPs (Virtual Power Pools) of plants, to participate in the electricity services market and to intercept economic advantages both in terms of power and of energy.	Easier achievement of target consumption results on contracts.	- Balanced grid congestion; - Power and energy provision through VPPs in a dynamic economic way.

5. DISCUSSION

Depending on the customer needs and requests, Simon can provide different set of services and, from a PSS perspective, can be either a product-based PSS or a functional-based pay-per-result solution, providing its customer with complete *in-situ* tailored services.

Indeed, as shown in Table 2, five services are categorized as product-oriented, three can be provided either as product- or result-oriented, and the last two result-oriented. The shift from product- to result-oriented is driven by a rise of smart capabilities (from their lack, through monitoring, up to autonomy), an always higher employment of digital technologies used for their delivery and more benefits brought to the three main stakeholder involved (customer, provider and TSO).

In detail, looking at product-oriented services, the first two services in Table 2 (consultancy on the modelling and design of the building infrastructure; installation/start-up and commissioning of the required technologies) can be considered pure product-oriented. They require a minimum use of digital technologies, do not enable any smart capability and bring few benefits only to the customer and provider of the PSS.

Other three services (Plant geolocation; Diagnosis & reporting: dashboard and graphic features; Help desk for product, process and business) can be included in the product-oriented context and are characterized by monitoring smart capabilities. In this case, it can be seen a first involvement of AI and an indirect benefit also for the TSO.

There are three services, mainly playing a monitoring smart function, that are product-oriented but can converge to the result-oriented dimension (updates/upgrades of HW and SW; remote control from centralized platform; alarm management and sending of commands in single and aggregate formats). Indeed, all of these services can either be delivered as simple add-on services of the physical product or can also contribute to the achievement of the results targeted on the contract of the result-oriented PSS. Their delivery requires a strong use of AI and directly activate the TSO's involvement.

Finally, the last two services in Table 2 are pure result-oriented (Advanced data analytics and model construction and autonomous remote control of the entire building; Demand Response mode for balanced grid congestion and electricity network services). They require a full adoption of the three digital technologies and provide benefits to all the stakeholders of the PSS solution in a dynamic way.

Indeed, through CPS- and AI-based approach, Simon not only monitors the consumption but also actuates the equipment. This can be possible thanks to a simulation and an equipment 'cyberization', always considering the customers conditions constraints (e.g. comfort for people in the building). Thanks to this, a result-oriented PSS can be provided, avoiding for the PSS provider the need of ordinary maintenance on equipment and opening the way to a digital-based predictive maintenance on the real system. Its adoption will bring the provider to increase its competitiveness on the national and international market and conquer new customers. Moreover, the company's competence and value will increase on the market due to the increasing competitiveness of the EMS (the Simon platform). This is also translated on one side, for the PSS provider, in a better maintenance (preventive with less machine downtime and reduced costs), a reduced environmental impact and an easier achievement of target consumption results on contracts (of the result-oriented PSS). On the other side, for the customer, in a reduction of energy consumption, saving of money and an enhanced customer comfort. Finally, from the TSO perspective, the Demand Response mode gives the opportunity to detect and map existing plants and to manage their power and energy in an efficient and effective dynamic way through the creation of VPP of plants.

6. CONCLUSION

This paper has been aimed at presenting the SIMON model, enabling an Italian SME, *Evogy srl*, to provide a result-oriented PSS for the EM of B2B smart buildings through the adoption of digital technologies (IOT, CPS and AI). The research method adopted was designed with the intention of building the model consistently to the related industry, EM in B2B smart building industry, adopting an interpretative, interactive and system development based research approach, conducted in a DIH environment to boost its digital potentialities.

Several results have been presented. From a theoretical point of view, several aspect have been presented. First, the Simon model has been proposed, declining the main technologies involved in it to implement a digital EMS. Second, its structure has been shown, highlighting its orientation to manage systems in multi-site configuration, being characterized by a hierarchical division of the related knowledge into levels. Finally, the functionalities of the model and the services enabled by its use have been discussed. Per each service enabled, several factors have been assessed and linked: the type of technology used, the smart capability enabled, the type of PSS enabled, the benefits obtained through the specific service provided per each stakeholder (customer, PSS provider, TSO).

From a practical perspective, generally speaking, benefits provided by Simon to its stakeholders (mainly customers, provider, TSO) can be summarized in four categories: cost reduction, reduced environmental impact, enhanced customer's comfort, improvement of maintenance (that becomes predictive and brings to a reduction of machines downtime and maintenance costs). In addition, the demand response mode can be activated to balance the electricity grid and create electricity network services through dynamic VPPs of plants. Indeed, this research wants to demonstrate that digital technologies enable and foster the product-service solution provision (especially result-oriented ones), leading to a set of benefits for all the stakeholders involved.

Finally, it must be said that the SIMON model has huge potentialities and can be expanded and used in different types of buildings and industries, creating new business opportunities. Some important considerations in this wider application to new contexts should be done about the current and future skills required and level of human-machine interaction. The application of SIMON can be replicated mainly in three contexts:

(i) residential area in which energy represents a cost and there is also an increasing pressure on sustainability,
(ii) tertiary sector which can gain the benefit of this solution and optimize also the building management thanks to a CPS approach,
(iii) companies (SMEs and large enterprises) which could apply the same infrastructure to improve also the employee satisfaction and the work environment and comfort.

The next step of this research will be the model validation in a building of a highly specialized hospital group in Milan area. Not only monitoring and analysis services will be delivered but also the remote control of the entire building through the centralized EMS platform (that is already enabled through the Simon model thanks to the IoT infrastructure but still not used) will be implemented.

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AUTHORS

Claudio Sassanelli
Department of Management Economics and Industrial Engineering, Politecnico di Milano, Milan (MI), Italy, 20133
+393491757459, claudio.sassanelli@polimi.it

Prof. Sergio Terzi
Department of Management Economics and Industrial Engineering, Politecnico di Milano, Milan (MI), Italy, 20133
+390223992803, sergio.terzi@polimi.it

Tiziano Arriga
Evogy srl, Seriate (BS), Italy, 24068
+393299016361, Tiziano.arriga@evogy.it

A MATURITY MODEL FOR DIGITAL SERVITIZATION: THE CASE OF AUTONOMOUS SOLUTIONS

Linus Thomson, Anmar Kamalaldin, David Sjödin, & Vinit Parida

RESEARCH MOTIVATION

Digital technologies introduced under the fourth industrial revolution (industry 4.0), including the internet of things (IoT), cloud computing, big data analytics, and artificial intelligence (AI), are driving the development of cyber-physical systems that integrate physical and computational elements to deliver higher levels of operational capability. An example of a cyber-physical system are autonomous vehicles, which integrate a wide array of sensors and digital technologies to enable autonomous operation. This leads to significant benefits, such as improved efficiency, productivity, safety, and sustainability (Parida et al., 2019). The perceived gains related to digital technologies have enabled manufacturers to transform from being product providers to autonomous solution providers (Hasselblatt, et al., 2018; Kohtamäki et al., 2019), where the provider takes on larger responsibility for the core operational processes of its industrial customer (Lerch & Gotsch, 2015). This transformation is referred to as 'digital servitization', which is "a large scale transformation in processes, capabilities, and offerings within industrial firms and their associated ecosystems to progressively create, deliver, and capture increased service value arising from a broad range of enabling digital technologies" (Sjödin et al., 2020).

Digital servitization literature considers autonomous solutions as the most advanced form of digital servitization capability, starting with remote monitoring, then control and optimization, before reaching autonomous solutions (Kohtamäki et al., 2019). However, autonomous solutions have mostly been treated at an abstract conceptualization, leading to confusion and lack of clarity when referencing autonomous solutions in digital servitization literature. More importantly, current literature provides limited guidance to equipment providers that intend to undertake a transformation from being simple digital service providers to become full-scale autonomous solution providers. We identify that transformation towards fully autonomous operation requires a multi-level analysis of complex interplay between the technical system evolution, ecosystem configuration, and business model design, which is lacking in existing literature.

To this background, the present study aims *to develop a maturity model that guides equipment manufacturers in the development of autonomous solutions*. The model considers the aspects of technical system evolution, ecosystem configuration, and business model design. The research is based on exploratory multiple case study (Yin, 2019) of four large industrial equipment manufacturers and their extended ecosystems. Data collection is mainly based on 38 semi-structured interviews with informants from the four equipment manufacturers as well as other actors in their ecosystems (e.g. distributors, technology partners, sub-suppliers, customers). In terms of data analysis, data was coded into first-order concepts, which were then clustered into second-order themes, and these were then congregated into aggregate dimensions that represent a higher level of abstraction (Gioia et al., 2013).

CONTRIBUTION TO THEORY AND PRACTICE

The study finds that autonomous solutions, including operations with no human operator, tend to take place only in small compartmentalized areas of operations, with little or no wider process integration. To enable the systemic improvements in efficiency and effectiveness to be obtained, fully integrated site-wide autonomous solutions are needed, rather than fragmented 'islands of automation'. However, full-scale autonomous site solutions are challenging to offer, with mixed equipment fleets, autonomous and non-autonomous interactions, and human safety concerns to manage. This highlights that the challenges in providing autonomous site solutions extend beyond the technological aspect to include the need for ecosystem reconfiguration and change in business model design. Therefore, the greater the maturity level of an autonomous solution, the more complex it is for an equipment manufacturer to manage its provision. The preliminary findings confirm that equipment manufacturer need to consider the three attributes (technical system evolution, ecosystem configuration, and business model design) for a successful provision of autonomous site solutions. The findings are synthesized in a three-stage maturity model (including sub-activities) that describes the evolution of the three attributes across the three maturity levels (please refer to the poster).

The study contributes to the emerging literature on digital servitization by focusing on exploring the context of autonomous solutions, which has been understudied. The study offers a preliminary insight about a maturity model that describes the interplay and complementarity of technology, ecosystem configuration, and business model design. In terms of practical implication, the model can be used as a roadmap for equipment manufacturers seeking to provide autonomous solutions to their industrial customers, as it suggests activities that can be undertaken to advance solution maturity.

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AUTHOR CONTACT DETAILS

- **Linus Thomson**, PhD Candidate, Luleå University of Technology, linus.thomson@ltu.se
- **Anmar Kamalaldin**, PhD Candidate, Luleå University of Technology, anmar.kamalaldin@ltu.se
- **Vinit Parida**, Professor, Luleå University of Technology, vinit.parida@ltu.se

- **David Sjödin**, Associate Professor, Luleå University of Technology, david.sjodin@ltu.se

PRELIMINARY RESULTS OF THE SUCCESSFUL COMMERCIALISATION OF A DIGITAL TWIN IN AN INDUSTRIAL PRODUCT SERVICE SYSTEM

Oliver Stoll, Shaun West, Prof. David K Harrison & Fintan J Corcoran

RESEARCH MOTIVATION

The purpose of this executive paper is to describe the design, development, and commercialization of a digital twin in an industrial product-service system (IPSS) based on a real case. The case is based within the context of a Swiss firm that has developed and commercialized a Smart Service based on digital twins. 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, the investigation of this case 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 Service-Dominant (SD) Logic assisted or hindered the co-development and delivery of Smart Services.

Industry 4.0 and the internet of things (IoT) is enabling manufacturing firms and system integrators to offer new value propositions to their customers (Sala et al. 2017). Anderson and Narus (1998), stated 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 (Sagiroglu and Sinanc 2013). One way to seize the opportunities of data insights is the Digital Twin (Barbieri et al. 2019). Digital Twins are, in general, a digital representation of a physical object or a process (Bolton et al. 2018), providing a link between the virtual and the physical (Barbieri et al. 2019). The investigation of the Digital Twin concept focuses mainly on monitoring and some maintenance services but very little on the overall PSS (Zhang et al. 2019). There has been a step-change with digitally enabled servitization (Paschou et al. 2020), and the emerging digital capabilities of original equipment manufacturers (OEMs) leads to an increased opportunity to develop smart services, and this has been confirmed by Kohtamäki et al. (2019). West, Gaiardelli, and Rapaccini (2018) assessed the smartness of services using SD logic premises by analyzing the service ecosystem, the service platform and the value co-creation. The use of SD logic supports the value discovery described by Anderson (Anderson and Narus 1998).

CONTRIBUTION TO THEORY AND PRACTICE

The digital twin developed monitors the Heating, Cooling and Air Ventilation (HVAC) system in a server room. Monitoring the HVAC system enables the firm to respond to failures of the system faster than without the monitoring system. The data collected is used to analyze the performance of the HVAC system and therefore contribute to the compliance requirements of the customer. The monitoring and alarming system provided by the digital twin is connected to a process support application which helps the maintenance and service engineers make better decisions during a failure aiming to reduce the meantime to repair of the equipment. The reduction of the meantime to repair adds to hey higher availability of the HVAC system. With the digital twin, the Swiss firm can guarantee 99.995 per cent of availability for the operational conditions needed by the servers. The revenue model is based, to some degree, on pay per use and outcome (availability) of the system.

The starting point was the development road map provided by the firm. The development road map consists of five stages. Stage 1 motivation: This stage aimed to gain an understanding of digitalization within the business context of the firm. Stage 2 Understand and ideate: in this stage, the firm tries to comprehend the system of processes and assets and people to understand the value. Stage 3 solution evaluation: this was used to narrow down which use case should be further developed into solutions. Stage 4 development of a sales road map: the road map contains activities to develop and sell the smart service. Stage 5 commercialization: develop pricing models for value sharing and design of a sales per process for value co-creation.

The concept of SD logic helped to describe and develop the complex value propositions that unfolded when taking a broader IPSS perspective in combination with open innovation and co-development. During the motivation phase, the concept of SD logic was used by management to create the foundation to understand value co-creation. Building this understanding for individuals who did not know about SD logic proved to be complicated. Particularly in the commercialization phase of the firm, people without this knowledge could not grasp the value of the Smart Service offerings. Traditional value assessment methods of procurement were not able to cope with the SDL value propositions, and the firm had to translate the value propositions to meet procurement guidelines, which lost some of the value from the propositions. 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 SD Logic and to develop new methods to operationalize SD Logic.

KEY DISCUSSION POINTS

- The paper describes the successful commercialization of digital twin technologies in IPSS.
- The development process is described in a five-step model.
- The use of SD Logic (value in use and value co-creation) supported the value discovery phase.

AUTHOR CONTACT DETAILS

Oliver Stoll (oliver.stoll@hslu.ch), Lucerne University of Applied Sciences and Arts
Shaun West (shaun.west@hslu.ch), Lucerne University of Applied Sciences and Arts
Prof. David K Harrison (D.K.Harrison@gcu.ac.uk), Glasgow Caledonian University
Fintan J Corcoran (fintan.corcoran@mebag-services.ch), Mebag, Planungs- und Bauträger AG

LINK TO REFERENCES

https://www.researchgate.net/publication/341050781_THE_SUCCESSFUL_COMMERCIALISATION_OF_A_DIGITAL_TWIN_IN_AN_INDUSTRIAL_PRODUCT_SERVICE_SYSTEM

USING DIGITAL TWIN FOR A BETTER UNDERSTANDING OF SERVITIZATION DYNAMICS

Raphael Wasserbaur, Andreas Schroeder, Ahmad Beltagui

RESEARCH MOTIVATION

There is a need for systems thinking in servitization. Servitizing manufacturers face multiple changes and developments, on the operational as well as the strategic level. This paper argues that simulation modelling tools can support the management of servitization. Further, it argues that an enhanced understanding of the simulation tools can help to derive more value from the information technology (i.e. digital twin (DT)) that is often employed to support the servitization process.

In servitization, DTs are understood as virtual reflections of product-service systems that combine the three levels of data, analytics and knowledge (GE, 2019). The data level is typically a data model comprising sensor data that reflects the state of the product-service system (PSS). The analytics level consists of the various models that provide various insights regarding performance and failure prediction, etc; the models are continuously updated according to the data. The knowledge level comprises of the learnings that accumulate, resulting in improvements of diagnostics and prognostics, understanding root causes of issues and overall improvements of efficiencies and productivity (Sturrock, 2019). The DT's core contribution is real-time data collection from assets in-use which creates the potential to explore the servitization dynamics.

Servitization implies dynamics at multiple levels. It creates a change and continuous refinement in organisational processes as well as interactions between constituent parts of the service delivery system. Simulation modelling can be used to better understand, predict and manage dynamic systems and contributes to the analytics of a DT.

In the field of operations management different simulation modelling paradigms are considered which are based on different principles and are apt to model different kinds of dynamics. System Dynamics (SD) uses stocks, flows and feedback loops to abstract from events and entities and study a system's behaviour over time. Discrete-event simulation (DES) models systems as flowcharts in which entities and resources flow through queues, delays, etc. Time and objects are discrete. DES and SD focus on the global system behaviour. In contrast, agent-based simulation (ABS) models are based on the interactions of single system components which have their own properties and set of rules determining the behaviour. The system behaviour emerges through the interactions of the agents.

While all three simulation paradigms have been used in a servitization context, it is not yet clear what their differential contributions are for understanding the servitization dynamics that characterise the servitization context and how they can help to make use of the potential the DT technology offers.

First, this study carefully explores these simulation modelling approaches and provides a literature review on their use in the servitization context. Second, the study draws on the case of a boiler manufacturer conceptualizing a DT to support its 'Heat as a Service' (HaaS) advanced service value proposition to explore the opportunities and limitations the specific simulation paradigms provide for the underlying servitization dynamics. Third, the study concludes by examining a DT proof of concept that supports the particular HaaS value propositions including a simulation model developed in collaboration with the manufacturer.

CONTRIBUTION TO THEORY AND PRACTICE

The three simulation modelling approaches SD, DES and ABS were used in a hybrid to better understand the servitization challenges the case company is facing.

ABS was used to model the engineers' daily activities ranging from idling, traveling to customer sites and back, diagnosing failures, and repairing. The heterogeneity of engineers is reflected by level of experience. This allowed to analyse the changes that the engineers face through a service-based offering like HaaS, in addition to after-sales services.

The DES was used to model the repair process. The process steps range from a customer's repair request, processing the request, allocating an engineer for the repair job, the engineer servicing the boiler, and once the boiler is fixed the process ends. The model allows to see how changes in the repair process, for example remote fixes through smart appliances, affect the overall service performance.

The SD model was used to model long-term effects. Central to the DT concept is the collection of data. It is assumed that through data collection and data analysis the maintenance processes can be improved such that average time to repair and the need for engineers can be reduced. This is a relatively slow process as it progresses with failures and their analysis and boilers are a long-lasting appliance, many with lifespans beyond 10 years. This model allowed to link daily operations with long-term developments. It supports the boiler manufacturer in understanding market dynamics, and how they can create a business case for a service-based offering, which is fairly new to the organisation.

The main theoretical contribution is a framework explaining how simulation modelling can help the dynamics of servitization. In a hybrid model three modelling approaches are interlinked, which allows simultaneous analysis of the system on multiple levels.

For practitioners, the paper offers practical guidance for building a decision support system that can support the manufacturer's servitization efforts. Both, operational and strategic considerations can be tested with this hybrid model.

KEY DISCUSSION POINTS

- How can companies use simulation methods to systematically plan and manage their servitization transformation?
- How can these simulation methods be integrated in order to develop a holistic understanding of servitization which reflects the interdependence between operational and strategic considerations?
- How can companies make systematic decisions about the different data and analytical processes required to develop a suitable advanced services digital twin?

AUTHOR CONTACT DETAILS

Raphael Wasserbaur (Raphael.wasserbaur@liu.se) Division of Environmental Technology and Management, Department of Management and Engineering, Linköping University, Sweden.
Andreas Schroeder, Advanced Services Group, Aston University, United Kingdom
Ahmad Beltagui, Advanced Services Group, Aston University, United Kingdom

SERVITIZATION OF SMALL- AND MEDIUM SIZED MANUFACTURERS: A TAXONOMY OF INDUSTRIAL PRODUCT-SERVICE SYSTEMS

Alexander Michalik, Frederik Möller, Michael Henke

RESEARCH MOTIVATION

In view of globalized markets, manufacturers face the transition from a conventional business model to a solution provider. The resulting development of industrial product service systems (IPSS) is a major differentiator in the manufacturing sector. Nevertheless, many companies struggle to evaluate their own IPSS portfolio and to identify the effort and complexity of advanced IPSS. That is particularly critical in small and medium-sized enterprises (SMEs), as they have limited resources and usually lack a sustainable and comprehensive servitization strategy. Furthermore, the literature barely addresses the digital and socio-technical perspectives of such a transformation, which further increases the hurdles for SMEs. The application of taxonomies is useful to make complex domains accessible to practitioners by classifying objects and deconstructing them into dimensions and characteristics, which can also be beneficial to SMEs in servitization. Thus, a taxonomy assists in the initiation of transformation by enabling manufacturers to classify their actual and intended product-service-portfolios within the IPSS continuum. Yet, in this context, there is a lack of taxonomies explicitly addressing SMEs. Hence, the authors propose an empirically derived and socio-technical based taxonomy that classifies IPSS to support SMEs in their servitization process. The development of the proposed taxonomy considers both small and medium-sized as well as large companies in order to provide the broadest possible coverage in the manufacturing sector. Therefore, SMEs can locate themselves within the new taxonomy and obtain a clearer understanding of their current and intended IPSS portfolio. Hence, this study stresses two research questions: **RQ1)** *What are the dimensions and characteristics of a taxonomy for IPSS to support SMEs in servitization?* Furthermore, the authors utilize a database, which provides financial and organizational information about the manufacturers. Accordingly, the paper discuss a second research question: **RQ2)** *Are there typical IPSS configurations and do they affect the financial success?* Addressing these questions with the help of a socio-technical taxonomy identifies further research needs and provides practical implications.

RESEARCH METHODLOGY

The research methodology follows the Design Science Research (DSR) approach by Peffers et al. (2006). The state of the art regarding taxonomies in the servitization and IPSS field is examined. The authors conclude that there is a need for research on a taxonomy that enables SMEs to identify their IPSS in a socio-technical manner and thus to derive the required steps for more complex IPSS. For taxonomy development and evaluation the authors follow the guidelines by Nickerson et al. (2013), which describe an iterative process for systematic development of taxonomies. Therefore, the authors first provide a conceptual model, which is then further developed iteratively and empirically. The database DAFNE provides annual financial reports of approximately 1,000,000 German companies and is used for the empirical analysis. Then, manufacturing enterprises are analyzed based on their web presence. The authors consider this approach to be target-oriented, as companies tend to present their offerings transparently. The analysis considers both, SMEs and large manufacturers: Firstly, this enables a broader coverage of the IPSS continuum in the manufacturing sector. Secondly, a comparison between the IPSS portfolio and financial indicators is thus possible. This provides new insights into the extent to which service components could have a financial impact for SMEs and how significantly the much-described differences between SME and large manufacturers actually affect the IPSS portfolio. Finally, this allows a concretization for further research needs.

CONTRIBUTION TO THEORY AND PRACTICE

Current literature identifies numerous research opportunities, including new approaches to service strategies and decision support systems. Further, there is a lack of research on the interplay between strategic, structural and business-oriented approaches. The proposed study addresses the research gap that SMEs are still insufficiently covered. The authors propose an empirically based taxonomy that covers nearly the entire IPSS continuum of manufacturing companies in Germany. Thus, this paper lays the foundation for a feasible analysis method of IPSS in SMEs and has the potential to narrow the outlined research gaps. The extensive insight into the IPSS continuum of manufacturers and the link to financial indicators will form the basis for further research work and new management approaches for sustainable servitization strategies.

INTERIM RESULTS AND FUTURE WORK

At the actual stage of development, the taxonomy is based on thirty SMEs. The interim findings show that further iterations with large manufacturers are necessary to cover a broad IPSS continuum and to ensure that the taxonomy is comprehensive. This is because only few SMEs can be identified offering advanced services such as remote diagnosis, predictive analytics or web-based self-services. Due to the limited space available, table 1 only shows the current (sub-) dimensions that can be defined by individual characteristics.

D	Human		Technological			Organisational			Informational		
SD	Function	Competences	Data generation	Type of data connection	Complexity / Effort	Initiator	Activities during the life cycle	Relation of products and services	Connectivity	Degree of automation	Extend of collecting relevant data

Table 1 Dimensions (D) and sub-dimensions (SD) of the taxonomy

With regard to the IPSS-classification, the results indicate a separation between "conventional" and "modern" manufacturers: Based on financial data and according to the latest results, the authors conclude that "modern" SMEs generate up to 20% higher total turnover than “traditional” competitors do (figure 1).

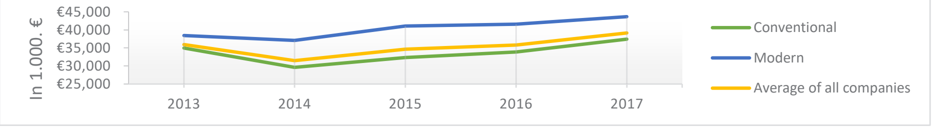

Figure 1 Average annual turnover – “conventional” vs. “modern” PSS-portfolio of manufacturers (n=30)

Although this first evidence suggests that the taxonomy is suitable for classification purposes and some preliminary findings regarding financial performance are emerging, further manufacturers need to be investigated in order to increase the data basis. Furthermore, these results do not provide insight into pure industrial service turnover, which is commonly applied as an indicator of servitization. Nevertheless, the data suggest that with advanced services, a higher turnover is feasible. In order to generate significant results, the number of screened manufacturers needs to be increased, which also further improves the taxonomy.

KEY DISCUSSION POINTS

- What are the dimensions and characteristics of a taxonomy for IPSS to support SMEs in servitization?
- Are there typical IPSS configurations and do they affect the financial success?
- Does a socio-technical perspective in IPSS characterization provides benefits for servitization?
- What challenges can hardly be addressed by an IPSS taxonomy?
- What are the specific research needs that can be derived?

AUTHOR CONTACT DETAILS

Alexander Michalik, TU Dortmund University, alexander.michalik@tu-dortmund.de
Frederik Möller, TU Dortmund University, frederik.moeller@tu-dortmund.de
Michael Henke, TU Dortmund University, michael.henke@tu-dortmund.de

FROM SELLING ASSETS TO DELIVERING EQUIPMENT-AS-A-SERVICE

Johanna Knapp, Claudio Lamprecht, Heiko Gebauer, Felix Wortmann

RESEARCH MOTIVATION

More than ever, megatrends such as digitalization, Industry 4.0, and servitization continuously challenge traditional value creation and capturing (Porter & Heppelmann, 2014). Especially the capital intensive manufacturing industry witnesses such a disruption, hence, faces enormous global competitive pressure forcing companies to implement innovative business models (Baines, Lightfoot, Benedettini, & Kay, 2009; Helo, Gunasekaran, & Rymaszewska, 2017). Moving from solely selling assets to delivering solution-oriented service models offers promising paths to embrace digital servitization. Intrigued by the enormous growth benefits of Internet of Things (IoT) enabled outcome-oriented solutions, both academic and practical discussions intensified immensely during the last century.

However, in reality, the implementation of industrial result-oriented product-service models (Ng & Nudurupati, 2010; Tukker, 2004), such as Equipment-as-a-service (EaaS) concepts, can pose a challenging, complex, and often overwhelming task for product-focused equipment manufacturer (Baines et al., 2009; Helo et al., 2017; Parida, Sjödin, Wincent, & Kohtamäki, 2014). Hesitations rooting in an insufficient understanding of the customer role within the EaaS ecosystem and of the potential customer value (Cusumano, Kahl, & Suarez, 2015; Kohtamäki, Henneberg, Martinez, Kimita, & Gebauer, 2019; Tuli, Kohli, & Bharadwaj, 2007) impede exploration efforts in practice. Until today, only a few capital equipment manufacturers successfully offer outcome-based contracts meeting relevant market demand, primarily based on financial results (Grubic & Jennions, 2018).

Despite acknowledged growth benefits and challenges, the fundamental question of *how* companies can utilize EaaS remains widely unanswered to practitioners. Aiming to unlock the enormous potential of industrial product-service offerings, recent research emphasizes the need for a deeper understanding of customers and their involvement in strategic choices as well as in the process of value creation and capturing (Kohtamäki et al., 2019). To obtain a holistic picture, leading changes in customer demand, processes, product usage, and, hence, the underlying value-stack deserve special dedication in future research.

CONTRIBUTION TO THEORY AND PRACTICE

This ongoing research addresses the identified gap between the acknowledged growth benefits of outcome-based service contracts and the limited diffusion of successfully released offerings of capital equipment manufacturers. Aiming to understand how EaaS offerings should be designed in order to deliver an attractive value proposition, a multiple case study approach applies. Sources of data consist of semi-structured interviews (15-20) with managing directors, digital service portfolio managers, and product owners employed at capital equipment manufacturers, who are either already experienced in EaaS offerings or are in concepting and piloting phases. Further, emphasizing the customer perspective, current EaaS users are interviewed (5-10). Completing the ecosystem of EaaS, the study includes additional expert interviews (5-10) within the area of financial services, software companies, system integrators, and consultants.

The study complements existing academic efforts as well as provides managerial implications and guidance. The shift from product to service-dominant offerings, thus, from traditional to innovative business models entails a wide range of challenges and organizational changes. While those find profound attention in current literature (Jardim-Goncalves, Romero, & Grilo, 2017; Matschewsky, Kambanou, & Sakao, 2018; Ulaga & Loveland, 2014) detailed insights on the design of the underlying solution value stack are insufficiently discussed (Kohtamäki et al., 2019). For instance, interviews with industrial manufacturers in the transition phase from product to service-centric offerings, point to a missing understanding of the value proposition of future concepts. With shifting market boundaries and increasing uncertainties, the customer demand for industrial equipment evolved and turned the exploration of product-service contracts to some extent to a "pandora's box". Complimenting those indications, interviews with companies already offering outcome-oriented concepts report a gap between offered value propositions and actual customer demand. In many cases, this results in disappointing market attraction and, thus, inefficient allocation of resources. Proving the need for a deep understanding of main changes in the value proposition, applying a customer-centric view, and analyzing each part of the value stack. Acknowledging the central position of customers, the analysis of their role within the ecosystem of EaaS forms an essential part of this study.

Further, enabling companies to open "pandora's box" of outcome-based contracts, this study identifies best practice approaches and highlights essential key performance indicators for attractive offerings. During recent interviews, successful EaaS providers continuously emphasized the essential customer role during exploration and exploitation. Building on further voices in the literature on the importance of such co-creation (Grönroos, 2011; Tuli et al., 2007; Vargo & Lusch, 2008), this multiple case study approach includes a description and analysis of the collaboration of customers and providers. The study aims to provide an understanding of the customer itself, attractive value propositions, and of the impact of key customers and collaborations during each phase of exploring and exploiting IoT enabled business models. By incorporating hands-on experiences, thoughts, and best practice approaches from practitioners, the work further improves accessibility and usage of academic insights in real-world fields of application.

KEY DISCUSSION POINTS

- Despite intense discussions of IoT enabled outcome-based contracts in manufacturing industries and recognized potential growth benefits, diffusion of actual offerings is still limited.
- Hesitations arise mainly from lacking expertise, limited customer understanding, and the fear of unattractively designed value propositions.
- Capital equipment manufacturing firms lack sufficient understanding of their customers to navigate through new opportunities brought by servitization and Industry 4.0.
- A link between the utilization of EaaS and unlocking new value streams enables manufacturers to address customer demand.
- Special attention is payed to the design of EaaS offerings aiming to deliver an attractive value proposition.
- In response to new innovative business models for manufacturers, customer co-creation and collaborations pave the way towards attractive value propositions.

AUTHOR CONTACT DETAILS

Johanna Knapp, University of St. Gallen, johanna.knapp@student.unisg.ch
Claudio Lamprecht, University of St. Gallen, claudio.lamprecht@unisg.ch
Heiko Gebauer, University of St. Gallen & Linkoping University, heiko.gebauer@unisg.ch
Felix Wortmann, University of St. Gallen, felix.wortmann@unisg.ch

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IDENTIFYING CUSTOMER REQUIREMENTS FOR SMES' SERVITIZED OFFERINGS – A DYADIC STUDY

Kars Mennens, Gaby Odekerken-Schröder, Wilko Letterie & Anita Van Gils

RESEARCH MOTIVATION

An important reason for companies to pursue servitization strategies is that services can increase customer loyalty and improve the response to and satisfaction of customer needs. Many SMEs are unsuccessful in their servitization efforts, whether because they provide a servitized offering that is not what customers need or because the offer fails to create sufficient value. To be both effective and efficient at employing servitization strategies, SMEs must understand how customers value their offerings, which can be achieved by developing servitized offerings in active collaboration with the customer, or what we refer to as co-creation. SMEs often lack resources and capabilities to analyze customer service requirements, and because it is unclear to what extent SMEs actually engage in co-creation when defining customer's requirements for servitized offerings, this study sheds light on the extent to which and the reasons why SMEs engage in co-creation when anticipating customer requirements. In addition, studies on servitized offerings rarely take a customer perspective despite the need to understand how customers derive value from service offerings. Therefore, this study also investigates the requirements for servitized offerings customers have.

CONTRIBUTION TO THEORY AND PRACTICE

Table 1 provides a structured overview of the findings related to which SMEs engage in co-creation when defining customer requirements, and their underlying motivations. It is found that a small majority of the SMEs does not engage in co-creation when defining their customer requirements for three possible reasons: First, they may be under the assumption that they have the customer knowledge available internally. Second, they may suffer from a lack of (human) resources to co-create. Finally, some SMEs argued co-creation was simply not in their company's nature. Reasons to engage in co-creation are either because the customer initiated the co-creation, or because the organization clearly noticed the importance of co-creation. Table 2 provides the taxonomy for the actual customer requirements for servitized offerings depending on the pursued servitization strategy by the supplying SME. It was found that some customer requirements are universal (reliability, customer-supplier relationship and pricing), but that other customer requirements differ based on the extent to which servitization strategy is followed by the supplying SME. Specifically, when a servitized offering requires a complete overhaul of the customer's business model, distinct priorities that have to do with alignment with the customer's organization and long-term effect rise to the surface, in contrast to requirements that focus more on the offering itself and its proper functioning.

First, this study adds to the SME literature by shedding light on how SMEs address one of their largely overlooked challenges as they transition from products to servitized offerings, namely: Whether they anticipate customer requirements in co-creation with their customers, despite their limited resources and capabilities. Second, this study contributes to the largely neglected customer perspective in the servitization literature. Through the dyadic research design, actual customer requirements for servitized offerings could be identified. Accordingly, a taxonomy was developed that reveals customers' priorities for servitized offerings, depending on the chosen servitization strategy.

Table 1 SME co-creation with customers when anticipating customer requirements for servitized offerings and underlying motivations

	No customer co-creation	Customer co-creation
SMEs	Conveyor Ltd. Shepherd Ltd. Digester Ltd. Flowchart Ltd. Moonraker Ltd.	Caretaker Ltd. Workbench Ltd. Stockingsupport Ltd. Merchant Ltd.
Underlying motivations	• Knowledge is internally available • Lack of resources to co-create • Co-creation is not in SME's nature	• Co-creation is initiated by the customer • SME see the added value of co-creation

Table 2 Taxonomy of customer requirements for servitized offerings per servitization strategy

Requirements	**Added services strategy**	**Activities reconfiguration strategy**	**Business model reconfiguration strategy**
Basic requirements across all servitization strategies			
1. Reliability	✓	✓	✓
2. Customer–supplier relationship	✓	✓	✓
3. Pricing	✓	✓	✓
Requirements focused on offering and its proper functioning			
4. Responsiveness	✓	✓	
5. Tangibles	✓	✓	
6. Feedback & training	✓	✓	
Requirements focused on fit with customer organization and long-term effects			
7. Sustainable impact on customer organization			✓
8. End-customer focus			✓
9. Alignment with internal processes			✓

KEY DISCUSSION POINTS

- About half of the SMEs involved in this study engage in co-creation with their customer when determining their customer's requirements for servitized offerings.
- SMEs that do not engage in co-creation do this because they assume they have the knowledge available internally, lack the resources to co-create or state that it is simply not in their nature.
- SMEs that do engage in co-creation do this because co-creation was initiated by their customer or because they clearly see the added value of servitization.
- Whereas reliability, customer-supplier relationship and pricing are always important requirements for customers, some requirements differ based on the extent to which the supplier's servitization strategy requires a complete overhaul of the customer's business model.

AUTHOR CONTACT DETAILS

Dr. Kars Mennens, Department of Marketing & Supply Chain Management, Maastricht University; k.mennens@maastrichtuniversity.nl
Prof. Dr. Gaby Odekerken-Schröder, Department of Marketing & Supply Chain Management, Maastricht University; g.odekerken@maastrichtuniversity.nl
Prof. Dr. Wilko Letterie, Department of Organization, Strategy & Entrepreneurship, Maastricht University; w.letterie@maastrichtuniversity.nl

Dr. Anita Van Gils, Department of Organization, Strategy & Entrepreneurship, Maastricht University;
a.vangils@maastrichtuniversity.nl

IS SERVITIZATION CALLING MANAGERS BY THEIR NAME? A SERVITIZATION TYPOLOGY OF THE MANUFACTURING FIRM

Rodrigo Martínez

RESEARCH MOTIVATION

Servitization is a broad research field that has been approached from different theoretical and practical perspectives. However, one of the main themes in servitization research is the potential of attaining competitive advantage to enhance performance by adopting service strategies. Consequently, servitization research is deluged with prescriptive conclusion remarks on what should manufacturing firms do, or avoid doing, in terms of service strategies, to attain competitive advantage and enhance performance. In spite of this, empirical evidence shows that manufacturing firms following the aforementioned prescriptive remarks sometimes struggle to achieve competitive advantage, or to realize the ultimate goal of enhanced performance. The prescriptive conclusions in servitization research lack a comprehensive description of the characteristics of the manufacturing firm that facilitates a more effective adoption of service strategies in practice. Therefore, this work-in-progress paper develops a typology of the manufacturing firm from a servitization perspective, to enable manufacturing firms to better discern which service strategies are more suited to their unique characteristics. This typology is based on a three-dimensional approach to servitization as an organizational change process: 1) content, taking account of internal factors of the manufacturing firm; 2) context, comprising external factors to the manufacturing firm; and 3) process, comprising time and continuity factors of service strategies adoption.

CONTRIBUTION TO THEORY AND PRACTICE

Manufacturing firms seeking competitive advantage are traditionally compelled to either heighten their efficiency on resource management (which in practice translates to cost reduction), or to imbue products with unique features to make them more appealing for customers (i.e., product differentiation). However, natural evolution of industries and markets create competitive conditions where these traditional strategies may no longer be enough to attain competitiveness. For instance, manufactured goods in mature industries might become commodities because their attributes are highly standardized, or because their use is limited to some specific and extensively-demanded niche. On the other hand, mature markets are more likely to be crowded with competing firms. Commoditized industries and crowded markets induce cost competition. Cost, however, has constrained basis that cannot be breached without upsetting firm performance. Likewise, creating new products or developing distinctive features requires the firm to develop or to possess ad hoc capabilities to successfully innovate, and the market to be ready to receive any new value proposition. Although manufacturing firms still can attain competitive advantage by lowering the basis of cost (changing cost structure), and by improving their innovative capabilities, servitization has arose as a more effective approach to competitiveness for manufacturing firms.

Although the conclusions of numerous research papers seem to encourage manufacturing firms to adopt servitization as a mean to attain competitive advantage, there is little discussion of prescriptive nature on the characteristics of the manufacturing firm adopting service strategies. A question that seems to be left unanswered is which manufacturing firms can realize the benefits of servitization, since repeated descriptive conclusions do not disclose the assumed characteristics of the manufacturing firm or that of their context that would fit in the descriptive models.

This research work is aimed to develop a three-dimensional model (referred to content, context, and process) that enables a description of the manufacturing firm to better define the scope of descriptive models, while allowing for a straightforward identification of the characteristics of the firms that could successfully implement servitization strategies following the descriptive models. This model is discerned from a conceptual approach to the organizational change that manufacturing firms must undergo to implement servitization.

KEY DISCUSSION POINTS

- Manufacturing firms adopting servitization experience change. However, the organizational change is not unidimensional. Change occurs along all of the aspects of the manufacturing firm, including internal and external variables. Since change is dynamic and time-bound, a relatable dimension is proposed to include the change process related characteristics of the firm.
- Individual features of manufacturing firms do effect the servitization path and outcomes. From an organisational change perspective, these are: firm's awareness, firm's preparedness, firm's intention, and firm's resources.
- Enclosing the firm in a specific context, external features to the firm also have an effect on the servitization path and outcomes. Relevant external features of the firm for servitization are: firm's position in value networks, firm's industry, maturity of the firm's market, resources of the value network.
- Internal and external conditions of the firm are dynamic and change over time. Implementing servitization prompt new challenges for the manufacturing firm. Features of the firm related to implementation are: firm's adaptability, firm's resilience, and firm's capability to attain benefits.
- Creating a manufacturing firm typology from a servitization perspective could bring new insights to both theory and practice. The aim is to create a typology that facilitate the description of a manufacturing firm before, during, and after the servitization process, and to assist managers and practitioners to better asses their position prior, during, and after the servitization process.

AUTHOR CONTACT DETAILS

Rodrigo Martínez
EGADE Business School, Tecnologico de Monterrey
Eugenio Garza Lagüera & Rufino Tamayo, Valle Oriente, San Pedro Garza García, 66269, Nuevo León, México.
E-mail: A01310220@itesm.mx
Phone: +52 81 8625 6000

Executive Paper

ADVANCING WASTE COLLECTION LOGISTICS SERVICES FOR INCREASED ENERGY EFFICIENCY AND CIRCULARITY

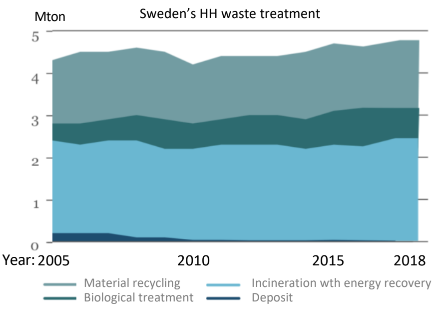
Anna Norinder, Árni Halldórsson & Ceren Altuntas Vural

RESEARCH MOTIVATION

Household waste is a growing global concern with 2 billion tons of municipal solid waste generated annually and it is expected to grow to 3.4 billion tons by 2050 (World Bank, 2018). The interest amongst scholars and practitioners in the circular economy (Kirchherr et al., 2017) has simultaneously increased rapidly. Several so-called 'R' frameworks related to waste hierarchies have been developed so as to explain the 'how to' in relation to circular economy. For example, the 4R framework of the European Union Waste Framework Directive describes a waste hierarchy with four options above waste deposit: Reduce, (prepare for) Reuse, Recycle and Recover. The aim is to move waste up in the hierarchy towards the first option.

Waste collection is viewed as a service by both the service literature (Coutelle-Brillet et al., 2014) and the circular economy literature (Lüdeke-Freund et al., 2019). Whilst consumers are seldom regarded as enablers in circular economy (Kirchherr et al., 2017), studies on waste collection logistics services identify them as co-producers of value when sorting and even transporting different fractions to enable recycling (Halldórsson et al., 2019) and thereby circularity. Moreover, these studies identify a tension between the quality of the collected waste and energy efficiency in waste collection logistics and encourage further inquiry into the actors' behaviour and interactions. Our results show that waste collection logistics services vary considerably, not only between countries but also across neighbouring municipalities. This study departs from an interest to understand *how* these services differ and which ones are the more energy efficient. This difference relates not only to logistics energy but also the energy efficiency of the resulting material treatment option in the waste hierarchy, i.e. the circularity level, which in turn is facilitated by household service co-production.

Not only are there large differences between waste collection logistics services, there is also limited overall progress with regards to recycling and circularity in many countries. We will in this study therefor, from a service perspective also explore the low advancement with regards to increased circularity.



We depart from a multi-actor perspective, here operationalized conceptually and empirically through the concept of service triads (Wynstra et al., 2015). As waste services are co-produced with several actors such as Municipality, Waste Logistics Service Providers and Household in direct contact, the service triad is a suitable analysis concept (Wynstra et al., 2015), but will be later discussed with respect to a wider eco-system.

The purpose of this study is to explore waste collection logistics service triads and their ability to foster service advancement for increased energy efficiency and circularity.

CONTRIBUTION TO THEORY AND PRACTICE

Household waste collection logistics services differ in three dimensions: 1 - waste collection logistics and thus logistics energy efficiency, 2 - service triad structures, relations and complexity, 3 - levels of waste quality, recycling and material circularity.

Practical contribution: When moving to recycling instead of incineration additional energy consumed in transport services is small in comparison to material energy savings. This holds also for the energy-intensive 'first mile' when collection services are more advanced, for example through use of four-compartment bin curbside collection. There is thus a clear connection between advanced service and high recycling & energy efficiency. In complex service structures the voice of the consumer is weak or even unheard and we find a low focus on the household perspective in these.

The convergence towards more efficient waste collection solutions through service advancement is hindered as:

- Financial incentives in municipalities owning incineration plant are weak to increase recycling & waste collection service levels.
- Incentives have been poor for packaging producers to improve recycling collection above minimum required targets.
- There are unclear concepts around 'responsibility', 'right to material' and 'monopoly' in the waste service eco-system.

We observed profitable private waste collection and recycling service providers acting on a double-sided market, i.e. managing to earn money both from the collection services and the sale of material for reuse.

Theoretical contribution: Waste collection can be regarded as a 'service supporting circularity' where consumer co-creation is a key enabler. It is further a 'local service' with a 'high physical content' and with a 'time lag' in the service interaction. Services with a time lag is not often discussed in the service literature where services traditionally have been defined as simultaneously produced and consumed. We find that consumer voice sensing needs to be specifically considered in time lagged services. The more advanced services are seen in the less complex structures where the consumer voice is clearer, and the actors have a higher customer focus.

One of the eight key components of a service eco-system is sensing and acting (Vargo and Lusch, 2011) and we know that one of the primary roles of a service eco-system is to foster innovation (Helkkula et al., 2018; Edvardsson and Tronvoll, 2013). In some of the studied triads we identify limited service innovation and we also find that one important actor is primarily sensing 'backwards'. The direction of service eco-system actors' sensing is hence important for service advancement to take place. We see this as an important contribution to the theory on service eco-systems.

The study is unique in its approach to use service triads to penetrate and describe the waste service eco-system, where waste collection logistics services are important 'services supporting circularity'.

KEY DISCUSSION POINTS

- Is it fair to say to waste collection is a 'Service Supporting Circularity' and also simultaneously a Service Supporting the Client's action and a Service Supporting a Product? Is it a new category of services?
- Is the link between complex service structures and slower service advancement unique to waste collection logistics services?
- Is it realistic to believe that customer voice and values could penetrate from behind and close the loop, that is lead to service advancement in the waste collection eco-system by consumers expecting more circular packaging and advanced packaging collection services from the packaging producers, rather than directly from the waste collection service actors?
- Some countries state that there is no conflict or tension between recycling and incineration but we believe our study show that there is. There are also different EU voices on this issue. How can the situation be improved?

AUTHOR CONTACT DETAILS

Anna Norinder, PhD Candidate, Chalmers University of Technology, anna.norinder@chalmers.se
Árni Halldórsson, Professor, Chalmers University of Technology, arni.halldorsson@chalmers.se
Ceren Altuntas Vural, Associate Professor, Chalmers University of Technology, ceren.altuntasvural@chalmers.se

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THE ACTORS OF SERVITIZATION

Carolline Amaral Paslauski, Daniel Andrews & Alejandro Germán Frank

RESEARCH MOTIVATION

Exploration of firms' capabilities through the offering of services has contributed for competitiveness of manufacturing firms. Servitization has been presented to have different orientations to support value creation. The decision over a servitization strategy that is suitable to the firm is part of what determines its success.

Strategies for superior customer value differ in prioritizing competences associated to product leadership, operational excellence, and customer intimacy. When looking for new opportunities, firms support on specific competences that can continuously differentiate them in the market. The choice of these competences is deeply sourced on inputs gathered from their industrial research, technological base and selling efforts.

Different functional areas inside the same firm have different perspectives and motivations. Industrial research is an activity attributed to the engineering functional area, selling effort is headed by the marketing functional area and technological base is mainly managed by the manufacturing functional area.

Besides, actors from different functional areas can be limited by their specific knowledge to perceive value in the activities of other functional areas and tend to prioritize their hall of competences in the strategy elaboration. Because actors from different functional areas tend to influence the firm's conduct according to its background and interests, we would expect that they would advocate in favour of different strategical orientations during servitization elaboration.

This is relevant once the decision over the servitization strategy to be conducted by firms can be influenced by decision makers with a greater or lesser affinity to different functional areas. Even when multifunctional teams take this decision; it is known that actors from different functional areas pull the output of these teams to configurations that favours their scope of knowledge and the predominant view usually is the one of the functional area with higher power between functional areas.

CONTRIBUTION TO THEORY AND PRACTICE

In this study, we have found that different functional areas have significantly different positions regarding some aspects of servitization strategies and can influence manufacturing firms in different directions. We contributed mainly by (i) prioritizing the aspects of servitization orientation that are more susceptible to be influenced by actors from different functional areas and by (ii) describing the orientation of actors from different functional areas regarding servitization.

Our contributions concerns practice because they are determinant to the quality of the process of decision making about servitization orientation and to highlight matters about strategy that will need more attention, once they represent aspects of divergence inside the firm. It also contributes to theory by helping to explain firms' decisions over servitization and calls the attention to a new aspect that can be determinant to the success of manufacturing firm servitization.

KEY DISCUSSION POINTS

- Because there are significantly different inclinations to the orientation of servitization between actors from different functional areas, we can also signal possible differences in engagement by different functional areas that advocate for servitization orientations that want to minimize changes.
- The result provides guidelines to servitization team's composition to the maximum exploration of firms' competences. The inclusion or not of actors from specific functional areas in the elaboration and conduction of servitization can alter the extent to which firms explore its competences through servitization and would result in different orientations of servitization.
- Some aspects of servitization orientation are a matter of divergence between actors from different functional areas. These aspects may be the ones that lead manufacturing firms to fail in servitizing because they prejudice the adherence of some functional areas to the transformation process when a decision is made.

AUTHOR CONTACT DETAILS

Carolline Amaral Paslauski, Organizational Engineering Group, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, 90035-190, +55 51 3308-3490, carollpaslauski@hotmail.com
Daniel Andrews, The Advanced Services Group City, Aston Business School, Birmingham, UK, B4 7ET, +44(0)121 204 3059, d.andrews@aston.ac.uk
Alejandro Germán Frank, Organizational Engineering Group, Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil, 90035-190, +55 51 3308-3490, frank@producao.ufrgs.br

SERVITIZATION IN THE AUTOMOTIVE INDUSTRY: CREATING VALUE BY LEVERAGING SERVICES IN CONNECTED DRIVING

Matthias M. Hampel, Kira Rambow-Hoeschele, David K. Harrison & Bruce M. Wood

RESEARCH MOTIVATION

The automotive industry is experiencing a great change in its history. Smart cars – connected, autonomous and personalised cars – are reinventing vehicle mobility. The servitization of mobility restructures the automotive ecosystem and value chain. New technologies, applications and services arise in the areas in-car-electronics, vehicle connectivity, autonomous driving and infotainment. Apart from new hardware concerning sensor systems or human-machine interfaces, new software will be particularly important in servitized future mobility. The technological development creates new roles for stakeholders and enables companies outside the industry to enter the automotive sector. Thus, the ecosystem will expand beyond the automotive industry, accompanied by opportunities and risks for traditional automotive companies. To withstand the increasing pressure to innovate, collaborations are important. The key trend is away from the car as a product to mobility as a service.

CONTRIBUTION TO THEORY AND PRACTICE

Traditional automotive revenues focus on vehicle production and sale – the so-called upstream part of the value chain (Gärtner, 2018; Seiberth & Gründinger, 2018). However, the traditional value chain has already developed into a value network which goes beyond the mere vehicle production and sale and opens up a broad spectrum of smart services (Schäfer, Jud & Mikusz, 2015). The future ecosystem will increasingly focus on services and after sales – the downstream part of the value chain as shown in Figure 1. According to a survey of around 1,000 high-ranking representatives of the automotive industry, 85 % assume that the revenue potential of the servitized digital ecosystem around the car is higher than the revenue potential of the vehicle hardware itself (Becker, 2017).

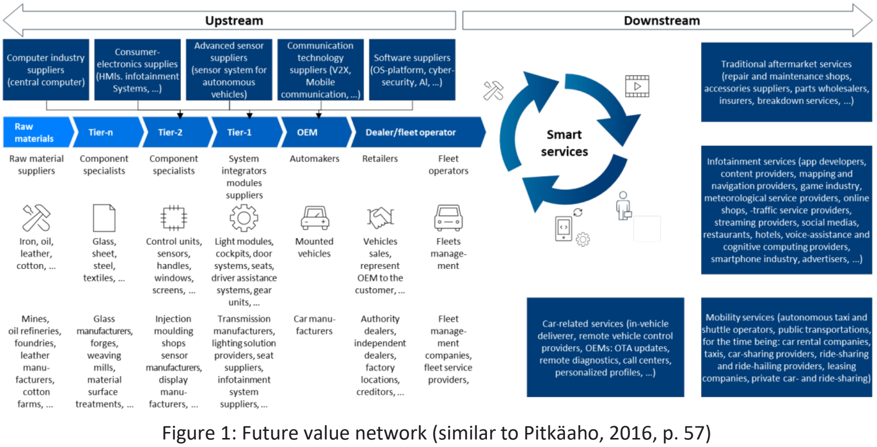

Figure 1: Future value network (similar to Pitkäaho, 2016, p. 57)

Smart cars will enable a variety of new service applications. Figure 2 provides an overview of potential service areas incl. car-related, infotainment and lifestyle services.

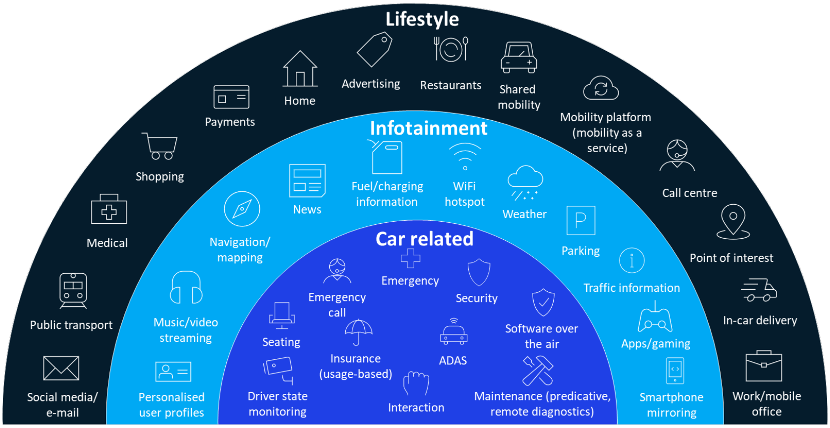

Figure 2: Smart car service applications
(similar to Karlsson et al., 2016, p. 8; Malik & Gupta, 2015, p. 3; Pitkäaho, 2016, p. 20; Seiberth & Gründinger, 2018, p. 26; Stricker, Matthies & Tsang, 2011; Winkelhake, 2017, p. 163)

KEY DISCUSSION POINTS

- Service development, consumer adoption and monetisation options
- Data use cases, data analytics and data management incl. transparency, security and privacy

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AUTHOR CONTACT DETAILS

Dr. Matthias M. Hampel, matthiasmhampel@gmail.com
Dr. Kira Rambow-Höschele, kira.rambow-hoeschele@t-online.de
Prof. Dr. David K. Harrison, d.harrison@gcu.ac.uk
Prof. Dr. Bruce M. Wood, b.wood@gcu.ac.uk
School of Computing, Engineering and Built Environment
Glasgow Caledonian University, Cowcaddens Road, Glasgow G4 0BA, UK

BUSINESS MODEL DYNAMICS FOR INCREASING REVENUE THROUGH DIGITAL OFFERINGS

Heiko Gebauer & Alexander Arzt

RESEARCH MOTIVATION

Equipment manufacturers no longer only provide combinations of physical products and classical services to their customers. They invest into digital technologies to make their products and services “smart”. Digital technologies allow equipment manufacturers to extend their traditional product and service offerings through digital ones in order to add customer value. However, there is anecdotal evidence of companies facing the so-called digitalization paradox (in short: digital paradox), which means that they invest in digital offerings, but struggle to achieve the expected revenue growth, despite proven growth potential of digital technologies (Gebauer et al., 2020; Kohtamäki et al., 2020; Wortmann et al., 2019). Obstacles in managing BM dynamics could be a reason for the digital paradox.

While the technologies (e.g. IoT, big data, and AI) for enabling digital offerings and BMs have been emerging research topics, little systematic research has examined BM dynamics for converting digital offerings into revenue enhancement. Firms must cope with the situation that BMs are in a permanent state of transitory disequilibrium. From a holistic perspective, BM dynamics describe the discovery and adoption of a fundamentally different business logic, whereas the component perspective suggests that BM dynamics are the result of deliberate modifications of one or multiple BM components (Calvante, Kesting, & Ulhøi, 2011; Markides, 2006). There are various frameworks describing obstacles in BM dynamics (e.g. Cavalcante, Kesting, & Ulhøi, 2011; Baden-Fuller & Mangematin, 2013; Berends et al., 2016; Morris, Schindehutte, & Allen, 2005). The obstacles that might explain the digital paradox include: a) companies fail to progress along the right sequence of phases for changing the overall business logic, b) companies might not overcome barriers in the management cognition, and c) companies are not able to modify the key BM components consistently. These three obstacles provide valuable guidance for our research approach.

We apply existing frameworks on BM dynamics to digital offerings in the equipment-manufacturing context. We screened industry reports and talked to industry experts to identify experienced companies for revenue enhancement through digital offerings. 27 companies agreed to participate. All 27 companies offer traditional products and services and have substantial experiences in providing digital offerings. Our research consists of three empirical studies with three different qualitative research methods. Study I entails a series of explorative interviews to identify the common phases on BM dynamics. Study II consists of focus groups exploring barriers in the management cognition for progressing through the three phases. Study III consists of in-depth case studies to identify the actual modifications in the BM components in each phase. Finally, we integrate these contributions into a framework that describes BM dynamics for converting digital offerings into revenue enhancement.

CONTRIBUTION TO THEORY AND PRACTICE

We explore the distinct phases changing the overall business logic and we describe relevant barriers, which limit the progress along these phases. Furthermore, we explain key modifications in the BM components in each phase. Our research findings provide new insights to both academics and practitioners with regard to BM dynamics when turning digital offerings into revenue enhancements.

Study I identified three phases on BM dynamics, which describe BM changes from a holistic business logic. In the first phase, companies progressed from their product-oriented BM toward augmenting products through a hardware plus logic. In the second phase, companies established a portfolio of multiple logics for creating customer value. In the third phase, business logic turned toward establishing a platform logic for integrating and parallelizing these multiple logics. This sequence of phases substantiates the notion of continuous change in BMs, suggesting that business models are frequently in states of disequilibrium (Demil & Lecocq, 2010). Study II revealed three barriers, which limit the progress from phase 1 to 3. First, a confidence barrier was observed to limit the progress from phase 1 to 2. Second, a mixing barrier was found to limit the emergence of multiple business logics. Third, a collaboration barrier was observed to constrain the integration of these three BMs into a platform BM. These barriers support the existing literature on constraints in the management cognition. Study III identified key modifications in the BM components unfolding revenue enhancement.

Our findings strengthen the multifaceted nature of BM dynamics and the actual interplay between holistic business logic, management cognition and BM components. We suggest that BM dynamics can lead to the digitalization paradox limiting revenue enhancement. According to our findings, BM dynamics triggered by digital offerings need to be considered on the overall business logic level, as well as on the BM component level. We show that "hardware-plus" business logic in Phase 1 and outcome-based BM in Phase 2 do not directly enhance revenue. Only software in Phase 2 and platform business logic in Phase 3 lead to direct revenue enhancement. In addition, barriers to management cognition, as well as temporal inconsistencies in the modification of BM components, might limit revenue enhancement.

Our framework can guide managers to cope with BM dynamics in order to turn digital offerings into revenue enhancement and to make decisions about BM modification while ensuring consistency in BM configuration. Managers should not adopt the merely dual perspective of changing from analog to digital BMs. Instead, they can assess relevant strengths and weaknesses according to our framework on BM dynamics. Managers should continuously modify BM components and ensure consistencies in their configurations.

KEY DISCUSSION POINTS

- We suggest that digital offerings do not simply shift from an old business logic to a new one. They also do not automatically trigger a change from the existing (product-oriented) BM to a new (digital) one. BM dynamics for increasing revenues through digital offerings are much more complex and evolve over time through different phases changing the overall business logic.
- Digitalization allows portfolios of BMs to flourish. Over time, such BM portfolios managed through a platform logic marginalize analog business logic and cultivate a digital business logic. As BM portfolios transcend company barriers, companies should adopt a business ecosystem perspective.
- The identified confidence, mixing, and collaboration barriers support and supplement the existing literature on constraints to management cognition. Established BM portfolios can only be sustained if managers succeed in mitigating cannibalization among the BMs, in ensuring synergies, strengthening cross-fertilization, and avoiding cross-penalization.

AUTHOR CONTACT DETAILS

Heiko Gebauer, heiko.gebauer@imw.fraunhofer.de
Alexander Arzt, alexander.arzt@imw.fraunhofer.de

PATTERNS OF VALUE PROPOSITIONS IN DIGITAL SERVICE OFFERINGS

Martin Ebel, David Jaspert, Jens Poeppelbuss

RESEARCH MOTIVATION

Digital technologies are fundamentally changing the way services are provided to customers. The development and integration of smart products enables companies to analyse data and transit from product-oriented to service-oriented firms, which characterises digital servitization and leads to digital service offerings. In addition, the creation and development of new customer value moves into the innovation focus, rather than new technological offerings. Thus, previous business models (BM) must be questioned, adapted or completely revised. Methods that support service business model development have not yet become widely used, so that new digital services seem to emerge rather unsystematically. Through providing exemplary solutions from practice Business Model Patterns (BMPs) have the potential to shorten the innovation process and the introduction of such while also reducing risks due to their practical orientation. In terms of BM innovation, knowing existing patterns and reusing them can help to generate new BMs or adapt existing ones. Recent collections of BMPs are not easy to use in terms of their huge quantity, remain abstract on the value proposition, or focus on different technologies and do not take digital services into account. Thus, we currently see a lack of a specific set with a manageable number of patterns for manufacturing companies to support digital service innovation. Hence, the purpose of this study is to deliver a lightweight tool with such patterns for the development of value driven digital service business models.

CONTRIBUTION TO THEORY AND PRACTICE

We studied 90 BM of digital service offerings in the manufacturing and the capital goods industry and classified them in regards to their value proposition. As a result, we identified 15 patterns of digital service offerings. Each pattern is divided into the three key pillars value proposition, value creation and value capture. The value proposition gives insight in what the main use of the overarching digital service is. Value creation refers to how the supplier of the digital service realizes the service offering. And value capture summarizes the monetarization of the combination of proposed and created value. Combined, those three fields give a comprehensible overview of a BM and are thus used to structure our patterns. In table 2 one exemplary pattern with described structure is shown.

Table 1: Pattern "Result-Oriented PSS" (D3)

D3 Result-Oriented PSS		
Value Proposition	**Value Creation**	**Value Capture**
Transmission of responsibility for processes with a guaranteed performance to achieve a desired result.	Takeover of activities and with it the risk of the customer for a successful execution of a certain process.	Contracting for a predefined performance or result for a fixed fee (pay-on-production, pay-per-X).

The patterns (Figure 1) range from Condition Monitoring (A1) to Result-Oriented PSS (D3) and condense a broad range of existing offerings from B2B-markets. The patterns aim to support the systematic development of digital service innovation in manufacturing firms. They shall be used to align service portfolios and possibly expand them. Hereby, practitioners can use the 15 patterns as an ideation tool for new digital service offerings and ask themselves if one or several patterns could be valuable in their specific markets. When applying a pattern, care should be taken not only to adopt obvious solutions, but also to consider and think through patterns that change the existing business model disruptively.

	Service Oriented Toward the Supplier's Good	Service Oriented Toward the Customer's Process
Promise to perform a deed	**Product Lifecycle-Service**	**Process Support Services**
	A1 Condition Monitoring	C1 Maintenance Management
	A2 Remote Support	C2 Self Service
	A3 User Training	C3 Process Analysis
	A4 Online Community	C4 Process Control
		C5 Integration Platform
Promise to achieve performance	**Asset Efficiency Services**	**Process Delegation Services**
	B1 Product Optimization	D1 Documentation
	B2 Predictive Service	D2 Fleet Management
	B3 Use-Oriented PSS	D3 Result-Oriented PSS

Figure 1: Classification of Patterns

The patterns are supposed to provide manufacturing firms with guidance in developing concepts for new digital services. We strongly suggest to use them in collaboration with the customer e.g., by jointly developing digital services in workshops or by letting them assess the usefulness of developed BM as the requirements of different markets and specific customers can vary. Thereby, it must be ensured that the customer benefit is the focus of digital service development activities in order to ensure marketability, which should be a core aspect of an innovative business model.

The set of patterns is limited to manufacturing companies that pursue digital servitization. We consider this specific scope to be reasonable in times where databases for BMPs grow constantly. Although we analysed a large number of digital service offerings, the resulting set of patterns are not likely to be exhaustive. Even though many innovative business models are actually based on the recombination of previously existing patterns, we can expect new patterns to evolve, especially in the course of the ongoing digital servitization of firms. Therefore, future research should consider how to categorize and thematically organize newly emerging patterns in the future. Further, the practical applicability of such BMPs should be investigated.

KEY DISCUSSION POINTS

- How to clearly differentiate between single patterns.
- Usefulness of the value lens as a key distinction between different patterns.
- Further development and consolidation of BMPs, as well as integration into previous research.
- Phases of innovation processes in which the patterns could be useful and how they conflict or interfere with creativity, e.g. for disruptive innovation.
- How to use these patterns in practise systematically.

AUTHOR CONTACT DETAILS

Martin Ebel, Ruhr-Universität Bochum, martin.ebel@isse.ruhr-uni-bochum.de, +49 234 32-27367

SERVITISATION AND DIGITALISATION

Dr. Phil Godsiff, Dr. Zena Wood & Prof. Roger Maull

RESEARCH MOTIVATION

This conceptual paper explores the impact of new innovative digital technologies on the servitisation process, and the challenges faced in servitising existing services. It argues that while new *digital technologies* facilitate and probably precede servitisation, the full impact of *digitalisation* both enables and requires fundamental business model change at the same time as different business model changes are required by servitisation. We suggest a model for digitalisation that underpins and enables servitisation and especially digitally enhanced advanced services.

The value creation potential of digitalisation is thought to be immense with a total economic impact estimated to be £800 billion to £2 trillion a year by 2025[1]. Servitisation, especially advanced services (AS) using innovative digital technologies, allows companies to deliver capability (i.e., an outcome) rather than the traditional product-based offering; companies can maintain their competitive advantage and increase the value that they can offer to their customers[2]. The opportunities for AS are enormous and pervasive across industrial sectors, yet maturity varies, with the majority of examples, and research in AS, focusing on the manufacturing sector. If AS are to be widely adopted across the different sectors, the relationship between servitisation and digitalisation must be understood.

We describe "digitalisation" as a "triptych" of activities. The 3 key themes are digitisation, datafication, and digitalisation. *Digitisation* is the turning of analog data into digital data, and the creation of new data sources, which can be easily shared and reproduced. *Datafication* is the analysis of the data and making use and sense of it. *Digitalization* is innovating the firm's business model as a result of the earlier two stages where new value opportunities can be identified, for which the whole business has to adopt a digitally and customer focussed mindset. Increasingly the end user can now begin to pull solutions towards them in conjunction with members of upstream supply chains, rather than have products pushed at them by manufacturers.

Servitisation is a series of steps from simple service agreements, to AS which employ customer or user outcome-based contracts, and involve less the simple sale of an asset, but an ongoing relationship. This, like digitalisation, requires radical changes to the organisation's business model matching service-based costs with service-based revenues, and creating additional value opportunities for supplier and customer. Servitisation experience and literature also tends to be focussed on B2B scenarios, where the immediate customer of the servitising firm is not necessarily the end user. As servitisation extends its influence, this is not likely to continue, especially when it begins to impact on "services" such as transport and insurance.

CONTRIBUTION TO THEORY AND PRACTICE

The theoretical contribution is to place the impact of digital technologies on servitisation and AS in the wider contexts of the impact of digitalisation on organisations and explore this in the context of transforming services (rather than manufacturing) into advanced services. The complementary of digitalisation and AS is clear; the use of data, the need for sense-making, which has two strands, the analysis of the data to identify its message: Is there sufficient data in the right format to make correct decisions about asset performance, degradation and service requirements, and then act on those decisions. These are essential parts of AS but there is a more outward looking part of sense making which is understanding and empathising with the challenges that organisations face in taking the next step of business model change. Both digitalisation and AS emphasise the need for business model innovation.

Practically, working with companies who are trying to servitize allows us to understand the challenges involved. Research has been undertaken into the necessary capabilities of digital technologies with regards to different servitisation offerings[2,3]. However, much of this research focuses on the manufacturing sector. In the DEAS network+ our community is beginning to explore how servitisation might work in industries that look or are increasingly like services, with the particular examples of transport/mobility and insurance. The research reported here considers organisations from different sectors, namely manufacturing, transportation and financial services, allowing the extraction of generalised learning. If the impact and challenges were understood it would help organisations in sectors, who are still struggling with servitisation, to change their business models accordingly. The research will also advance theory in servitisation business models whilst giving practical insights to industry.

KEY DISCUSSION POINTS

- It is clear that technology plays an important role in facilitating a servitisation business model[3]. Business models can be described by three components: the value proposition, the value creation and how the value is captured[4]. Digital technologies provide a 'significantly new way of creating and capturing business value'[5]. Driven by digitisation, digitalisation occurs when there is an innovation in an organisation's business model[5]. It could be argued that all digital innovation requires business model innovation.
- Many services are data-driven. Datafication is only possible through digialtisation[5].
- For many organisations, it is not new services that are being adopted but existing services requiring servitisation. This can prove a major challenge. Different levels of servitisation exist[2].
- One of the challenges to adopting servitisation is the speed at which technology advances. There are many different technologies available to organisations (e.g. AI techniques, data analytics, Internet of Things, Cloud), each with different capabilities. These technologies can be transformative if used correctly. Research has been undertaken to investigate the role of specific technologies in servitisation[2,3].
- We argue that digitalisation requires organisations to fundamentally change their business models to become digitally aligned throughout, in a similar manner to which servitisation requires significant business model change. The latter may be voluntary and strategically informed. The former is likely to be a requirement just to stay in business. The tension between these fundamental restructurings needs to be properly researched.

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AUTHOR CONTACT DETAILS

P.j.godsiff@exeter.ac.uk, University of Exeter Business School

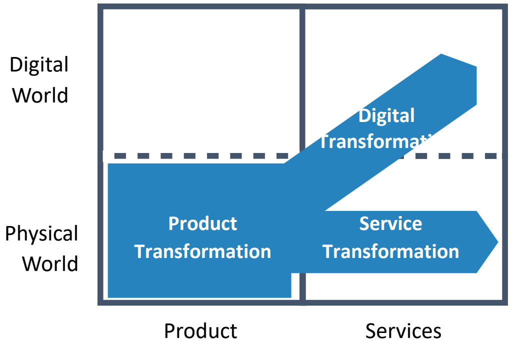
SERVICE CAPABILITIES NEEDED TO RESHAPE THE SERVICE MARKET AFTER TECHNOLOGICAL AND DIGITAL SHIFTS

Besma Glaa, Heiko Gebauer & Lars Witell

RESEARCH MOTIVATION

Nowadays, climate change and CO2 reduction have been pushing many manufacturing firms to undertake transformations of their businesses. In particular, three major transformations are challenging the manufacturing firms and they are highly interrelated: Service, digital and product transformations (see Figure 1). Product technology shifts (such as combustion to electric engines and from human-driven to autonomous self-driving vehicles) and digitization are changing the service market logic. For instance, while the service market for combustion engines benefits from high product complexity and intensive product usage, electric engines are much less complex and have less mechanical wearing. Following the existing service market logic, electric engines provide less business opportunities. As a consequence, it becomes relevant to study what a manufacturer can do, when experiencing a technology shift in the core product? Will new digital technologies and autonomous driving services, open-up sufficient new business opportunities, or do manufacturers facing such changes need to reinvent their business model? Moreover, what are the capabilities needed to re-shape the service market. Besides, the study aims to gain a better understanding on the current and future situation of automated driving by identifying the value proposition and appropriation for truck automation from the operator perspective.

Figure 1: Service, digital and product transformation



CONTRIBUTION TO THEORY AND PRACTICE

Manufacturing firms engage in servitization to respond to the challenges of unceasing change in the business environment and to achieve competitive advantage (Forkmann et al. 2017; Zeithaml et al. 2014). Therefore, services are impacting the organization and are becoming a crucial part of manufacturing firms' offerings (Gebauer et al., 2010). Certainly, after-sales services are often the longest part of a product's life and an important source of revenues for manufacturers (Kowalkowski, Gebauer and Oliva, 2017; Gebauer et al., 2005). Aircraft manufacturers, for instance, can gain revenues for as long as 25 years after a sale. Besides, providing after-sales services can help manufacturers to gain valuable knowledge about customers, their needs and build stronger business relationships. However, what happens to the service business when there is technological leap in the core product technologies? The servitization literature assumes that the core product technology is stable, but neglects situations, in which it is going through a dramatical change. Especially, when the technology shift reshapes the boundaries and logic of the service market. Following the service market logic, electric engines provide less traditional service business opportunities. The service provider has to serve to parallel markets for service provision, one shrinking market for combustion vehicles and one growing market for electric engines with a limited service growth potential. In this scenario, it becomes interesting to investigate how to win the service market when there is a shift in the core product technology. To the best of our knowledge this is the first research exploring the effect of core product technology shift on the service market.

The main contributions of this research are as follows. First a theoretical contribution aiming at addressing a research gap in the servitization literature by investigating how the service market is affected by a shift in the core product technology and a digital shift. In particular, the influence on the business model and the service capabilities are explored. Second, a managerial contribution in order to help them how to win the service market for different core product technologies, secure the service market as a profit pool and to determine the role of manufacturing firms in the service market during a digital and technological shift in the core product technology.

KEY DISCUSSION POINTS

- The effect of the three transformations: Service, digital and product transformation on the existing business models.
- How various technologies change the service market logic and affect the existing business models?
- What are the synergies between different core product technologies for the service market?
- Will new digital technologies and autonomous driving services, open-up sufficient new business opportunities, or do such manufacturers need to reinvent their business model?
- What are the capabilities needed to re-shape the service market?

AUTHOR CONTACT DETAILS

Besma Glaa, Assistant Professor of Industrial Economy at Linköping University, Sweden (besma.glaa@liu.se).
Heiko Gebauer, Professor of Business Administration at University of St.Gallen, Switzerland and Fraunhofer IMW, Germany. Guest Professor at Linköping University (heiko.gebauer@liu.se).
Lars Witell, Professor of Business Administration at Service Research Center (CTF), Karlstad University and at Linköping University, Sweden (lars.witell@kau.se).

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