

INTRA-FIRM AND INTER-FIRM CHALLENGES IN SERVITIZATION ECOSYSTEM: EXPERIENCES FROM FIVE PRODUCT-CENTRIC FIRMS IN DIFFERENT INDUSTRIES

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ABSTRACT

The purpose of this paper is to analyse the challenges in the servitization journey of product-centric firms from an ecosystem perspective, considering both intra-firm and inter-firm levels. Prior research addresses the challenges of servitization in many sectors from different perspectives. However, the majority of studies primarily focus on the provider of an offering. There is a lack of in-depth studies on analysing servitization challenges from the broader set of network actors including customers, suppliers, and sub-suppliers at the intra-firm and inter-firm levels. A multiple case study method was used to analyse five product-centric firms from different industries that were engaged in servitization. At intra-firm level, our analysis shows that ‘coordination’ is a major challenge for the provider, supplier, and sub-suppliers, and that ‘uncertainty’ and ‘risk’ is a major challenge for the provider, customer, and supplier. At inter-firm level, ‘partnership management’ found to be a most significant challenge for provider, customer, supplier, and sub-suppliers. The study contributes to the discussion of the relational view approach for servitization research.

Keywords: Product-Service Systems (PSS), Circular economy, Business models and considerations

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1 INTRODUCTION

Today many product-centric firms attempt to reshape their image as “solution providers” instead of “product sellers”. Such shift as a competitive operations strategy has gained increased attention both in academia and in the industrial practice in last three decades (e.g., Baines *et al.*, 2017; Eloranta and Turunen, 2015) and conceptualized as Product-Service Systems or servitization of manufacturing (Baines and Lightfoot, 2013). Despite growing body of literature on servitization, several researchers highlight the “non-maturity” of the concept and its strategy implementation as most companies are still limited to traditional product-related services compared to the advanced types of services (Dachs, *et al.*, 2013). The financial outcomes and performances are even reported as non-linear (Neely, 2009). Extant literature reported underlying challenges for this non-maturity, calling for a major paradigm shift in the strategic, operational, and management aspects and dimensions (Oliva and Kallenberg, 2003; Martinez *et al.*, 2010; Baines and Lightfoot, 2013; Chirumalla, 2013).

Many scholars positively linked the success of the value co-creation process in the servitization with the networking activities of firms (Windahl and Lakemond, 2006; Raddats *et al.*, 2017) since a single firm cannot accommodate necessary skills, competences, and resources needed for the servitization. Thus, effective collaboration within the value chain networks plays a key role, whilst a single firm may be responsible for delivering the servitized offering, the services and support processes need to be organised by multiple actors within a network. Such network of firms often referred in literature as manufacturing service ecosystem (Lüftenegger *et al.*, 2013) or service networks (Eloranta and Turunen, 2015; Basole and Rouse, 2008). Thus, taking into account a provider’s embeddedness in the network and its direct and indirect connections and dependencies on other firms is likely to provide a more complete picture of the challenges connected to the servitization (Raddats *et al.*, 2017).

Despite the significance of the network context, prior research, however, mostly examined servitization challenges either from the perspective of a single firm or a focal firm or a provider (e.g., Oliva and Kallenberg, 2003; Matschewsky *et al.*, 2017). In general, there are few empirical studies focus on multi actor network in servitization (Ayala *et al.*, 2017; Martinez *et al.*, 2010; Windahl and Lakemond, 2006; Johnson and Mena, 2008; Eloranta and Turunen, 2015). Those studies are even limited in exploring the role of only few actor networks (i.e., provider—customer, provider—suppliers, customer-provider-suppliers). From the perspective of challenges in servitization, major studies either focus on inter-firm challenges (e.g., Cenamor *et al.*, 2017; Rabetino *et al.*, 2015) or intra-firm challenges (e.g., Martinez *et al.*, 2010; Sjodin *et al.*, 2017). To the best of our knowledge, there are only few empirical works that discuss challenges of servitization ecosystem both at intra-firm and inter-firm levels (Alghisi and Saccani, 2015; Martinez *et al.*, 2010; Burton *et al.*, 2016). Even those studies treated challenges at a more general level and have not analysed them from an individual actor per se (such as: provider, customer, suppliers, and sub-suppliers). This gap is in fact stressed by recent studies claiming that servitization, at both inter- and intra-firm relationships and ecosystem perspective, is a salient area which needs further investigation (Baines *et al.*, 2017; Eloranta and Turunen, 2015).

Against this backdrop, the purpose of this study is to fulfill the above-cited gap, by examining and analysing the challenges in the servitization journey of product-centric firms from an ecosystem perspective, considering both intra-firm and inter-firm levels. Empirical insights were drawn from case studies of five different industries that are in a strategic transition towards increased servitization.

2 THEORETICAL BACKGROUND

2.1 Servitization ecosystem

Servitization can be considered as a network activity which involves not just the servitized firm but suppliers, customers, regional units, other related partners to create an ecosystem of partnerships for delivering greatest possible customer value (Burton *et al.*, 2016; Johnson and Mena, 2008; Raddats *et al.*, 2017). The manufacturing service ecosystem (MSE) concept (Lüftenegger *et al.*, 2013) builds on the business ecosystem idea, but adds characteristics typical for the servitization of manufacturing. The MSE is a non-hierarchical form of collaboration, consists of a loosely coupled upstream suppliers, original equipment manufacturers (OEMs), downstream channels to markets, supplementary service providers and customers (Basole and Rouse, 2008). The value is co-created by these actors by sharing

their core competences with the cooperation of other network actors (Basole and Rouse, 2008). Servitized ecosystem abilities are different from the traditional ecosystems as they need to be more responsive to the customer demands in dynamic situations (Johnson and Mena, 2008). Nevertheless, value co-creation is not an easy process as barriers like operational cultural resistance, loss of operational know-how and risk of operational conflicts exist (Sjodin, et al., 2017). Consequently, the practical implementation of “value-in-use” and “value co-creation” need further development in a network setting (Lightfoot et al., 2013). Burton et al., (2016) stressed the need to involve value chain actors upstream and downstream to identify appropriate mechanisms for value creation in the servitization process. Windahl and Lakemond (2006) argues that inter- and intra-firm relationships can both enable and obstruct the development of servitization and that servitized firms must manage such duality in an efficient way. Lüftenegger et al. (2013) discussed that multi-actor firms that rely on adding value from actor’s assets with services could easily face disruption on their business if the ecosystem is not defined and managed properly.

2.2 Challenges of servitization ecosystem at intra-firm and inter-firm levels

Existing research have discussed the core challenges of servitization (Martinez et al., 2010; Zhang and Banerji, 2017; Parida, et al., 2015; Raddats et al., 2017). However, few researchers discussed these challenges at intra-firm and inter-firm network levels. Specifically, Martinez et al., (2010), Kinnunen and Turunen (2012), Alghisi and Saccani (2015) and Zhang and Banerji (2017) all identified servitization challenges and grouped them into different categories. A close review of the challenges classifications reveals the commonality among many of the challenges. These challenges have been harmonised under core categories and presented as intra-firm and inter-firm challenges in Table 1.

Table 1. Harmonisation of servitization challenges from literature

Ecosystem level	Servitization challenges	Martinez et al. (2010)	Kinnunen and Turunen (2012)	Alghisi and Saccani (2015)	Zhang and Banerji (2017)
Intra-firm level	Culture	Embedded product-service culture	Creating a service-oriented organizational culture	--	Organisational structure & culture change
	Offering	Delivery of integrated offering	Creating and developing market-oriented services	Service portfolio offering	Business model
	Internal structure or operations or organization	Internal processes and capabilities	Managing service knowledge and communication	Company internal organization	Development process
	Strategy	Strategic alignment	Defining a service strategy	Company strategy	--
Inter-firm level	Networking	Supplier relationships	--	Service networks	Business model – supplier collaboration
	Customers	--	Establishing a customer-centric organizational configuration	Customers	Customer management
	Risk	--	--	Company strategy – Risk management	Risk management

2.2.1 Intra-firm network level challenges

The analysis at the intra-firm level challenges have provided following four category of challenges:

- **Culture.** Martinez et al., (2010), Kinnunen and Turunen (2012), Alghisi and Saccani (2015) and Zhang and Banerji (2017) explained this construct as encompassing cultural change from product-centric to product-service mindset as well as effective communication with internal and external stakeholders to achieve intra-organisational synergy. They argued that if traditional manufacturing culture is strongly embedded in the organization, it could hinder transition towards provision of an integrated offering.
- **Offering.** The intangible feature of services makes them differ greatly from products, yet the servitization concept necessitates an integration of both in the offering, which is undeniably

difficult (Zhang and Banerji, 2017; Alghisi and Saccani, 2015). Product-services solutions require innovation and servitization providers must understand how to achieve this given the dynamic nature of customer requirement in ever changing markets (Kinnunen and Turunen, 2012).

- *Internal structure/operations/organization.* The development and implementation of product-services solutions are challenging as it requires significant investment in technological resources, human resources, right operating conditions etc. to realise success (Sjodin *et al.*, 2017). Martinez *et al.*, (2010), Kinnunen and Turunen (2012), Alghisi and Saccani (2015) and Zhang and Banerji (2017) also emphasised the need for servitization providers to acquire new capabilities in order to compete in new service spaces. Sometimes, management also pose peculiar challenge to servitization as they have little confidence in the economic potential of services and may be unwilling to support the servitization agenda (Luoto, *et al.*, 2017).
- *Strategy.* Organisational strategy defines the direction for the company, hence the corporate strategy must provide a clear definition of the service strategy to enable successful implementation of the servitization activities (Martinez *et al.*, 2010; Alghisi and Saccani, 2015; Kinnunen and Turunen, 2012). This process would require change in value proposition from internally informed proposition to embrace value co-creation with the customer (Zhang and Banerji, 2017).

2.2.2 Inter-firm network level challenges

The analysis at the inter-firm level challenges have provided following four category of challenges:

- *Networking.* Coordination among different network actors to leverage value co-creation is very crucial for the design, implementation and survival of servitization offering (Cenamor, *et al.*, 2017). There is a challenge of overcoming information asymmetries, which may be existing between the customer and servitization provider (Aarikka-Stenroos and Jaakkola, 2012). The effort to capture and share information among network partners may be difficult, as it requires the establishment of trust, common understanding and appreciation of the value of network approach, rather than a single-firm approach to servitization (Chirumalla, 2013; 2016). This could be labor-intensive with the difficulty of standardizing information (Parida *et al.*, 2015). In addition, capabilities at the supplier interface are also needed to allow for greater integration (Alghisi and Saccani, 2015).
- *Customers.* Customer perception of value and their involvement in value co-creation would have an impact on the servitization offering (Zhang and Banerji, 2017). While the idea of value co-creation is an ideal aspiration for the success of servitization, it is sometimes met with cultural resistance from the customer due to limited understanding and perception of their role in the co-creating process (Rabetino, *et al.*, 2015). When they are not well informed about the process and trust is low, they are unwilling to share data (Zhang and Banerji, 2017; Sjodin, *et al.*, 2017). This shows the need for servitization provider to define the roles and the relationship required for the co-creation process in order to reduce friction and overcome barriers (Baines and Lightfoot, 2013; Alghisi and Saccani, 2015).
- *Risk management.* Risks arise at different stages of the servitization journey due to the huge requirement of financial investment, technology evolution, government regulations, market trends, etc. (Alghisi and Saccani, 2015; Zhang and Banerji, 2017). The prevalence of risk makes customers unwilling to commit to long-term contracts which hinders the realization of the benefits related to a full life-cycle offering (Rabetino, *et al.*, 2015; Sjodin, *et al.*, 2017). This poses a major challenge in deciding the level of ownership and risk management within the servitization network, as customers sometimes fear the loss of knowledge to supplier (Lightfoot *et al.*, 2013; Rabetino, *et al.*, 2015). Risks can arise from multiple causes while co-creating value with the customer; therefore, the ambition of designing for product-service systems to overcome inherent risks requires extensive research (Lightfoot *et al.*, 2013; Rabetino, *et al.*, 2015).

3 METHODOLOGY

3.1 Research approach and case companies

To examine the challenges in the servitization ecosystem of product-centric companies, we adopted a qualitative multiple-case study research design (Yin, 2009). Case studies was deemed appropriate as the servitization ecosystem challenges have not been studied in depth in research (Yin, 2009). Such multiple-case study design can enable systematic analysis of different firms and generate more

comparable and generalizable results than a single firm (Eisenhardt and Graebner, 2007). We selected five product-centric firms (referred as case A, B, C, D, and E) following purposive sampling technique, which allowed to identify and select information-rich cases that would provide detailed insights to perform an in-depth study (Patton, 2002). Specifically, we selected relevant firms from different industrial sectors, which were at different stages of the servitization journey based on following criteria: 1) the firm is knowledgeable about or experienced with a phenomenon of interest and offers some form of integrated product-service offerings; 2) the firm had been implementing servitization strategies for more than five years and has a vision to increase revenue share from services in coming years; and 3) the firm gives access to collect rich data about servitization ecosystem involving suppliers, customers, distributors, and other related actors. All case firms operate in completely different industries, but they share a common strategic goal of competing by providing servitized offerings, which fits well with the focus of this study.

Table 2 summarises the key information related to five case firms.

Table 2. Empirical case firm's background

	Case A	Case B	Case C	Case D	Case E
Firm	Aero-engine component manufacturer and OEM	Bike-sharing schema operator	Technology and consulting firm	Waste recovery technology manufacturer	Heavy-duty vehicle component manufacturer
Industry	Aerospace industry	Bike-sharing industry	Technology and consulting industry	Waste recovery industry	Heavy-duty vehicle industry
Firm location	Sweden	UK	USA	Sweden	Sweden
Main products	Aero-engine components for commercial aircrafts; OEM for military aircrafts	Bicycles, bicycle parts, docking station	Computer hardware, middleware and software	A complete reactor and related process that thermo-chemically breaks hydrocarbon waste to basic molecules.	Construction equipment
Main services	Spare parts, engine mounting, maintenance, monitoring systems, fleet management, spare engine availability, product support	Rental services, maintenance services, distribution services	Hosting and consulting services: cloud computing, cognitive computing, commerce, data and analytics, Internet of Things, IT infrastructure, mobile, and security	Part financing, installation, commissioning, legal processes to obtain environmental permissions, operation management of the plant, monitoring, sales of the outputs	Spare parts, preventive maintenance services, monitoring systems, fuel efficiency services, safety and productivity services
Position in P-S continuum	Service- and use-oriented	Use-oriented	Service-oriented	Result-oriented	Product- and use-oriented
Interviews	15	10	14	14	5

3.2 Data collection

Data were collected primarily through face-to-face semi-structured interviews conducted at servitizing firms' facilities. In total, 58 interviews of between 60-90 minutes were performed with respondents from five cases, which had a range of different roles and functions or business units closely related to the servitization implementation, including R&D, business development, production, logistics, sales and marketing. The average length of respondents' employment is 7 years. The interviews covered a set of questions related to key themes, namely, servitization transition, servitized offerings, servitization network, intra-firm and inter-firm challenges, and required capabilities. The unit of analysis for the study is at the intra- and inter-firm level of ecosystem actors of servitization. All interviews were audio-recorded and transcribed verbatim. Reliability was ensured by maintaining a regular log of field notes, involvement of multiple researchers, and regular discussions.

3.3 Data analysis

The data analysis followed three simultaneous activities— data reduction, data display and conclusion drawing (Miles and Huberman, 1994). Initially, we reviewed servitization literature with a deductive approach, which resulted into the common servitization ecosystem challenges at intra- and inter-firm levels (Table 1). Then, for each case, we separately followed the thematic analysis method (Braun and Clarke, 2006) to code raw data from interview transcripts, i.e., intra- and inter-firm challenges per each ecosystem actor. In this phase, firstly, using a cross-interview analysis, the insights emerged from each interview were compared with those from other interviews to identify similar constructs (Eisenhardt and Graebner, 2007). This procedure was repeated for each ecosystem actor per each case. This analysis eventually provided the first-order categories of codes for each case. In the second phase, the analysis built on the first-order categories of codes to further discover patterns within the

codes for identifying themes. This analytical process helped to formulate second-order themes by combining the first-order categories. After we have done second-order themes for all five cases, the themes were transferred to a new spreadsheet which is structured as intra- and inter-firm challenges per each ecosystem actor against five cases. This third phase followed a cross-case analysis, where constant comparison technique (Strauss and Corbin, 1990) was used to identify similarities between the cases, helping to convert empirical content into theoretical concepts. This third level of abstraction in the coding resulted in defining overarching third-order dimensions. From the display of the second and third categorisation results were compiled, and conclusions drawn

4 RESULTS

Our empirical analysis found typology of critical challenges in servitization ecosystem for key constituents of the ecosystem actors such as provider, supplier, sub-supplier, and customers. Figure 2 illustrates the typology of challenges in servitization ecosystem.

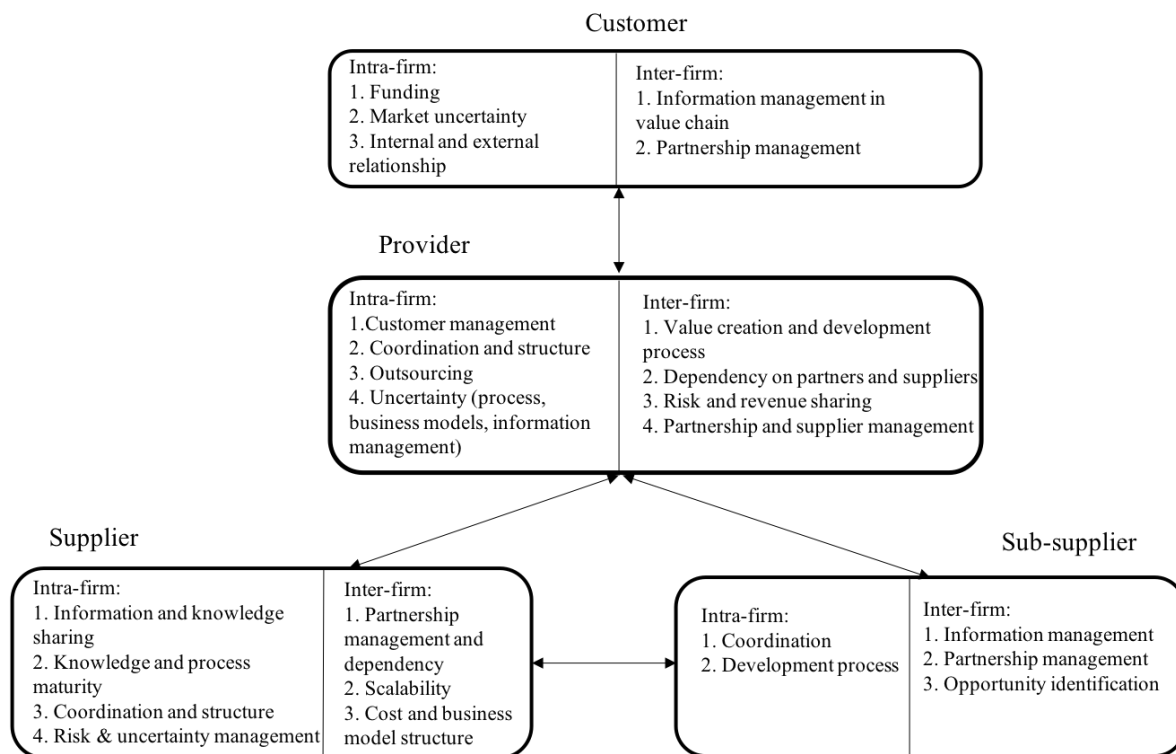


Figure 2. Identified typology of critical challenges in servitization ecosystem

4.1 The most common intra-firm challenges in servitization ecosystem

At the intra-firm level, the most common challenges among the network actors are coordination (i.e., for provider, supplier, and sub-supplier), and uncertainty and risk (i.e., provider, customer, and supplier).

4.1.1 Coordination- A common challenge for provider, supplier, and sub-supplier

From a development perspective, balancing both conventional and new businesses at the same time is a hurdle within the firm. The shift from the old to the new is presented in the following analogy (Case E): “the analogy that we are on an oil rig and it’s burning...should we go into the safe house and lock ourselves in and hope that it will...be alright? Or should we jump off and try to swim to a new one? Nobody knows if locking ourselves in will work, or if we will survive the jump...So, it’s that kind of situation...and nobody knows the right answer.” Although designated departments are expected to explore and identify new servitized offers, they are often restricted because of the budget limitation. According to one product portfolio manager (Case B): “it’s very hard to balance what you have today, where you make the money, and then actually trying to scale down to do other stuff.” Few firms took steps to overcome the difficulties in adding services to its core business. In particular, some have set up a distinctive division, exclusively dedicated to the services provision and consulting services. A process manager (Case C)

stresses the benefit of such division as follows: *“In this way, it was possible to allocate the right people, with the right knowledge, to the right place.”* Servitization requires a high degree of cross-functional collaboration, which necessitates the integration of an extended set of competencies from different functional areas of expertise, to develop the business case at team/department levels. In Case A, the supplier had to bring in many consultants in order to keep the competence in the team since there were no such resources at the firm. People with different expertise follow diverse ad-hoc processes and ways of communication, which is positive for the specialisation, but makes it harder for those from other departments to understand. Therefore, finding a common way of communication and collaboration is a challenge to avoid innovative ideas being viewed as fuzzy or “out of the box”.

4.1.2 Uncertainty and risk- A common challenge for provider, customer, and supplier

Provider firms acknowledged that there is no clear pathway in exploring new areas, which are unknown. This leads to uncertainty in firm processes, business models and information management related to servitization, calling for a change of strategies (e.g., digitalization) in order to fill the gaps and capture new value to generate other sources of revenue. This means that additional processes are required to deliver the promised results. Thus, one technical developer (Case D) said, *“there are obviously more risks and challenges now. We are going into a new business sector which may not be our expertise anymore”*. There were challenges to transfer information from the field operation to the headquarters for remote monitoring and troubleshooting, causing the engineering team to travel to the customer country and be present during the field operational testing often. In addition, supplier firms stated that the integration of service to the product offer can lead to customers viewing suppliers as competitors since customers provide the same kind of service offers in the industry. This could lead to uncertainty in revenue generation, especially when collaborating with other supply chain actors as shown in Case E: *“how should we get paid for it? which partner should we have? which split should we have? how do we support it? etc.”* Furthermore, evaluating the potential of a servitized offer is much more challenging and riskier than for traditional products because it affects several organizational areas both internal and external. Hence, it can challenge the marketing of the servitized offer. One business development manager (Case A) in the supplier firm declared: *“To be able to sell it [the servitized offer] you must find the economical buyer...the person that can see the value. If you go through the traditional entrance, where you sell your product...they might close the door in front of you.”*

4.2 The most common inter-firm challenge in servitization ecosystem

The cross-case analysis revealed that all four actors (i.e., provider, customer, supplier and sub-supplier) identified ‘partnership management’ as a major challenge at the inter-firm level.

4.2.1 Partnership management- A common challenge for all actors

Given the complex nature of the offering, effective selection and management of the right supply network found to be crucial for the success of servitization. Provider in case C explained that the nature of the customer requirements coupled with regulatory standards created a major challenge in identifying

the “right” suppliers to deliver the solution and to meet expectation. *“It is fundamental to have a set of rules and suppliers that respect them, for example in terms of the use of our brand name [...] all is governed by our procurement's policies, practices, and business controls.”* The process of tendering and supplier selection could be time-consuming and expensive in some cases. Upon selection, there is a need for close engagement to ensure there is common understanding within the supply network and market fluctuations are handled appropriately to deliver the servitized offering successfully.

The servitized providers in all cases expressed that dependency is a major inter-firm challenge. For example, in Case A and C, the dependency on business partners and suppliers is a challenge and in Case E the dependency on group companies and third-party companies is a tension and challenge. An informant from Case E said, *“for example, if you take telematics, we are dependent on the trucks’ platform. It is a shared technology within the group. If we want to update our system, we are dependent on the update on the truck side. If they plan to introduce it five years later than we are, then we are kind of stuck.”* From a customer and a provider perspective, identifying a good partnership found to be crucial especially in exploring new or un-known areas such as digital telematics services. Such new areas involve a lot of risks and more unanswerable questions. *“For example, how do we share risk? how can we partner up? who pays for what? how do we setup the support? who’s responsible for the quality?”*

when should we launch stuff?." In Case A, the engine components are developed in close collaboration with the engine OEM through partnership programs by maintaining both strong and weak ties. One experienced informant from supplier pointed out that, "we work collaboratively early, we want to be even earlier, of course, to have a better plan to develop our offer." Similarly, sub-suppliers from all cases acknowledged that maintaining relationship and trust building with suppliers and providers are a critical challenge. Currently, most of the sub-suppliers are lacking a direct communication or a direct access to the needs with the provider due to the non-establishment of relationship.

4.3 Unique challenges of ecosystem actors at intra-firm and inter-firm levels

In addition to the above common challenges, the analysis also showed several unique challenges for each ecosystem actors. Table 3 outlines the unique intra-firm challenges and Table 4 outlines the unique inter-firm challenges with the related excerpts from cases.

Table 3. Unique intra-firm challenges for each ecosystem actors

Provider	Outsourcing	"We outsource over 95% of our operations to other companies...This means over-reliance on suppliers for core requirements." (Case B) "The PC business sale cut the production costs and led new life into the business (service) unit." (Case C)
	Customer management	"we need to be more responsive in our operations in a real time to achieve service expectations. Our operations need to be highly interactive, which is a new thing for most of our internal departments." (Case A) "Whether the human resource should be sent from Sweden to manage and supervise the service operation or local people to be trained. Different options have their own difficulties and benefits." (Case D)
Customer	Market Uncertainty	"Changes in the business environment such as change in the oil price impacted the customer original motivation for servitization and its values" (Case D) "It's not like we have a mature market where we can just launch stuff and then people will buy it and try it. It's too big gap from where we are and they (customer) as well" (Case E)
	Internal and external relationship	"Accepting changes is not easy, especially if this means to reinvent yourself"(Case A) "To guarantee the needed knowledge to all employees, a lot of different learning methods have been applied and most of them are IT-based" (Case C) "You are led to consider them [external employees] as the enemy" (Case C)
Supplier	Information & knowledge sharing	"We are a small organization... so there is a small number of individuals that we do all our communications with" (Case B) "There are ten to fifteen different functional areas involved sometimes...It's really difficult to communicate" (Case A)
	Knowledge and process maturity	"The value is there. No doubt about that. The question is how to sell it." (Case A) "You can't manufacture something and keep them in stock...technical requirements are often pretty different...for each customer." (Case B) "In some cases, they can deliver, but it is not fast enough. In some other cases they just don't have the capabilities to develop that technology" (Case E)
Sub-supplier	Development process	"We have to synchronize knowledge development with product development. It requires an inclusive approach." (Case A) "We have to change performances of products due to changing operating conditions.... It is difficult from a process perspective." (Case D)

Table 4. Unique inter-firm challenges for each ecosystem actors

Provider	Value creation and development process	"We have to maintain closer relationships with customers and building knowledge base of the customer operations and product usage. This is crucial for understanding the value-creation opportunities" (Case D) "The new part is basically the uncertainty level. It is not just enough to identify the value, but we also need to communicate the value to make some business.....do not have a clear process here" (Case E)
Customer	Information management in value chain	"Customer requirement might change, input specification might change, or business environment might change. The challenge arises because the overall change impacts on the components and sub-systems functionality and creates arguments between the provider and suppliers." (Case D) "Dealing in a B2B environment is more complicated [...] and you need to establish a real relationship of trust with the customer....deal with different knowledge base and technical languages" (Case C)
Supplier	Scalability	"We might have a simple setup to start with, and then with our internal resources we can scale. But then it's not certain that they (other actors) can scale in the same pace...then you will have a bottleneck." (Case E) "We know our application. So, it is all about going out there and trying to find those pieces of puzzle that you need. We need to go outside our door" (Case A)
Sub-supplier	Information management	"We need an up-to-date suppliers' specific problem and needs... We are capturing this information in different systems across the company... Sometimes they are too specific to a department." (Case A) "We like to know more about customer needs. But we do not have a centralized system for sharing data with focal firm" (Case B)
	Opportunity identification	"The company makes money on selling spare parts. If those revenues are decreased, we are forced to think of other ways to make money" (Case A) "Customers always have different types of requests. Sometimes we fail to response faster to focal company" (Case B)

5 DISCUSSION AND CONCLUSIONS

At intra-firm level, extant literature (Martinez *et al.*, 2010; Kinnunen and Turunen, 2012; Alghisi and Saccani, 2015; Zhang and Banerji, 2017) revealed four main internal challenges, namely, culture, offering, strategy, and internal structure/operations/organization. Our empirical analysis shows that three actors (i.e., provider, supplier, sub-supplier) identified ‘coordination’ as a major challenge. Again, three actors (i.e., provider, customer, supplier) identified ‘uncertainty and risk’ as a major challenge. The challenges categorised under ‘uncertainty and risk’ are similar to those categorised under ‘risk’ in the literature. Our findings expand this category by considering uncertainties as well as risks. The case firms in our research identified uncertainty in business processes as well as future business models. Uncertainty was also identified in relation to unknown needs and an immature market, all of which are potential areas that could generate risk. Our findings bring a dimension to the consideration of risk management by expanding it to focus on areas of uncertainty, which could generate risks, thereby advocating a pro-active approach to managing uncertainty before risks emerge. The challenges categorised under ‘coordination’ were also identified in literature under ‘internal structure/operations/ organisation’ categories, therefore findings from this study support extant literature. Some of the challenges in these categories were covered under different categories in literature (e.g., ‘customer management’ covered under ‘offering’ and ‘culture’ categories in literature; process maturity covered under ‘offering’ category in literature); while others were not explicitly covered in literature such as ‘outsourcing’.

Overall, our findings confirm some of servitization challenges identified in literature, whilst – at the same time – expanding them by providing a wider consideration of intra-firm challenges that is not only based on providers but encompasses other actor firms within the servitization ecosystem.

At inter-firm level, findings from our case firms revealed that four actors (i.e., provider, customer, supplier and sub-supplier) identified ‘partnership management’ as a major challenge. Undeniably, partnership and coordination between different value chain actors – who have different capabilities, processes and goals – can pose significant challenges to the servitization process (Basole and Rouse, 2008). Four actors from our case firms stated that there is significant level of dependency on other value chain actors, which necessitates close collaboration and relationship. If this is not well managed, it poses a risk to the delivery of the servitization offering.

This paper provides fresh insight in understanding (common) challenges among ecosystem actors and it enables servitization providers to better understand them from the perspective of each value chain actor and to consider how to address these challenges to maximise the chances of success in their effort to achieve competitive advantage. First, we stress the role of the ecosystem and the need for transformation of capabilities, practises, structure and operations to deliver a competitive servitized offering. Second, we stress the importance of partnership and relationship management among the actors within the ecosystem in order to design and deliver innovative offerings to achieve competitive advantage. Our findings confirm that most of the actors have a similar kind of challenges, especially provider, customer, and suppliers (while sub-suppliers differ). Therefore, close relationship management and interaction to identify and mitigate these challenges in order to deliver successful servitization initiatives are obligatory. Third, we stress the importance of taking a proactive approach to identify areas of uncertainty among actor firms and address these early before they begin to pose risks to the success of servitization. The complexity of servitization naturally leads to some uncertainty, therefore actor’s firms need to identify these early to avoid major risks to servitization during the life cycle (Rabetino, *et al.*, 2015). This is important in order to avoid the servitization paradox or deservitization processes.

These findings would enable engineering designers and managers in manufacturing firms to take a more holistic approach to managing challenges by focussing on each individual actor firm and encouraging them to work together. By interacting and engaging closer with other firms within their ecosystem, tensions and challenges can be mitigated at the level of individual actors in order to achieve a higher level of cohesion across the whole ecosystem.

The present study has contributed to knowledge through a typology of ecosystem challenges, therefore, future research could focus on identifying strategies and capabilities to overcome the challenges from an ecosystem perspective. This would help to foster a collective approach to overcoming these challenges. Future research may consider categorizations which reflect quantitative factors along the qualitative ones. Finally, future research could involve performing studies with cases that have a wider level of actor participation including more supplier and sub-suppliers.

REFERENCES

- Ayala, N.F. et al. (2017), "Knowledge sharing dynamics in service suppliers' involvement for servitization of manufacturing companies", *International Journal of Production Economics*, Vol. 193, pp. 538–553.
- Aarikka-Stenroos, L. and Jaakkola, E. (2012), "Value co-creation in knowledge intensive business services: a dyadic perspective on the joint problem-solving process", *Industrial Marketing Management*, Vol. 41 No. 1, pp. 15–26.
- Alghisi A. and Saccani, N. (2015), "Internal and external alignment in the servitization journey – overcoming the challenges", *Production Planning & Control*, Vol. 26, No. 14–15, pp. 1219–1232.
- Baines, T. et al. (2017), "Servitization: revisiting the state-of-the-art and research priorities", *International Journal of Operations & Production Management*, Vol. 37, No. 2, pp. 256–278.
- Burton, J. et al. (2016), "Identifying Tensions in the Servitized Value Chain", *RTM*, Vol. 59, No. 5, pp. 38–47.
- Basole, R.C. and Rouse, W.B. (2008), "Complexity of service value networks: Conceptualization and empirical investigation", *IBM Systems Journal*, Vol. 47, No. 1, pp. 53–70.
- Braun and Clarke (2006), "Using thematic analysis in psychology", *Qualitative Research in Psychology*, Vol. 3 pp. 77–101.
- Cenamor, J. et al. (2017), "Adopting a platform approach in servitization: Leveraging the value of digitalization", *International Journal of Production Economics*, Vol. 192, pp. 54–65.
- Chirumalla, K. (2013), "Managing knowledge for product-service systems innovation: The role of Web 2.0 technologies", *Research-Technology Management*, Vol. 56, No. 2, pp. 45–53.
- Chirumalla, K. (2016), "Organizing lessons learned practice for product-service innovation", *Journal of Business Research*, Vol. 69, pp. 4986–4991.
- Dachs, B. et al. (2013), "Servitisation of European manufacturing: evidence from a large scale database", *The Service Industries Journal*, Vol. 34, No. 1, pp. 5–23.
- Eloranta, V. and Turunen, T. T. (2015), "Seeking competitive advantage with service infusion: a systematic literature review", *Journal of Service Management*, Vol. 26, No. 3, pp. 394–425.
- Eisenhardt, K. M. and Graebner, M. E. (2007), "Theory building from cases: Opportunities and challenges", *Academy of Management Journal*, Vol. 50, No.1, pp. 25–32.
- Johnson, M. and Mena, C. (2008), "Supply chain management for servitised products: a multi-industry case study", *International Journal of Production Economics*, Vol. 114, No.1, pp. 27–39
- Kinnunen, R. and Turunen, T. (2012), "Identifying Servitization Capabilities of Manufacturers: A Conceptual Model", *Journal of Applied Management and Entrepreneurship*, Vol. 17 No. 3, pp. 55–78.
- Lightfoot, H. et al. (2013), "The servitization of manufacturing: A systematic literature review of interdependent trends", *IJOPM*, Vol. 33 No. 11/12, pp. 1408–1434.
- Lüftenegger et al. (2013), "The Service-Dominant Ecosystem: Mapping a Service Dominant Strategy to a Product-Service Ecosystem", In: *IFIP AICT* Vol. 408, pp. 22–30.
- Luoto, S. et al. (2016), "Critical meta-analysis of servitization research: Constructing a model-narrative to reveal paradigmatic assumptions", *Industrial Marketing Management*, Vol. 60, pp. 17–32.
- Lightfoot, H. and Baines, T. (2013), "Made to serve", *Made to Serve: How Manufacturers Can Compete Through Servitization and Product Service Systems*. Wiley.
- Miles, M. B. and Huberman, A. M. (1994), "Qualitative data analysis: An expanded sourcebook". Sage.
- Martinez, V. et al. (2010), "Challenges in transforming manufacturing organisations into product-service providers". *Journal of Manufacturing Technology Management*, Vol. 2 No. 4, pp. 449–469.
- Matschewsky, J. et al. (2017), "Designing and providing integrated product-service systems—challenges, opportunities and solutions resulting from prescriptive approaches in two industrial companies", *International Journal of Production Research*, Vol. 56 No. 6, pp. 2150–2168.
- Neely, A. (2009), "Exploring the financial consequences of the servitization of manufacturing", *Operations Management Research*, Vol. 1 No. 2, pp. 103–118.
- Oliva, R. and Kallenberg, R. (2003), "Managing the transition from products to services", *International Journal of Service Industry Management*, Vol. 14 No. 2, pp. 160–172.
- Parida, V. et al. (2015), "Developing global service innovation capabilities: How global manufacturers address the challenges of market heterogeneity", *Research Technology Management*, Vol. 58 No.5, pp. 35–44.
- Patton, M.Q. (2002), *Qualitative research*, SAGE Publications.
- Rabetino et al. (2015), "Developing the concept of life-cycle service offering", *IMM*, Vol. 49, pp. 53–66.
- Raddats, C. et al. (2017), "Interactively developed capabilities: evidence from dyadic servitization relationships", *International Journal of Operations & Production Management*, Vol. 37, No.3, pp. 382–400.
- Sjodin, D. et al. (2017), "Barriers and conditions of open operation: a customer perspective on value co-creation for integrated product-service solutions", *International Journal of Technology Marketing*, Vol. 12 No. 1, pp. 90–111.
- Strauss, A. and Corbin, J.M. (1990), *Basics of qualitative research*. Sage Publications, Thousand Oaks, CA, US
- Windahl, C. and Lakemond, N. (2006), "Developing integrated solutions: the importance of relationships within the network", *Industrial Marketing Management*, Vol. 35, No. 7, pp. 806–818.
- Yin, R. K. (2008), *Case study research: Design and methods*. Sage Publications, Thousand Oaks, CA.
- Zhang, W. and Banerji, S. (2017), "Challenges of servitization: A systematic literature review", *Industrial Marketing Management*, Vol. 65, pp. 217–227.