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International Journal of Production Research

ISSN: 0020-7543 (Print) 1366-588X (Online) Journal homepage: https://www.tandfonline.com/loi/tprs20

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To cite this article: V.J.T. Peters, B.R. Meijboom & E. de Vries (2018) Interfaces in service modularity: a scoping review, International Journal of Production Research, 56:20, 6591-6606, DOI: 10.1080/00207543.2018.1461270

To link to this article: https://doi.org/10.1080/00207543.2018.1461270

Published online: 26 Apr 2018.

International Journal of Production Research, 2018
Vol. 56, No. 20, 6591–6606, https://doi.org/10.1080/00207543.2018.1461270

Interfaces in service modularity: a scoping review

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(*Received 30 March 2017; accepted 21 March 2018*)

This paper is intended to provide a scoping review on interfaces in service modularity. There is little detailed understanding of this concept despite its attributed importance. We identified 12 papers, showing that interfaces in service modularity are an area still open to research, especially with regard to interfaces that cross organisational boundaries. We found common themes in the available literature: the nature of interfaces, service fragmentation and predefined interfaces. Further research is needed on interfaces in service modularity, especially for complex services with components that stem from multiple, autonomous organisations. More specifically, there is a need for more studies that explore in detail how interfaces manifest themselves, and how they can be addressed to improve complex service provision. In addition, we argue why healthcare could be an interesting domain in which to conduct those studies. Our paper's contribution comprises a detailed description of interfaces in service modularity, the dissemination of summarised research findings and suggestions for potential future research.

Keywords: interfaces; service modularity; scoping review; complex service provision; supply chain management

1. Introduction

Research on modularity has moved beyond manufacturing, extending to areas in supply chain management (SCM), for example, supply chain design (Fixson 2005), mass customisation (Mikkola 2007) and supply chain flexibility (Gualandris and Kalchshmidt 2013). More recently, modularity has entered the context of services, such as service architecture (Tuunanen, Bask, and Merisalo-Rantanen 2012), human interaction (De Blok et al. 2010) and customer involvement (Iman 2016). The mainstream research on modularity seeks to understand how complex systems can be decomposed into simpler subsystems with well-defined interface specifications, so each subsystem can be designed and managed independently (Baldwin and Clark 1997).

Each of these subsystems can be optimised and they must be coordinated to fit the overall goal of the complex system (Simon 1962; Schilling 2000); this is the role of interfaces. Interfaces are the linkages between subsystems that allow interaction and communication between those components (Voss and Hsuan 2009). They provide loose coupling of subsystems, making sure that they can function independently. Moreover, they allow for substitution of subsystems if the system requires it, even when subsystems will be delivered by different organisations (Schilling 2000). The notion of interfaces is thus a key element in the field of modularity.

Interfaces make sure that combined, but independent, modular parts form a functional whole. Their role is twofold: on one hand they establish boundaries, but on the other hand they develop connections. This indicates that without interfaces, a system would simply collapse. This is certainly true for services that operate in a complicated network of various stakeholders (e.g. construction services, health services, tourism services). Those networked operations underline the importance of modularising services; they facilitate the division of tasks within the network, rather than each provider doing the operations by themselves (Bask et al. 2010). This follows from the fragmented structure of those services, and the complicated needs and wishes of customers that increase the complexity of the context (Nolte et al. 2012).

More specifically, health services must deal with high risk at 'boundaries' such as handover moments between professionals; potentially, interfaces could decrease those risks. If health service providers are to meet challenges such as those mentioned above, they will have to put more effort into finding new, effective ways of organising their services (Vähätalo and Kallio 2015). One way could be the modularisation of those services.

Although the functioning of interfaces is well understood in the product modularity literature, the implications are less apparent in the service modularity literature (Vähätalo 2012). Current literature in service modularity only provides

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basic understanding of interfaces, despite its attributed importance (Voss and Hsuan 2009; De Blok et al. 2014). Furthermore, the numerous approaches in definitions and conceptualisation of interfaces impede rigorous studies and constrain the development of the field of service modularity. While several authors have classified existing literature on modularity using a rather broad approach to the subject (Bask et al. 2010; Campagnolo and Camuffo 2010; Vähätalo 2012; Iman 2016; Frandsen 2017), this is the first review paper aiming to provide an overview of past research and to identify common themes in the literature on interfaces in service modularity.

In order to elucidate the concept of interfaces in service modularity, in this paper we address the following question: *How can interfaces in modular services be defined and characterised according to the literature?*

The purpose of this review paper, therefore, is to compare the literature on interfaces in service modularity, highlighting what they have in common, how they differ and which are the critical issues. As such, we offer more clarity with respect to the definitions and conceptualisations of interfaces in service modularity. This paper advances our understanding of interfaces in service modularity by presenting the diverse conceptualisations, definitions and implications.

The paper has been divided into six sections. The Introduction briefly introduces the topic and highlights its importance. The Theoretical Background section gives an overview of modularity and interfaces. The Methodology section discusses the review methodology we used. The next section presents the results from our review and is followed by a section which discusses the new understandings and insights about the issue at hand. The Conclusion section concludes with the findings from our review.

2. Theoretical background

2.1 *Modularity and interfaces*

Service modularity has its roots in manufacturing. In the past years it has been a fast-emerging area of research (Bask et al. 2010) and, consequently, various review papers have been produced on this matter (Table 1). Table 1 reveals that scholars do not provide consistent conceptualisations and definitions in the service modularity literature. Many disciplines have contributed to service modularity research, making modularity a way to design services so that customised service packages can be created from distinct components for individual customers (Pekkarinen and Ulkuniemi 2008). Services are distinguished from products in the use of modularity in that services do not only have an outcome dimension but also a process dimension (Voss and Hsuan 2009). The outcome dimension describes the bundle of services offered, both tangible and intangible, (Grönroos 2000) and the process dimension refers to the interactions between the service provider and the customers, and to the activities that need to be carried out to transform customer inputs into service outputs (Eissens-van der Laan et al. 2016).

In this paper, we follow Rajahonka's definition of a module (2013, 47): 'a relatively independent part of a system with a specific function and standardised interface'. There is no universal understanding of modules, since many authors use the concepts of modules, components and elements interchangeably (Pekkarinen and Ulkuniemi 2008; De Blok

Table 1. Summary of review papers on (concepts of) service modularity.

Authors	Review method	Relevant findings	Relevant suggestions
Bask et al. (2010)	Systematic literature review	Interfaces are important in product, process and service modularity, yet we know little about their conceptualisation and implication	Authors of literature on service modularity do not provide or use consistent terms and definitions
Campagnolo and Camuffo (2010)	Literature review	Very few works have tried to identify interfaces despite their important conceptual functioning	Ambiguity in definitions and measures of the modularity concept impedes rigorous empirical studies
Iman (2016)	Critical review	Service modularity is still in its infancy. To make matters worse, there are also numerous approaches to using the modular concept and its underlying concepts	Future studies should utilise the available data to develop the measurement and concepts of service modularity
Vähätalo (2012)	Systematic literature review	The results revealed that although the need for joint delivery and service coordination is recognised, there is no description of modular partnerships or interfaces on the organisational level	Emphasis should be placed on defining interface specifications between service providers on both the professional and the organisational level

et al. 2014). In order to develop a common language, we want to make a clear distinction between these different concepts. We interpret them as concepts that each fulfil their own specific role in a service offering (Table 2). The definition by Rajahonka (2013) serves as the starting point for this paper and is in line with the following three design principles that underpin the concept of modularity.

The first design principle entails that each module should have a *specific function,* meaning that the module is expected to contribute to the overall service offering. The function of a module can be helping, providing or facilitating something in, or for, the process (Ulrich 1995). In other words, it should be possible to distinguish independent, interchangeable modules with a specific function. The notion of 'specific' refers to the level of detail in which functions are specified. Functions can be specified in general (e.g. visit Florence) or in more detail (e.g. visit the cultural highlights of Florence). The second design principle, *relative independence,* implies that components comprising a module should be mutually interdependent, but that the interdependence with other modules should be minimised (Campagnolo and Camuffo 2010). This principle relates to the 'mixing-and-matching' process of a modular package, which is a process of choosing and combining modules in order to achieve a customised service offering. Using the travel example, changing the public transport component or the museum component within one module does not affect the design of the other modules. The last design principle, *standardised interfaces*, involves the typically standard linkages between modules that allow for interaction and communication between them (Voss and Hsuan 2009). Interfaces make sure that the combined independent modules can form an integrated whole (Baldwin and Clark 1997). A travel company should arrange that modules and components are connected, e.g. making sure that the transportation component is linked to the right museum component. They are essential for connecting modules into a variety of service configurations to address the diverse needs and wishes of customers. This connectivity is the reason we have a specific interest in the concept of interfaces.

Moreover, interfaces specify in detail how components will interact with each other; they define the fit, connection and communication between the components (Baldwin and Clark 1997). This definition of interfaces is commonly used in the literature and serves as a good starting point for our exploration of the concept of interfaces in service modularity.

Interfaces are an important aspect of modularity, both in products and services. In modular products (Fixson 2005), interfaces manage the connections and interdependencies across various types of physical components that comprise the final product and are typically standardised. Furthermore, interfaces enable the substitution and exchange of these components (Sanchez and Mahoney 1996). In modular services, interfaces also enable the substitution and exchange of components and it is suggested that interfaces include people, information and rules governing the flow of information (Pekkarinen and Ulkuniemi 2008; De Blok et al. 2010). The distinctive factor in service modularity, as compared to product modularity, is the central role of people. Based on the arguments above, De Blok et al. (2014) proposed an adapted definition of interfaces in service modularity: 'the set of rules and guidelines governing the flexible arrangement, interconnections, and interdependence of service components and service providers' (186).

3. Methods

By systematically searching, selecting and synthesising existing knowledge, scoping reviews are suitable for knowledge synthesis that addresses an exploratory research question aimed at mapping key concepts and gaps in research related to a defined area or field (Colquhoun et al. 2014). A scoping review combines a systematic literature search with a qualitative thematic analysis. Our efforts here aim at more detailed understanding of the diverse conceptualisations of interfaces in service modularity. We followed the iterative methodology for scoping reviews as described by Arksey and O'Malley (2005), and further enhanced by Levac, Colquhoun, and O'Brien (2010): (1) identifying the research question; (2) identifying relevant studies; (3) study selection; (4) charting the data; (5) collating, summarising, and reporting results, and (6) consultation exercise.

Table 2. Definition of concepts used.

Concept	Description
Component	The smallest elements into which a service offering can be meaningfully divided
Module	A relatively independent part of a system with a specific function and standardised interface
Service offering	Combination of several modules that are connected to each other
Service provider	A professional that fulfils their assigned role in a service offering
Organisation	An organisation that fulfils its assigned role in a service offering

3.1 *Search strategy*

We systematically searched Web of Science, Google Scholar, Elsevier, JSTOR and WorldCat Discovery. The databases were selected to be comprehensive and to cover a broad range of disciplines. We used 2000 as the starting date for the search because that was the year of Schilling's (2000) landmark publication. Also, according to Frandsen (2017), research in service modularity increased substantially around that time. Search strategies were similar for each database (Table 3). A librarian at Tilburg University verified the databases and search strategy of our study.

3.2 *Study selection*

The selection process is visualised in a flowchart (Figure 1). We removed all the duplicate papers. All the authors of this paper screened all the titles, and differences in opinion were discussed. Titles were included in the next selection phase when it was demonstrated that service modularity, as such, was discussed in the paper. Most titles ($N = 231$) were removed because they dealt with modularity of software or systems engineering. Abstracts were scored for relevance based on more narrow inclusion and exclusion criteria (Table 4). VP scored all abstracts and BM and EV each independently scored a random selection of 25% of all abstracts. The 10% of papers for which VP, BM and EV differed in their scoring were all passed on to the third phase, the full text selection. VP scored all full texts for relevance, and BM and EV each independently scored a random selection (25% of all full texts each). Only papers dealing with the concept of service modularity that went at least briefly into the subject of interfaces, thereby revealing one or several features of interfaces, were included in the final selection of full texts.

In order to find any additional relevant papers that had been unintentionally overlooked in the search, the snowball method was applied: going through references of papers already included. To this end, VP scanned the reference list of all full text papers and used judgement in deciding whether to pursue these further. If a title suggested the paper was potentially relevant, it was retrieved and, after examination of the full text, VP decided whether the paper should be included in the final selection.

3.3 *Data extraction and analysis*

Consistent with Arksey and O'Malley's (2005) framework, we extracted data related to our research question; this was inspired by a semantic-level, thematic analysis approach (Braun and Clarke 2006). First, data were entered into a Microsoft Excel spreadsheet. Data included authorship, publication year, research design, research setting, research aim, phenomena of interest, how modularity/interfaces was used and definition/description of interfaces provided. This step facilitated further data reduction and coding.

Second, all data regarding the conceptual elements involved in the application of interfaces in service modularity were extracted from the papers. We did this by transforming those sentences into more precise data for classification, by tracking the main concepts and the papers that supported each piece of evidence. Sentences regarding interfaces were gathered in each paper, and the concepts that emerged in those sentences were transformed into coded information such as 'interface entities', 'interface aims' and 'fragmentation'. This was important for identifying the common themes within the papers.

Next, we categorised the concepts found. For instance, 'service fragmentation' was found to be a common theme. All papers dealing with that concept were analysed to enhance information about its role. The approach based on these three steps allowed us to answer our research question. Any differences in interpreting the content of papers or their underlying themes were resolved through discussion. This is in line with the iterative nature of all the stages in scoping reviews (Levac, Colquhoun, and O'Brien 2010).

Table 3. Search strategy.

Database	Search strategy	Search limit
Web of Science	'Service modula*' AND interface*	1 January 2000–31 December 2016
Google Scholar	'Service modularity' AND interface*	
Elsevier	'Service modula*' AND interface*	
JSTOR	'Service modula*' AND interface*	
WorldCat Discovery	'Service modula*' AND interface*	

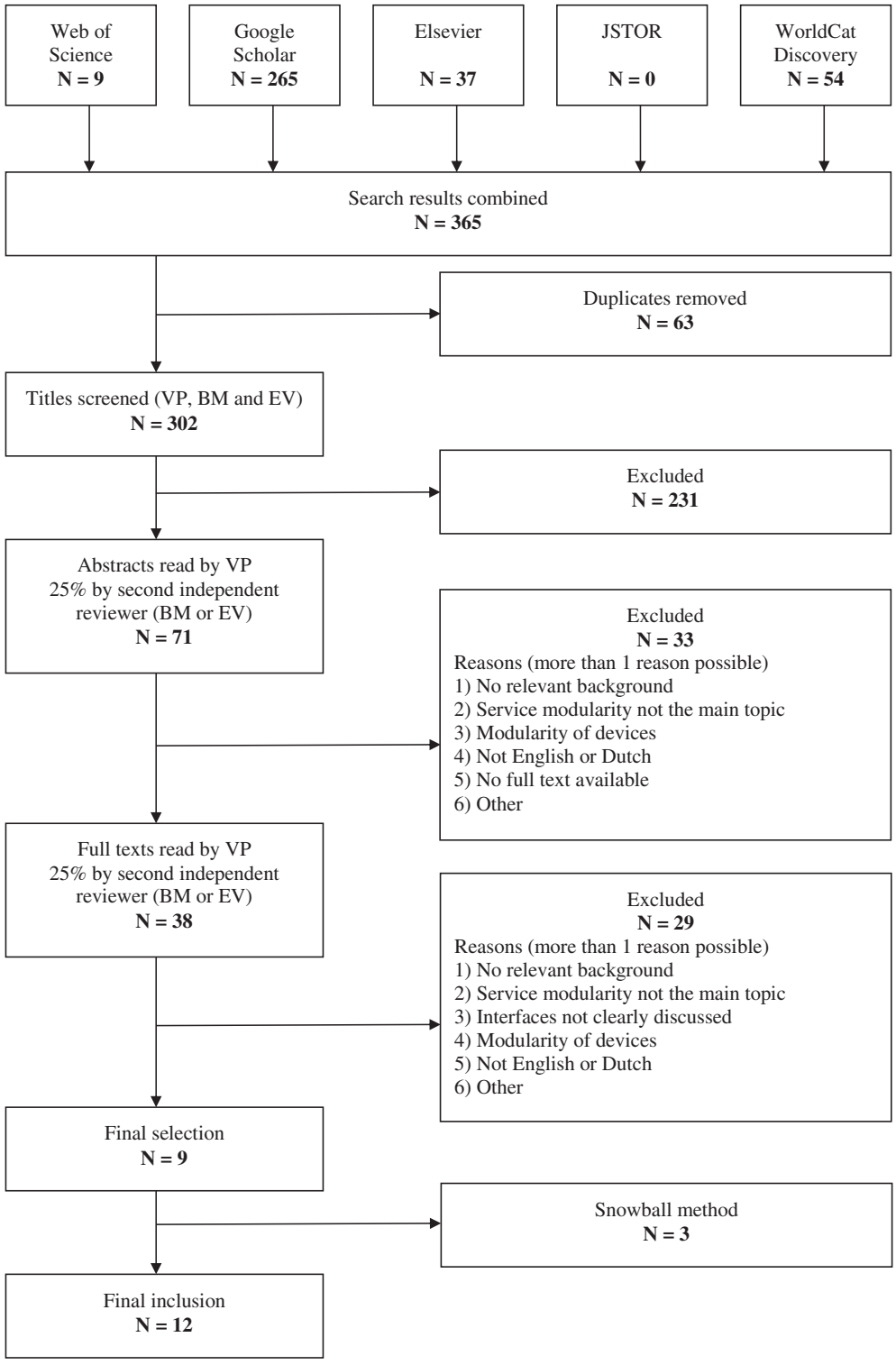

Figure 1. Flowchart of selection process.

3.4 *Consultation exercise*

An expert in the field of service modularity was approached to review the list of selected papers. This is the final stage in the scoping review methodology of Arksey and O'Malley (2005). The expert concluded that the list seemed to include all relevant papers on interfaces in service modularity, but proposed an additional follow-up search strategy to

Table 4. Criteria for inclusion and exclusion.

Inclusion criteria	Exclusion criteria
• Papers focusing on the application of service modularity; • Papers focusing on the application of interfaces in service modularity; • All kinds of scientific publications: journal papers, books, proceedings, theses, etc.	• Papers concerning service modularity or interfaces in computer science/information systems/engineering; • Papers where service modularity is not the main topic; • Modularity of devices; • Written in languages the research team does not master (Not English or Dutch); • No full text available.

compare with the outcomes of our strategy. The proposed search strategy consisted of the keywords service* AND modula* AND interface* and was the same for each database.

4. Results

The literature search yielded 365 papers, three were added using the snowball method; 12 papers were included in the final selection (Figure 1; Table 5). The outcomes of the additional strategy as suggested in the consultation exercise did not yield any additional papers.

4.1 *General description of the papers included*

The selected papers span two decades. Two were written in the 2000s and ten between 2010 and 2016 and were all submitted to different journals. Interestingly, the papers described only two sectors: healthcare and logistics service providers. The remaining three papers were of a conceptual nature. The predominant research design was exploratory, using

Table 5. Selected papers.

Initial selection

1 Cabigiosu, A., D. Campagnolo, A. Furlan, and G. Costa. 2015. 'Modularity in KIBS: The Case of Third-Party Logistics Service Providers.' *Industry and Innovation* 22 (2): 126–146
2 De Blok, C., B. R. Meijboom, K. Luijkx, J. Schols, and R. Schroeder. 2014. 'Interfaces in Service Modularity: A Typology Developed in Modular Healthcare Provision.' *Journal of Operations Management* 32 (4): 175–189
3 Iman, N. 2016. 'Modularity Matters: A Critical Review and Synthesis of Service Modularity.' *International Journal of Quality and Service Sciences* 8 (1): 1–15
4 Rajahonka, M. 2013. 'Views of Logistics Service Providers on Modularity in Logistics Services.' *International Journal of Logistics Research and Applications* 16 (1): 34–50
5 Soffers, R., B. Meijboom, J. van Zaanen, and C. van der Feltz-Cornelis. 2014. 'Modular Health Services: A Single Case Study Approach to the Applicability of Modularity to Residential Mental Healthcare.' *BMC Health Services Research,* No. 14: 210–220
6 Spring, M. and J. Santos. 2014. 'Interfaces in Service and Process Modularity.' Paper presented at the 5th International Seminar on Service Architecture and Modularity, Copenhagen, January 16–17
7 Tuunanen, T., A. Bask, and H. Merisalo-Rantanen. 2012. 'Typology for Modular Service Design: Review of Literature.' *International Journal of Service Science, Management, Engineering, and Technology* 3 (3): 99–112
8 Vähätalo, M. 2012. 'Modularity in Health and Social Services: A Systematic Review.' *International Journal of Public and Private Healthcare Management and Economics* 2 (1): 1–15
9 Van der Laan, M. R. 2015. 'The Feasibility of Modularity in Professional Service Design: Towards Low Cost Person-centred Care.' PhD diss., University of Groningen
10 Voss, C. A., and J. Hsuan. 2009. 'Service Architecture and Modularity.' *Decision Science* 40 (3): 541–569

Snowball method

11 De Blok, C., K. Luijckx, B. Meijboom, and J. Schols. 2010. 'Improving Long-term Care Provision: Towards Demand-Based Care by Means of Modularity.' *BMC Health Services Research*, No. 10: 278–293
12 Gittell, J. H., Hagigi, F., Weinberg, D. B., Kautz, C. and Lusenhop, W. 2008. 'Modularity and the Coordination of Complex Work.' Paper presented at the annual conference for Industry Studies, Boston, May 1–2

qualitative research methods. A case study research design was used in seven papers, three papers were reviews combined with empirics and two of the papers consisted of conceptual reasoning (Tables 6 and 7).

4.2 *Findings*

De Blok et al. (2014) developed a typology on interfaces in service modularity that is based on two dimensions, interface *entities* and interface *aims*. The interface entities refer to the decomposition level – components and services providers – while the interface aims can either provide coherence or provide variance. The authors label the interfaces that create coherence as 'closed' interfaces, since they strive for standardisation and unity. The interfaces aiming at providing variety are called 'open' as they enable individualised adaptations for each customer. The interface entities stem from the analytical level at which they are in play: either on the component level or on the service provider level. Interfaces between components support the *customer* flow from component to component and interfaces between service providers affect *information* flow in the service package as a whole (De Blok et al. 2014). Based on those insights, four different types of interfaces can be distinguished: closed-customer (C-C), open-customer (O-C), open-information (O-I) and closed-information (C-I) interfaces.

Spring and Santos (2014) make a distinction between *structural* and *procedural* interfaces. Structural interfaces address the outcome dimension of service modules whereas procedural interfaces address the temporal nature of the service delivery. The procedural interfaces focus on integration of the process dimension of service offerings and relate to the interaction between the service provider and the customer.

Van der Laan (2015) makes a distinction between *functional* and *organisational* interfaces. Functional interfaces link content parts with their own specified function and align the outcome dimension of a service offering. Organisational interfaces link service providers, including customers and are expected to align the process dimension of a service offering. Insights on interface conceptualisations are summarised in Table 6.

All in all, this shows that the topic of interfaces is largely overlooked, despite the acknowledgement that interfaces constitute a research priority (Voss and Hsuan 2009). Systematic studies of interfaces in practice, and their relationship to outcomes of modularity, remain scarce (Voss and Hsuan 2009; De Blok et al. 2010; Tuunanen, Bask, and Merisalo-Rantanen 2012; Soffers et al. 2014). Available studies mostly focus on interfaces as a means of linking and connecting components or modules, but do not elaborate on how to further specify, define and recognise interfaces (Voss and Hsuan 2009; Vähätalo 2012; Rajahonka 2013; Iman 2016). This results in too little understanding about how interfaces mani-

Table 6. Summary of literature with interfaces in service modularity as the main topic.

Author(s), Year	Interface type	Interface definition	Interface example
De Blok et al. (2014)	Closed-customer (C-C)	Enable the arrangement of components in a way that interdependencies among components are managed and that components work together	Strict planning rules
	Open-customer (O-C)	Provide a structure that enables components to be combined and re-combined, according to the individual customer needs	Brochure with services
	Closed-information (C-I)	Provide a set and codified arrangement of interactions so that interactions are predictable and the amount of information that has to be exchanged is diminished	Work schedule
	Open-information (O-I)	Offer a structure in which service providers are brought together so that information concerning e.g. package (re)configuration can be exchanged	Needs assessment
Spring and Santos (2014)	Structural	Regard the outcome dimension of service modules	Handover from provider A to B
	Procedural	Relate to the temporal nature of the delivery of services	Agreement between bus driver and hotel
Van der Laan (2015)	Functional	Focus on linking modules with one another	Information exchange between information systems
	Organisational	Focus on coordinating work between providers and making interactions among various (groups of) service providers manageable	Internal contract

Table 7. Summary of literature on interfaces in service modularity.

Author(s), year	Research design	Research aim	Main implications of interfaces in service modularity
Cabigiosu et al. (2015)	Case study	To investigate service modularity and inter-organisational coupling in a knowledge intensive business	Customised interfaces are important for information and knowledge transfer
De Blok et al. (2010)	Case study	To examine the application of modularity in long-term care for the elderly	Problems at interfaces between and within (large) healthcare organisations have been recognised
Gittell et al. (2008)	Case study	To explore the concept of modularity in a professional service context and whether higher levels of complexity increased or decreased the modularity of their coordination	Interfaces between modules need to be specified in advance, indicating that how modules will interact must be well defined
Iman (2016)	Review	To investigate the existing research, to provide a critique of the empirical literature and to discuss future research opportunities on service modularity	If interfaces cannot be fully specified in advance, this challenges the assumed embedded coordination
Rajahonka (2013)	Case study	To increase our understanding of the concept of service modularity and to present examples of applications of modularity approach in logistics services	The importance of interfaces is understandable because logistics is an industry involving multiple network partners often operating around the globe
Soffers et al. (2014)	Case study	To explore the applicability of modularity in residential care provided in Assisted Living Facilities of Dutch mental healthcare institutions	Only a minority of the interfaces concern modules and a large number of interfaces concerning people could be identified. The lack of module interfaces caused a lack in clarity about the available modules
Vähätalo (2012)	Literature review	To study the potential relevance of modularity in the health and social service sector	There is no description of interfaces on the organisational level. Interface specifications could facilitate collaboration among multiple providers from different sectors
Tuunanen, Bask, and Merisalo-Rantanen (2012)	Literature review	To present a typology for modular service design	It is important to take a better look at interfaces, i.e. the connectivity of service components in the modular service offering
Voss and Hsuan (2009)	Case study	To gain more understanding of the nature of service architecture and modularity	Identify key interfaces between different parts of the service. Service design often includes customer contact, communication with the customer through a choice of modes and channels. Information transfer is a key interface

fest themselves in the service sector (Gittell et al. 2008; Rajahonka 2013; Soffers et al. 2014; Cabigiosu et al. 2015), as in-depth empirical papers on interfaces in modular services, testing conceptualisations of interfaces in service modularity, are rare (Soffers et al. 2014). Rajahonka (2013) reasons that this may be due to there being fewer industry standards in services than in the manufacturing industry.

The remainder of the results section is organised along three themes.

4.2.1 *Nature of interfaces*

Little is known about the nature of interfaces and the analytical level at which interfaces are at play. Following this, there is an ongoing debate in the literature about whether interfaces provide linkages between components and service providers, or between customer and service provider (Gittell et al. 2008; Voss and Hsuan 2009). Vähätalo (2012) added organisations to this debate, revealing that there is no readily available description of interfaces at the organisational level. Iman (2016) argues that this debate stems from the fact that the literature is inconsistent on whether service providers are defined as professionals or organisations. Some papers use the term service provider to refer to organisations (Rajahonka 2013; Cabigiosu et al. 2015) whereas others use the term to refer to professionals (De Blok et al. 2010; Soffers et al. 2014). As a result, it remains unclear how interfaces have been conceptualised in the existing literature. More specifically, it is not clear at which analytical level interfaces are at play in the delivery of (multiple) components in the

total service offering. Vähätalo (2012) was the first to address this issue. She argued that understanding the nature of interfaces becomes even more important when multiple components are supplied by multiple, independent service providers who are responsible for these components. The functioning and our understanding of interfaces might be affected when modules or components originate from multiple, autonomous organisations.

4.2.2 *Service fragmentation*

Some papers (De Blok et al. 2010; Vähätalo 2012) indicated that organisational boundaries were problematic when a customer required services from multiple organisations instead of a single organisation. The complicating factor is that these organisations become dependent on each other, something which stems from the structure of the complex services and has a negative effect on the coordination of those services. According to Vähätalo (2012), the fragmented structure of services is attributable to a lack of interfaces. An essential element in preventing service fragmentation is information exchange between organisations and service providers (Vähätalo 2012). This is a challenging task because it is difficult to synchronise operations and information exchange (Cabigiosu et al. 2015). Use of IT such as electronic health records (Soffers et al. 2014) and other contemporary developments in information systems in general (Cabigiosu et al. 2015) have been found to be one of the ways to improve information exchange between professionals within and across organisations. However, this seems counterintuitive because the modularisation of services ensures that *less* information exchange (between modules) is required, since more information is readily available within modules (Cabigiosu et al. 2015). De Blok et al. (2010) and Vähätalo (2012) also point out that when modules stem from different organisations and service fragmentation occurs, the need for information exchange becomes more evident.

4.2.3 *Predefined interfaces*

Demand heterogeneity and expanded service requirements from customers increasingly challenge organisations and professionals from different sectors (Vähätalo 2012). However, if organisations collaborate to address demand heterogeneity and service requirements, problems arise when interfaces are not specified before the collaboration begins (Gittell et al. 2008). Voss and Hsuan (2009) argue that when interfaces are defined in advance, the possibility of connecting, complementing and substituting modules is enhanced, with little effort involved in the coordination. This becomes evident when sensitive information is exchanged through an interface, for example, personal information via an electronic patient file (Soffers et al. 2014). It should require little coordination to establish boundaries through interfaces, even though it should be possible to share knowledge, competences and information among service providers. Developing such interfaces requires well organised and consistent coordination (Gittell et al. 2008; Tuunanen, Bask, and Merisalo-Rantanen 2012). Predefined interfaces have the potential to facilitate collaboration among multiple organisations from different sectors (Vähätalo 2012). Iman (2016) suggests that if interfaces cannot be fully specified in advance, the embedded coordination, often assumed to be a consequence of interfaces in service modularity, is challenged.

5. Discussion

5.1 *Alignment of the papers explicitly addressing interfaces*

Three papers explicitly addressed interfaces in service modularity, i.e. De Blok et al. (2014), Spring and Santos (2014) and Van der Laan (2015). All three papers developed their own conceptualisation of interfaces in service modularity. They distinguished between interfaces that link components (content) with one another and interfaces that are responsible for linking service providers (people) with one another. The interfaces that link components support the mixing-and-matching of a service offering, and the interfaces that link the service providers with each other facilitate the coordination of work between service providers.

However, we think the conceptualisations of interfaces made by these different studies can be aligned because, in fact, *customer* flow interfaces (C-C and O-C) address the same dimension as *structural* interfaces and *functional* interfaces do. They all focus on the *outcome* dimension of a service offering and refer to the content part of the service offering, i.e. interactions between components or modules. Additionally, *information* flow interfaces (C-I and O-I) discuss the same dimension as *procedural* interfaces and *organisational* interfaces do; they focus on the *process* dimension of the service offering and provide linkages between service providers. It refers to the 'people' part of the service offering, i.e. interactions between service providers. The alignment of those conceptualisations is shown in Figure 2.

The 'labels' applied to those interface conceptualisations relate to Grönroos (2000) and, more recently, Eissens-van der Laan et al. (2016) definition of boundaries of a service offering. They refer back to the theoretical distinction

between the outcome and the process dimensions of a service offering. As argued above, the conceptualisations by De Blok et al. (2014), Spring and Santos (2014) and Van der Laan (2015) differ in wording rather than content. What does make a difference is that De Blok et al. (2014) discovered the dimensions of the interacting aims 'variety' and 'coherence' in both the outcome and the process dimensions. As such, their typology is more comprehensive. Our research shows that interfaces on the outcome and process dimension are required to ensure pertinent service delivery over time. However, the current conceptualisations do not capture the modularisation of services in multi-provider contexts. In more complex service offerings, interfaces need to establish connections across organisational boundaries. We believe our classification of interfaces in service modularity will contribute to a more detailed understanding of the concept and that illustrating them will provide insight into how interfaces manifest themselves in practice, especially in complex service provision.

5.2 *Interfaces in complex services*

The common denominator of the themes revealed in the results section is the lack of knowledge on interfaces in complex service provision. The papers included in our review were all produced in a single-provider context and have therefore not examined interfaces that cross organisational boundaries. It seems to be the case that organisational boundaries are problematic when customers require services from multiple, autonomous organisations, and this is often the case in the healthcare sector. Healthcare is a complex domain due to the necessary involvement of multiple health care providers which leads to inter-organisational problems such as communication, integration and coordination (Meijboom, Schmidt-Bakx, and Westert 2011).

Those problems are often discussed under the heading of chain care, and this idea of 'a chain of activities' is related to SCM practices. Managing relationships among the providers involved is essential for the integration of professionals and organisations along the supply chain and the related coordination tasks (Xie and Lawley 2015). Interfaces in service modularity, conceptually, have the potential to guide those relationships.

With a broader view on this topic, SCM practices are also discussed by means of modularity in production systems (Takeishi and Fujimoto 2001; Bask et al. 2010). Efficient production of a product portfolio is often attributed to the flexibility of manufacturing (Ulrich 1995), which is primarily a function of (product) architecture and the technology used within the supply chain (Ramdas 2003; Gualandris and Kalchschmidt 2013). Modularity allows these components to be mounted in separate lines, thus forming modules that are sent to the final assembly line (Baldwin and Clark 1997; Takeishi and Fujimoto 2001). Thus, there is a significant reduction in the complexity of the production process. For this to happen, certain aspects of modularity that influence subsequent decisions in the production process must be considered, namely: (i) product architecture, which specifies the modules of the system; and (ii) interfaces, which are responsible for the interaction of the modules (Baldwin and Clark 1997). Once more we see the importance of interfaces. Therefore, we make a comparison of the interfaces in service modularity and production system modularity (see Table 8). We found that service modularity literature is mostly influenced by manufacturing modularity that follows the traditional systems view and approach. Our comparison shows that service modularity does not yet capture the multi-layer structure of complex services. Moreover, there is potential for studies that apply principles from modularity in production

		Outcome dimension of a service offering	Process dimension of a service offering
		Structural interfaces *Functional* interfaces	*Procedural* interfaces *Organisational* interfaces
	Interacting entities		
Interacting aim		Between modules/components	Between providers
	Variety	*O-C* interfaces	*O-I* interfaces
	Coherence	*C-C* interfaces	*C-I* interfaces

Figure 2. Visualisation of interface types.
Note: Derived from De Blok et al. (2014), Spring and Santos (2014), and Van der Laan (2015).

Table 8. Comparison of interfaces in service modularity and modularity in production systems.

Conceptual element	Summary description	Comparison	References
Interdependence between modules	Degree of structural independence the modules/components have among themselves	Both in services and production systems there is a certain degree of interdependence between modules arranged	Baldwin and Clark 1997; Takeishi and Fujimoto (2001); Voss and Hsuan (2009); Gualandris and Kalchschmidt 2013;
Customer included	Refers to the degree of customer involvement in service delivery/ production process	In services, interfaces include people and this makes it less predictable as opposed to production systems	Takeishi and Fujimoto (2001); De Blok et al. (2010); Iman (2016)
Standardisation of interfaces	Makes it possible to recombine the components of services without an elaborate adaptation of interfaces	In production systems, this enables the possibility of fewer changes in machinery, even with more variation. In services, this is less common due to the absence of industry-wide standards that provide descriptions of processes in service delivery	Ulrich (1995); Baldwin and Clark (2000); Ramdas (2003); Rajahonka (2013); De Blok et al. (2014)
Interface specification	Specifications of interfaces must be visibly specified to avoid inconsistencies when coupling modules and components	In production systems, interfaces are predefined in order to ease the overall production process. In services, there is less emphasis on interface specification	Sanchez and Mahoney (1996); Takeishi and Fujimoto (2001); Vähätalo (2012)

systems, like standardisation of interfaces and interface specifications, in a service context. These concepts play a vital role in production systems. In modular services, there is little evidence about their role in complex service offerings.

5.2.1 *Healthcare as potentially fruitful research area*

The healthcare sector is a domain comprising many medical specialties focused on various age segments, for example, children and elderly people, and concerned with physical and/or with mental ailments (Frenk et al. 2010). This generates a substantial number of care providers. Even when focusing on a specific disease (e.g. dementia) or target group (e.g. independently living elderly), multiple disciplines and providers are often necessary to ensure continuity of care (D'Amour et al. 2008). At the organisational level, concepts such as primary and secondary care indicate the highly specialised nature of healthcare provision (Frenk et al. 2010). As a consequence, specialisation among professionals creates sharp boundaries, both between an organisation's own professionals and across organisations (Vähätalo and Kallio 2015).

Few services in healthcare are provided by a single provider, or even by a single organisation. Instead, treatment takes place over a long period of time and involves multiple providers (De Blok et al. 2014; Soffers et al. 2014). For the actual process of treatments and procedures designed to serve patients, this implies that complementary care components must be combined into an effective, integrated whole (Johnson 2009; Chung et al. 2012). Failure over time to properly link and align various types of components, modules and providers might have severe consequences for the patient's wellbeing (De Blok et al. 2010). A tight fit between the complementary components and the providers involved will prevent gaps as well as duplications. This tight fit can be achieved through interfaces because they provide linkages between components and service providers that allow interaction and communication between them (Voss and Hsuan 2009). So, as well as interfaces between care content components, interfaces between the service providers involved are crucial, at both the professional level and the organisational level. As a result, it is possible to understand the supply side of healthcare as a collection of modular packages built from cure, care and social services (Vähätalo 2012). The sector therefore serves as a fruitful avenue for further exploration of the role of interfaces in complex service provision.

5.3 *Strengths and limitations*

To our knowledge, this is the first review in the service modularity literature that has taken interfaces as the central unit of analysis. Scoping reviews are a relatively new approach for which there is not yet a universal study definition nor a definitive procedure (Levac, Colquhoun, and O'Brien 2010). To compensate for this, the research was guided by a

protocol reviewed by a research team with expertise in scoping reviews. We have guaranteed the rigour and transparency of our review by following the steps for executing a scoping review as described by Arksey and O'Malley (2005). Next, our data analysis was inspired by the seminal work of Braun and Clarke (2006). The analysis involved a constant moving back and forward within the data, the coded extracts of data that we analysed, and the analysis of the data that we produced. We thoroughly reviewed our study against all 15 criteria and determined that we met them all (Table 9). To illustrate, one important criterion was 'ongoing analysis to refine the specifics of each theme' (Braun and Clarke 2006) which we fulfilled by going back to collated data extracts and organising them into a coherent and sound theme. In doing this, we did not merely paraphrase the content of the data extracts, but identified what was of interest about them and why.

Our scope was broad, and we have attempted to sketch out what is currently known about interfaces in service modularity. Consulting someone with relevant expertise as the last step of the scoping review enabled us to check whether we had unintendedly missed relevant papers, and strengthened our paper. Lastly, as recommended by Creswell and Miller (2000), we made use of peer review to assess the quality of our findings. Another researcher analysed the data

Table 9. Adherence to the criteria checklist for good thematic analysis.

Phase	Criteria	Check
Familiarising	1. The data have been read to an appropriate level of detail	We immersed ourselves with the data to the extent that we were familiar with the depth and breadth of the included articles
Coding	2. Each data item has been given equal attention in the coding process	We worked systematically through the entire data-set, giving full and equal attention to each data item
	3. Themes have not been generated from a few vivid examples (an anecdotal approach), but instead the coding process has been thorough, inclusive and comprehensive	We made sure that codes identified a feature of the data that appeared interesting to the authors
	4. All relevant extracts for all each theme have been collated	We coded the extracts manually, by using highlighters, and collated them in Microsoft Excel
	5. Themes have been checked against each other and back to the original data-set	We considered how different codes may combine to form an overarching theme
	6. Themes are internally coherent, consistent, and distinctive	We discussed (candidate) themes and sub-themes and made sure not to overlook relevant codes in the data
Analysis	7. Data have been analysed - interpreted, made sense of - rather than just paraphrased or described	We fulfilled this by going back to collated data extracts and organising them into a coherent and sound theme. We identified what was of interest about them and why
	8. Analysis and data match each other - the extracts illustrate the analytic claims	We gave full and equal attention to each coded extract, and identified those interesting aspects in the coded extracts that formed the basis of common themes in our data
	9. Analysis tells a convincing and well-organised story about the data and topic	We reported on three themes. Each theme is clearly linked back to the overall research question, but each is distinct
	10. A good balance between analytic narrative and illustrative extracts is provided	We ensured this by including examples from the included articles, while staying on a conceptual level
Overall	11. Enough time has been allocated to complete all phases of the analysis adequately, without rushing a phase or giving it a once-over-lightly	Since coding is an ongoing organic process, we assured that we went back and forth between the data
Written report	12. The assumptions about, and specific approach to, thematic analysis are clearly explicated	By describing our data analysis in the method section, we made sure that the assumptions of thematic analysis were clear
	13. There is a good fit between what you claim you do, and what you show you have done – i.e. described method and reported analysis are consistent	We thoroughly explained our approach to the scoping review as described by Arksey and O'Malley (2005)
	14. The language and concepts used in the report are consistent with the position of the analysis	We moved from the levels of phrases, sentences and paragraphs to the level of the writing as a whole, to their context-independent meanings, fitting the semantic-level
	15. The researcher is positioned as active in the research process; themes do not just 'emerge'	We guaranteed this by going back and forth between the data. We constantly questioned whether the right codes belonged to the right theme

independently and any discrepancies in interpretations were resolved through discussion. This enhanced the validity of our research.

5.4 *Agenda for future research*

In this section, we offer directions for future research in the form of tentative propositions and related methodological suggestions.

Modular services are increasingly delivered as part of a complex system involving multiple providers. Within these multi-provider contexts, individuals from different organisations with often different professional backgrounds are expected to work together. In turn, this may well give rise to conflicts on organisational procedures or professional values, respectively. As a consequence, standardisation of interfaces proves difficult. While this standardisation may reduce coordination costs, the within and between module coordination mechanisms will remain demanding (e.g. interoperable IT systems) given the high complexity of these services (Cabigiosu et al. 2015). Based on the above, we formulate the following proposition:

> Proposition 1: Modular services that need input from multiple different service providers constrain the standardisation of interfaces.

There is potential for future studies to synthesise and operationalise the knowledge gained in this scoping review. This is necessary in order to further our understanding of interfaces in service modularity. Areas that merit examination in greater depth are the nature and definition of interfaces, as well as the ways in which they vary with context. One way of addressing this is to conduct studies with interfaces as the central unit of analysis, instead of interfaces being just one theme among many (Voss and Hsuan 2009). Key decisions revolve around issues such as delineating the boundaries of each component and establishing predefined interface specifications to ensure smooth functioning between modules (Voss and Hsuan 2009). Moreover, there is a need for studies to explore how interfaces manifest themselves in multi-provider contexts (Vähätalo 2012), with special reference to coordinating and integrating fragmented services such as healthcare. We propose:

> Proposition 2. Interfaces in complex modular services improve coordination of decomposed tasks within service provision not only across professional boundaries, but also organisational boundaries.

How should predefined interfaces work? Essentially, by specifying in advance exactly how subsystems will interact with each other. A predefined interface, such as a planning scheme, comprises the a priori specification of what organisations must do individually so that joint actions are coordinated. This is in contrast with independent organisations who may coordinate their activities by communicating and making decisions as they go (Puranam and Jacobides 2005). While components can be developed autonomously by different organisations, coordination of the overall system is generated through the presence of interface specifications embedded in the service architecture, thereby shifting the burden of coordination away from managerial authority (Sanchez and Mahoney 1996). It is in this sense that predefined interfaces 'embed' coordination, as suggested by Iman (2016). Interfaces enable linked subsystems to act in a coordinated manner, by specifying ex ante what each subsystem must do in order for the complex system to work effectively (Baldwin and Clark 2000). In complex services such as construction and healthcare, this becomes even more important because of the fragmented structure of those services. We therefore postulate:

> Proposition 3. Predefined interfaces promote the assumed coordination embedded in interfaces.

From a broader theoretical perspective, we argue that interfaces are useful concepts for understanding the architecture of complexity (Simon 1962). They demarcate the sub-systems that comprise the complex system as well as the manner in which sub-systems interact with each other. It is important to note that interfaces refer not only to those points where the linkages in a complex system manifest themselves, but also to the nature of those linkages (Puranam and Jacobides 2005). Loose coupling of sub-systems through interfaces embraces the idea that most systems are neither entirely decoupled nor fully coupled and instead are nearly decomposable (Simon 1962). We therefore argue that in services, as opposed to products, in addition to the complete independence of action across sub-systems, the major issue is the extent to which the nature of the interaction between subsystems is fully predictable.

6. Conclusion

Publications on interfaces in service modularity are scarce. The available literature focuses on interfaces (1) between *components* as they are needed in the formation of a coherent service offering and (2) between *people*, in order to construct the service offering that meets the changing needs of customers. Little is known about interfaces (3) between *organisations* that facilitate collaboration and coordination with multiple, autonomous organisations, perhaps even from different sectors, in a coordinated service offering. This is especially the case in services such as construction or healthcare as they often operate in a complicated and fragmented network of various stakeholders. Service modularity, and in particular the concept of interfaces, is important in understanding how organisations can overcome the complexities of customer needs for complex services. We conclude that more research should be conducted on the topic of interfaces between organisations, especially on the role of interfaces in the case of complex service provision. By understanding interfaces in service modularity as a possible way of preventing service fragmentation that involves the emergence of new connections within and across organisational boundaries, this paper provides a bridge between service modularity research and SCM practices.

Acknowledgements

The authors would like to thank the anonymous expert for the consultation exercise of the scoping review. We also gratefully acknowledge the assistance of the librarian from Tilburg University for verifying the search strategy of this research. Further, the authors would like to thank the researchers who provided feedback on the previous version of this manuscript during the service modularity workshop 2017 in Copenhagen.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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