Service Modularity and Architecture – an overview and research agenda

Introduction

This special issue on service modularity responds to the growing demand for architectural and design knowledge focusing on service offerings and service business.

Modularity has intrigued researchers for many years (Starr, 2010) and can be traced back to the early work of Simon (1962) who, in developing a general systems theory, argued that hierarchical decomposition of systems can lead to the reduction of complexity. Since then there has been a substantial development of our understanding of modularity across many dimensions, but with the prime focus on the architecture of manufactured products. Sanchez (1999) elaborated on the systems view of Simon (1962), and Ulrich (1995, p. 419) saw the interfaces between components as "the scheme by which the function of a product is allocated to physical components". Architecture is a broader concept that includes product modularity, component complexity, product platforms, loosely coupled interfaces, component commonality and number of components (Fixson, 2005). Product architecture decisions are closely related and include the way that systems are decomposed, the selection of components to be used, and the way that these components are aligned with one another (Mikkola, 2006). Despite the rapid growth of modularity research, the research has been almost exclusively confined to the assembled products context and, seemingly, it is expected that the principles of product modularity apply in the services context (e.g., Schilling, 2000).

The growing interest in service business and services led to the question as to whether the principles and theories developed in the context of products could be applied to service systems and whether the application of modularity could also lead to the benefits put forward for products (Bask *et al.*, 2010). Opening the discussion in the service management field, Sundbo (1994) considered modularization as a means to increase standardization in service production. Menor *et al*. (2002) viewed the development and application of the modularity concepts as one of the key challenges in service design and innovation. Recent theory in the field of service operations management considers service offerings to be process-based (Brax, 2013) and typically dependent on customer input (Sampson and Froehle, 2006; Sampson, 2010; 2012). For this reason, modularity concepts and principles that developed in the context of physical products and manufacturing need to be reconsidered.

Recognizing this gap led Voss and Hsuan (2009) to develop a conceptual review of service architecture and modularity. In conceptualizing service architecture, they built on the systems approaches of Simon (1962) and Sanchez (1999) decomposing services in a four level approach; industry, service company/supply chain, service bundle and service package/component. They then identified some of the issues that needed to be explored further including architectural choices, customization and personalization and service agility. Voss and Hsuan (2009) also examined some of the issues in applying modularity concepts in services in particular the high degree of heterogeneity in services and the growth of new areas of service such as 'servitization' (cf. Baines and Lightfoot, 2014; for a recent meta-analysis, see Brax and Visintin, 2017).

An emerging service modularity research community

This overview of service architecture and modularity research was used as the starting point for annual academic seminars on modularity and architecture in services. The special issue call has its roots in these seminars, which have discovered and further promoted a growing area of research around multiple aspects of service modularity and in different empirical contexts. The first International Seminar on Service Modularity was held at Copenhagen Business School, Denmark, in 2010, where the

contributions came from a limited number of institutions, primarily from northern Europe. Since then, the cross-disciplinary seminar has been organized annually across Europe, bringing together research contributions related to service modularity and architecture on a wide range of areas, from new ideas to more developed research. Institutions that have hosted the seminar to date are Copenhagen Business School (Denmark) in 2010 and 2017; Aalto University (Finland) in 2011 and 2015; Brunel University (United Kingdom) in 2012, and University of Hamburg (Germany) in 2013.

One of the objectives of the seminars has been to support doctoral students with their research by providing the opportunity to get feedback from senior researchers. Since the initiation of this international service modularity community several doctoral dissertations on the topic (and other modularity perspectives) have been published (e.g., de Blok, 2010; Frandsen, 2012; Brax, 2013; Rajahonka, 2013a; Van der Laan, 2015; Dörbecker, 2016; Kubota, 2017; Vähätalo, 2016), and many more forthcoming. Within this community a number of articles have also been published.

Brief overview of research on service modularity

Published research in this area has examined a wide range of topics. Synthetizing on earlier works, Tuunanen *et al*. (2012, p. 101) define a *service module* as "a system of components that offers a well-defined functionality via a precisely described interface and with which a modular service is composed, tailored, customized, and personalized". Important benefits expected from modularity are *customization* and *personalization*, which have been explored by de Blok *et al.* (2010a), Moon *et al.* (2010), Bask *et al*. (2011), and Silvestro and Lustrato (2015).

Another central theme in modularity design is the *interfaces* between components, modules and subsystems and within the modular architecture. De Blok *et al*. (2014, p. 186) define interfaces in modular services as "the set of rules and guidelines governing the flexible arrangement, interconnections, and interdependence of service components and service providers". Furthermore, de Blok *et al*. (2014) developed a typology of interfaces in modular services. They divide interfaces into four categories: open-customer flow (O-C) interfaces among service components that support variety; closed-customer flow (C-C) interfaces among service components that support coherence; open-information flow (O-I) interfaces among providers enable variety in service packages; and closed-information flow (C-I) interfaces that support coherence and unity among providers (de Blok *et al.*, 2014).

Associated with interfaces is the concept of *decomposition* (Eissens-van der Laan *et al.*, 2016). Using decomposition as the starting point, Simon (1962) defines a *service architecture* as the way in which the service system functionalities are decomposed into individual functional elements that together deliver the overall services provided by the system. The architecture can be viewed as consisting of decomposition levels that can vary from integral to modular (Mikkola, 2006). The development of interfaces enables decomposition of the service production system, which in turn favors multi-organizational constellations such as outsourcing (cf. Miozzo and Grimshaw, 2005).

The role of *platforms* and platform thinking is a theme of growing importance, and was widely discussed at the 2017 Seminar on Service Modularity. Studies contributing to this stream in the service context include those by Meyer and DeTore (2001), Meyer *et al*. (2007), Pekkarinen and Ulkuniemi (2008) and Hofman and Meijerink (2015). A product platform is often interpreted as a set of subsystems and interfaces that form a common structure for developing a family of products and the foundation for offering a wide range of product variety through the mixing-and-matching and reuse of modular components (Meyer and Lehnerd, 1997; Muffatto and Roveda, 2002; Mikkola and Skjott-Larsen, 2006). It comprises a collection of assets that a set of products share (Robertson and Ulrich, 1998). A robust platform serves as the foundation of successful product families (Meyer and Utterback, 1993), which is closely interrelated with product architecture modularity strategies (Baldwin and Clark, 1997; Henderson and Clark, 1990). Having platform leadership enables a firm to drive innovation around a particular technology (Cusumano and Gawer, 2002). Research on product platform management has

been predominant in the automotive industry (Muffatto and Roveda, 2002; Mikkola, 2003; Fixson, 2005) and consumer electronics (Sanderson and Uzumeri, 1995; Lau *et al.*, 2010).

As mentioned, one of the issues in service modularity is the heterogeneity of the *contexts* in which the concepts could be applied. A popular context for service modularity research is *healthcare*, particularly through the work of de Blok *et al*. (2010a; 2010b; 2013; 2014) but also from Meyer *et al*. (2007), Vähätalo and Kallio (2015), and Eissens-van der Laan *et al*. (2016). *Logistics* services is another context with great potential for exploitation of service modularity (Rajahonka, 2013a, 2013b; Rajahonka *et al.*, 2013; Cabigiosu *et al.*, 2015; Rajahonka and Bask, 2016). Other contexts that have attracted research focus so far are financial services (Sundbo, 1994; Voss and Hsuan, 2009; Frandsen, 2012; Silvestro and Lustrato, 2015), electronic commerce (Bask *et al.*, 2014), automotive industry (Bask *et al.*, 2011), ICT services (Hyötyläinen and Möller, 2007; Dörbecker and Böhmann, 2015), and sea cruise services (Voss and Hsuan, 2009). Conceptual groupings of services that cross industry sectors include B2B and business services (Pekkarinen and Ulkuniemi, 2008; Böttcher and Klingner, 2011) and knowledge-intensive business services (Brax and Toivonen, 2007; Cabigiosu *et al.*, 2015).

New service development and service *innovation* is a popular research topic across the different contexts (Meyer and DeTore, 1999; Miozzo and Grimshaw, 2005; Brax and Toivonen, 2007; Rajahonka and Bask, 2016). Another one is implementing modularity in *supply chains* (Lin and Pekkarinen, 2011; Rajahonka, 2013b; Bask *et al.*, 2014). Further analytical perspectives on modularity in services, examined so far, include the levels of *process modularity* (Carlborg and Kindström, 2014; Tuunanen and Cassab, 2011) and *organizational modularity* (Cabigiosu *et al.*, 2015).

A more detailed analysis of service modularity literature was recently conducted by Iman (2016). To conclude, this overview demonstrates that the pioneering work in the area of service modularity is spread across a broad array of topics and research contexts, and topics are far from becoming matured and replete.

Research agenda

Despite the pioneering and growing work in this field of study, as might be expected in a relatively new area is that the common language in service modularity is still developing. In a young research field this is to be expected, and bringing together extant and new research in this special issue will contribute to resolving this. Thus, this section portrays recommended areas in which to target further research on service modularity and architecture.

1. Theoretical underpinnings of service modularity and service platforms

Definitions of various key areas are evolving; what is a service architecture, a module, or a platform? As Voss and Hsuan (2009) put it, the problem with definitions is not only limited to service modularity, but more broadly on how services are defined and categorized (for an analysis of definitions, see Brax, 2013). This overview has adopted a broad and inclusive view of services including core services and supporting or auxiliary services, as well as what is traditionally considered as a service firm or organization and a service industry.

Another area to be addressed is what the generic levels of decomposition are. How to distinguish between a component, a module and a subsystem in the context of service production where the key aspects of the offering are immaterial? The level of architectural analysis in modularity varies; examples of different levels are components, modules, offerings, product families, subsystems, organizations, industries, and markets. Navigating this field is difficult, as concepts like platforms can span across the different levels. Thus, theoretical and conceptual clarity needs to improve in the field and its common language to develop, suggesting that high quality contributions with theoretical focus on service modularity, platforms or service architecture can make a significant impact.

2. Studies on platform-based service business models, including mass-customization in services

Similar to modularity research, platform thinking has recently been extended to include wider perspectives, such as industry and supply-chain platforms (Gawer and Cusumano, 2014), multi-brand platforms (Sköld and Karlsson, 2007), multi-sided/two-sided platforms (Eisenmann *et al.*, 2006; Parker *et al.*, 2016), service platforms (Pekkarinen and Ulkuniemi, 2008), development of new services (Meyer and DeTore, 2001), and servitization (Eloranta and Turunen, 2016). The product variety enabled by platforms and modularity has spawned many studies on mass customization of products (Duray *et al.*, 2000; Salvador *et al.*, 2002; Mikkola, 2007), and recently extending it to business-to-business and business-to-consumer (Fogliatto *et al.*, 2012; Mikkola and Skjott-Larsen, 2006). Recent years have introduced many new service business models that are based on commercial service platforms connecting the customer side with the supply side, such as Amazon, Alibaba, Uber, Etsy, and Airbnb. An example of a mass-customized service concept is Yousician, a musical online training service for both students and teachers. Thus, possibilities to conduct empirical research on platform based services area are now better than ever.

3. Comparative research to move away from context-specific theorizing

The industries that have received most of the attention so far in this field are healthcare and logistics services. This is not surprising when considering the organization of service production in these industries. Healthcare is a complex network of specialized service production units, personnel, resources and information, the duration of a service is relatively long and involves several interactions, and processes are standardized and monitored. Logistics keeps the global operations on the move and consists of a network providers spread geographically with a clear ability to bring together different type of service modules and service providers. It is likely that drivers, needs and requirements for modularization are different in service contexts such as mass services, service factories, service shops and professional services (Schmenner, 1986; Silvestro *et al.*, 1992).

Service research encompasses great contextual diversity and there is a need to identify the context-specific nature of middle range theory and the contextual logic of general theory (Voss *et al.*, 2016). Thus, research needs to go beyond focusing on modularity in particular types of organizational settings; our understanding of modularity in services can be advanced through comparative research. Comparison helps to identify context-specific characteristics and provides insight on aspects that could be generalizable to broader contexts in terms of theoretical generalization (Yin, 1994). Comparative research assists by increasing understanding, for example, where modularity could provide competitive advantage for companies in different industries.

4. Implementing modularity in service operations

Given that services are inseparable from their production and consumption systems (Brax, 2013), the adoption of modular service architecture may represent major change in the level of individuals, units, organizations and their suppliers and customers. In many cases service modularity develops as a result of organizational, technological and industry evolution. As knowledge about service modularity increases, experience and insight on the design and implementation of modular architecture and adoption of related technologies will be sought for. Design and management of interfaces in a modular service system is also an important organizational aspect and spans beyond the level of designing product-level modular architecture. For example, acknowledging the mirroring hypothesis (e.g., Sanchez and Mahoney, 1996; Cabigiosu and Camuffo, 2012), whether modular service products would lead to organizational modularity in service networks could be one future research topic.

5. Service experience and customer perspectives on modularity

Modularization often changes the service design experienced by the customer. Services differ in their experiential intensity; in transactional services customer satisfaction focuses on the efficiency and convenience of the service delivery, whereas in experience-centric services evoking emotional processes in customers is at the core of the service (Voss *et al.*, 2008; Zomerdijk and Voss, 2010). It has been argued that modularity can be used to increase customization and personalization (cf.

Tuunanen *et al.*, 2012). However, un-modularized services may be less standardized, and thus able to accommodate customer requests to adjust the service more flexibly. There is thus scope for increasing our understanding of the impact of modularity on the customer experience. While modularity can increase manageable variety it may also impose restrictions to customers' scripts and habits in particular service setting when some particular configurations are no longer provided. On the other hand, modularization can be used as a means to make the service production more efficient and improve coordination between service modules and options and between their producers, without providing increased variety for the customer. Customers have essential role in co-creation of service as they actively participate in service production process. Customer perceptions are likely to differ between customer segments and depending on the type of service offering (Voss *et al.,* 2008).

Research on service experiences and customer perspectives should provide answers to two key questions: First, how does implementation of modularity, and the co-creation of a modularized service, influence the customers' service experience? Second, how to determine best approaches and combinations of service elements in different service settings in order to combine modular elements, customize and personalize the service offering effectively?

6. Determinants of performance in the context of modular services; empirical evidence on benefits and challenges

Organizations face tightening pressures to offer and organize their services in effective, efficient and customer-oriented manner. The literature suggests that modularity can endorse performance efficiency and cost savings due to the improved operational and functional flexibility (Schilling, 2000; Voss and Hsuan, 2009; Bask *et al.*, 2010). Despite assertions as to how modularity can positively influence performance in services and service delivery processes, there rigorous research in this area is scant. The intersection of modularity, interfaces and performance management points to an important avenue for future research. Will different approaches of service modularity lead to different performance outcomes? How does the object of measurement influence the service delivery and the outcome of service? Are the performance indicators of service modules supporting the overall performance of the service delivery process? How to avoid unwanted sub-optimization of performance in service delivery, especially in multi-provider contexts?

Moreover, Dörbecker and Böhmann (2013) indicate that scholars have overlooked the risks and negative effects of modular service designs. They argue that possible trade-offs in design choices need to be explored in order to identify boundary conditions for the application of service modularity. There is thus a need to investigate the risks and possible downsides associated with modularization and modular service architectures.

7. Architectural innovation in services

Architectural innovation has been found to be a driver of radical innovation (Henderson and Clark, 1990). The implementation of modularity in new contexts may represent an architectural innovation, and earlier research has identified architectural service innovations enabled by introducing modularity in the level of the service offering (Brax and Toivonen, 2007). This encourages future studies on the processes for innovating, designing and developing modular services. Moving beyond the level of the offering, Fine (2000) introduced clockspeed strategies and double helix dynamics between integral to modular supply chains structures in the product context. Similarly, the dynamics in service architectures and industry structures should be studied, to increase understanding of the patterns and drivers associated with the moves of service industries towards more integral or modular organizational forms.

8. Modularization of services in multi-provider contexts

Services are increasingly delivered as part of an ecosystem involving multiple players. A potential and relatively unexplored aspect of service modularity is exploiting the characteristics of modularity in a multi-provider context to allow rapid and effective configuration of complex services provided by

multiple suppliers. Although this has been studied in the context of logistics and healthcare, there is potential for identifying contexts where this can lead to benefits for both providers and customers. The abovementioned platform examples identified services that connect independent providers and customers for relatively simple service exchanges. In more complex service offerings, modularity enables the participation and coordination of independent service providers producing component services. Component services are those that are delivered to subsequent customers, directly, i.e., without transformation by the buying firm (Wynstra *et al.*, 2006). Research on such modular production networks in the services context is scant, and attention is needed in both B-to-B and B-to-C contexts, and including organizations from private and public sectors and their combinations.

9. Modularity in hybrid offerings that combine service and tangible product modules

The special issue and the research agenda has focused on service offerings in service dominant contexts, as this is the side of modularity that needs to be studied to complement the vast body of modularity literature on physical products and systems. However, complex offerings in the markets are rarely pure services or purely tangible goods, but packages that combine elements of both types and information (cf., Brax and Jonsson, 2009). How is modularity theory adjusted to serve these contexts? A fruitful field to explore modularity and platform-based approaches in complex hybrid offerings are the integrated solutions business model and the companies that are engaged in servitization. Thus it is encouraged that scholars in the servitization and product service systems fields turn towards research questions on modularity.

The special issue

Compiling the special issue

This special issue welcomed manuscripts with research themes that combine a research problem in the area of modularization, modular architecture and/or platforms with a clear focus on services. Submissions called for papers relevant for the Operations Management community that addressed modularity, modularization, platforms or other structural aspects of business models and offerings in a service context. We welcomed manuscripts that present rigorous qualitative or quantitative empirical studies, including case based research and design science approaches. We also encouraged manuscripts with conceptual work that significantly develops the foundations and theory of modularity in services.

The review process followed the IJOPM editorial process structure consisting of an initial desk review and subsequent rounds of double-blind reviews with at least two reviewers. The Special Issue received 24 manuscript submissions; the 71 authors represented 32 academic institutions from 15 different countries in five continents. Despite this highly international participation, the acceptance rate of the Special Issue remains at 16,7 % with four articles. Throughout the process, four papers were desk rejected (16,7 %), 12 rejected after first double blind review round (50 %) that utilized three reviewers, one withdrawn, three papers rejected after second review (12,5 %). Case research was the most popular research approach with 13 contributions, followed by four quantitative surveys, two modeling studies, two conceptual papers, two design research studies and one literature review with bibliometric analysis.

The submitted manuscripts addressed the research area broadly. Keywords included topics related to *modularity theory* (e.g., module, platform, interface, architecture); specific *domains of modularity* (e.g., process modularity, organizational modularity, customization); different types of *business contexts* (e.g., professional service firm and knowledge-intensive services, servitization, product-service systems, healthcare, digital services such as mobile payments and e-commerce); and included broader *themes and concepts* such as business models, value propositions, processes and supply chains, vertical integration and make-or-buy decisions, innovation and the design process, business ecosystems, performance, coordination, operations strategy, cloud platforms, e-business, and internet of things. This

listing gives some idea about the themes that currently interest researchers and from which contributions can be expected in the near future.

The editorial process was strictly double-blinded with all submissions. Saara Brax, Anu Bask, Juliana Hsuan and Chris Voss guest edited the process for 22 contributions. The manuscript by Viktor Avlonitis and Juliana Hsuan was guest edited by Brax, Bask, Voss and Associate Editor Pamela Danese, and the manuscript by Silander *et al.* by Pamela Danese. For all manuscripts three reviewers were involved in the first review round to provide ample constructive feedback and to ensure fair process despite the relatively small size of the research area. The Special Issue consists of four articles that are presented next.

Presentation of the papers

This special issue features one bibliometric analysis and three empirical research papers. First, in "Evolution in modularity literature: a 25-year bibliometric Analysis", Thomas Frandsen (2017) provides a comprehensive analysis of modularity literature. Then, the three empirical articles provide significant additions to theories on service architecture. In their article, "What professionals consider when designing a modular service architecture", Manda Broekhuis, Monique Eissens Van der Laan, and Marjolein Van Offenbeek (2017) investigate designing a modular service architecture in elderly care setting. In the article "Exploring modularity in services: Cases from tourism", Viktor Avlonitis and Juliana Hsuan (2017) examine two polar cases representing opposite extremes in the modular-integral continuum in the context of traveling. Finally, in "Modularizing specialized hospital services: constraining characteristics, enabling activities and outcomes", Katariina Silander, Paulus Torkki, Paul Lillrank, Antti Peltokorpi, Saara Brax and Minna Kaila (2017) compare modular and integral operating models in specialist healthcare.

The article "*Evolution in modularity literature: a 25-year bibliometric Analysis*" by Frandsen (2017) reviews and analyzes literature on modularity using a systematic literature search methods, bibliometric techniques and network analysis. In addressing the view of modularity from a managerial perspective, Frandsen follows Baldwin and Clark's (2000) definition of modularity. He identifies both established and emerging approaches on modularity.

Frandsen maps citation patterns to discover how the modularity research area evolved between 1990 and 2015. The articles were divided in three periods; early period (the 1990s), formation period (the 2000s), and recent period (2010–2015), and the patterns of development are nicely visualized. Interestingly, in the period 2010 to 2015 the *International Journal of Operations and Production Management* (IJOPM) was the 10th most cited journal by articles on modularity. The findings demonstrate how literature has developed from the initial focus on the product modularity to the broader area of modularity, becoming a diverse and interdisciplinary field of research with widened scope and extended levels of analysis. The findings also demonstrate an evolution from theoretical frameworks and propositions to empirical studies based on diverse research methods. Frandsen's analysis discovers eight emerging sub-research areas of modularity, one being the modularity in the context of services. In this area, he finds three articles forming a core in service modularity; these are by Pekkarinen and Ulkuniemi (2008), Voss and Hsuan (2009), and Bask *et al.* (2010). The analysis provides an important addition to the pre-existing body of literature reviews on this topic by identifying established and emerging areas of research on modularity. The article concludes by suggesting several future research avenues in modularity research based on the analysis.

The article "*What professionals consider when designing a modular service architecture*" by Broekhuis *et al.* (2017) explores how and to what extent modularity principles can be designed into a service architecture, more precisely how functional and appropriateness arguments impact the adoption of modularity principles during the design of a professional service architecture. Appropriateness means that organizations and the actors within them respond to the functional demands of their work activities and also to broader ideas and norms in their industry or field. The aim is to show how tensions between

functional requirements and between functional and appropriateness arguments affect the made design choices.

To investigate the design process of a modular service architecture for specialized elderly care by a multi-professional group Broekhuis *et al.* (2017) implemented action research design, which allowed them to collate feedback from professionals over time. Their analysis focuses on the emerging design choices and the arguments underlying them, and recognizes a wide range of both functional and appropriateness considerations during the design process. They identified three core modularity principles for modules: the modules need to have a specific function; be relatively independent; and, for integration purposes, have standardized interfaces. These modularity principles are converted into five key design choices (decomposition layers, orientation, relative independence, interface standardization and with-in module standardization). In their case setting, all three modularity principles were adopted in varying degrees, but for the 'relative independence' and 'standardized interfaces' principles adoption was quite limited.

The study makes an important extension to service modularity theory by formulating three trade-offs that are required in translating the core modularity principles and explaining how tensions between functional requirements and between functional and appropriateness arguments affect the design choices. Moreover, the study demonstrates that an iterative design process is required for the deployment of the core modularity principles in professional services: the inherent ambiguity of the service setting may facilitate developing a design that is deemed appropriate in that task environment.

In "*Exploring modularity in services: Cases from tourism*", Avlonitis and Hsuan (2017) analyze manifestations of modularity in service designs. Their conceptualization of service architectures draws on service design, modularity, and market relationships. They examine the overall service architecture of two travel service firms at three different levels of analysis: service concept, service delivery system, and service network. In this framework, customer experience is divided into three sequential stages (before, during and after of a service encounter) and constitutes a vital element of the service concept. The service delivery system focuses on inter-organizational work routines and processes, where functions (tasks) and structures (departments) become interdependent. The service network examines modularity in terms of downstream and upstream partners involved in service delivery.

The research follows a multiple embedded case study, where the authors compare two tourism companies that offer similar services in the same geographical region but represent polar case types, that is, cases that represent opposite extremes of the modular-integral continuum. The analysis shows that both cases demonstrate a mix of modular and integral characteristics; i.e., different segments of the architecture can be modular or integral independent of how an offering is made available to the market. Demonstrating that the design rules for modularity and integrality may differ at each level of the architecture, this study extends the modularity continuum concept to services, also adding new dimensions. The three-stage perspective for the service concept yields preliminary insights into the long-standing gap about the impact of modularity on customer experience. It is also a way to unravel the complexity of the mirroring hypothesis in services.

The article "*Modularizing specialized hospital services: constraining characteristics, enabling activities and outcomes*", by Silander *et al.* (2017), explores modularity of an outpatient care unit in a university hospital to identify enablers, constraints, and outcomes related to modularization in advanced healthcare contexts. In the study, enablers refer to factors and conditions that influence the studied outcome favorably or even as prerequisites, and constraints refer to factors and conditions that prevent or hinder modularization. The research design, qualitative comparative study of a hematology unit with modular service architecture (re-designed as modular, before integral) and an oncology unit with integral service architecture in the same university hospital, provides a rare opportunity to conduct comparative analysis within a single parent organization; i.e., to compare the pre-existing and the redesigned service architecture to provide specialty healthcare service.

Through earlier literature and the case study, the researchers identify and analyze how the following hospital characteristics may affect modularization: fragmented service delivery, professional autonomy, hierarchy, information asymmetry, and the requirement to treat all. The case study demonstrates how modularization can be used in complex specialized hospital services and how modularization changes the service architecture in the studied unit. The study identifies enablers such as clear division of work tasks and well-defined patient criteria that influence the process of modularization of the hematology unit. Yet, the modular design constrains informal communication between personnel groups, and the standardization required in packaging of services combined with the hospitals' requirement to treat all creates a need to decide which care procedures are frequent enough for modularization.

The findings are summarized into a framework. Five propositions combining the characteristics of specialized hospital services, enabling activities, and outcomes of modularization are developed to identify how the underlying characteristics of hospital services can influence modularization; what actions enabled the modularization of outpatient care; and what were the outcomes of service modularization in the hospital care context. The research contributes to service modularity literature by demonstrating how the enabling activities in the design phase support modularization of services when inherent characteristics of the service cause inertia in the modularization process. In addition, the study elaborates on the existing literature by presenting concrete propositions of the detailed relationships between service characteristics, design activities and outcomes.

Concluding remarks

The current Special Issue on Service Modularity and Architecture at hand draws attention to the topical research stream. The needs to better understand the possibilities and requirements in designing modular service architectures are increasing due to major megatrends influencing service provision in both consumer and B2B arenas, such as outsourcing, servitization, digitalization and mobility. Digitalization accelerates the innovation of new service offerings and opens up the business ecosystem in which services are provided and consumed. Outsourcing influences organizational design but also the service as former in-house operations become service offerings between organizations. Servitization provides pay-per-use alternatives to investing on capital goods and enables sharing of resources between different parties. As a consequence services are becoming increasingly modular and complex, and involving different providers in service supply networks. The four articles and this guest editorial serve as a starting point and inspiration for researchers interested in cross-disciplinary work related to service modularity and architecture.

Saara A. Brax
PhD. (Tech.), Postdoctoral Researcher (Academy of Finland)
Department of Industrial Engineering and Management
Aalto University, School of Science, Finland
saara.brax@aalto.fi

Anu Bask
PhD. (Econ.), Assistant Professor
Department of Information and Services Economy
Aalto University, School of Business, Finland
anu.bask@aalto.fi

Juliana Hsuan
PhD., Professor of Operations and Innovation Management
Department of Operations Management
Copenhagen Business School, Denmark
jh.om@cbs.dk

Chris Voss
PhD., Professor of Operations Management,

Warwick Business School, UK
Emeritus Professor of Management Science and Operations
London Business School, UK
cvoss@london.edu

Short bios:

Saara A. Brax

Saara Brax holds a Post-doctoral Researcher position, granted by the Academy of Finland, at the Department of Industrial Engineering and Management in Aalto University's School of Science. Her research focuses on industrial and business-to-business services, especially companies that provide integrated solution offerings or implement Servitization strategies. Her research and teaching interests include the development of service processes, offerings, organizations and systems; service modularity and architecture; and interfaces and operations in service organizations. Saara Brax gained her D.Sc. (Tech.) degree from the Department of Industrial Engineering at Aalto University, and her dissertation focuses on the process aspect in both industrial and knowledge-based services. Previously she has worked as Post-doctoral Researcher at Aalto University, School of Business and in BIT Research Centre in Aalto SCI. She has served as a Co-guest Editor for the *Journal of Service Management*. Her research has been published in *International Journal of Production and Operations Management*, *Industrial Marketing Management*, *Journal of Service Management*, *Supply Chain Management – an International Journal*, *Managing Service Quality*, *and Service Business*, among others.

Anu Bask

Anu Bask is an Assistant Professor in Logistics at Aalto University School of Business, Department of Information and Service Economy. Before current position she has worked as Academy of Finland Postdoctoral Researcher at the same department. She serves as Director of the Kataja's Finnish Graduate School of Logistics and Supply Chain Management and has served as the Leader of the Aalto Service Factory's SERMO thematic group. She has been also a Visiting Researcher in Chalmers University of Technology, Sweden, and Copenhagen Business School, Denmark. Her research interests include service supply chain management, supply chain relationships, modularity approach in services, service processes and sustainable service supply chain management. She has published over twenty articles in international refereed journals and a number of other publications. She has also been a co-editor of a special issue of the *International Journal of Productivity and Performance Management* and *MarIus Periodical.*, and a reviewer for several international journals and conferences. Her research has been published in *Service Science, Journal of Business and Industrial Marketing, International Journal of Services and Operations Management, Tourism Management, International Journal of Physical Distribution and Logistics Management, International Journal of Logistics Management, Journal of Transport Geography*, among others.

Juliana Hsuan

Juliana Hsuan is Professor of Operations and Innovation Management at the Copenhagen Business School, Denmark. She worked as an automotive electrical design engineer with Motorola in U.S. before joining academia. She served as an officer for INFORMS TMS, a board member of EUROMA and is a faculty member of CEMS Logistics Group. Her teaching and research interests include (service) operations management, servitization, supply chain management, innovation management, modularization strategies, mass customization, and portfolio management of R&D projects. Her research has been published in *International Journal of Operations and Production Management, Decision Sciences, Journal of Product Innovation Management, IEEE Transactions on Engineering Management, Production Planning and Control, Technovation, R&D Management, Journal of Cleaner Production*, among others. She has co-authored two textbooks: *Managing the Global Supply Chain*

published by Copenhagen Business School Press, and *Operations Management* published by McGraw-Hill.

Chris Voss

Chris Voss is Professor of Operations Management Warwick Business School and Emeritus Professor of Operations Management at London Business School, where he served as deputy dean, and a senior fellow at the UK's Advanced Institute for Management Research. He obtained his PhD from London Business School. He is a fellow of DSI, EurOMA and POMS and was elected distinguished scholar by the OM division of the Academy of Management in 2008. He has researched and written extensively in the area of service operations and is founder and leader of the International Service Study, a multi-country study of service operations, and was president of the POMS college of Service Operations from 2006-2009. His recent research has included service design of experience-centric services, service architecture and modularity, e-services, globalization of services and service innovation. His research has been published in: *Journal of Service Research*, *Journal of Operations Management*, *Production and Operations Management*, the *Journal of Product Innovation Management*, *Decision Science Journal*, *International Journal of Operations and Production Management* and others. His teaching has included Management of Services, and Managing Sport and Entertainment. He was founder and long-term chairman of the European Operations Management Association, and serves on several editorial boards.

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