Proceedings of the International Conference on Industrial Engineering and Operations Management
Paris, France, July 26-27, 2018

Proposal to Assess the Results of Service Modularization

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Abstract

Service modularity has been attracting growing interest in the last decade, especially in how modularity can benefit service research and service providers. The application of modularity concepts in service context has been discussed as a way to achieve benefits such as increased variety, economy of scale, and decreased lead times. Nevertheless, although the literature suggests that service modularity can positively influence service performance, the research on the evaluation of service modularization results is still scarce. The assessment of service modularity results is necessary for the application of modularity concepts in service organizations by demonstrating the potential of modularization in achieving benefits and improvements. Therefore, this work proposes an approach to assess service modularity results based on the performance measures from modularity literature. These modularity performance measures should be selected and prioritized according to service characteristics, to assess the modularization outcomes. The results are valuable for proving the benefits related to service modularization and providing a holistic view of modularization outcomes. Further work involves expert assessment concerning the proposal and fieldwork by simulating a healthcare service within a modular scenario.

Keywords
Modular services; Service modularization; Modularization assessment; Service operations.

1. Introduction

The growing importance of service sector in the global economy and international trade in services led to increased competition among service providers (Gleich *et al.*, 2017). In this scenario, organizations face pressures to offer effective, efficient and personalized services (Avlonitis and Hsuan, 2017; Brax *et al.*, 2017). Service modularity has emerged as a solution to this challenge, offering performance efficiency and lower costs due to the improved operational and functional flexibility (Voss and Hsuan, 2009; Brax *et al.*, 2017).
Modularity refers to the decomposition of a complex system into simpler parts that may function independently (Chorpita *et al.*, 2005; Voss and Hsuan, 2009), which can be mixed and matched to address the customer needs (Hsiao *et al.*, 2015). Service modularization has the potential to achieve benefits such as cost savings, enabling customization, fostering service innovation, increasing module performance and quality, and expanding options for the development of new services (Dörbecker and Böhmann, 2015; Iman, 2016).
Given these benefits, the research on service modularity has attracted attention in the last decade (Eissens-van der Laan *et al.*, 2016), and its application has been explored in different service contexts. Nevertheless, although the literature suggests that modularity can positively influence service performance and service delivery processes (Pekkarinen and Ulkuniemi, 2008; Lubarski and Poeppelbuss, 2016), the research on the evaluation of these benefits is scarce (Iman, 2016; Brax *et al.*, 2017).
In this sense, this paper proposes an approach for assessing the outcomes related to service modularization. This proposal is based on the definition of performance measures, based on product and service modularity literature (*e.g.* Otto and Hölttä-Otto, 2007; Böttcher and Klingner, 2011; Peters and Leimeister, 2013). The development of measures of service modularization, representing measurable goals, has the potential to direct studies to better methods and models for the design of modular services (Dörbecker *et al.*, 2015). Therefore, the purpose of this proposal is also to demonstrate an overview of the modularization outcomes and to identify actions that may be applied to improve the service performance.

The paper is structured as follows. Section 2 presents a brief review regarding service modularity and service modularization assessment. The phases of the research design are outlined in section 3. Section 4 describes the proposal to assess the results of service modularization. Finally, section 5 presents the conclusions, limitations of this study and perspectives for future studies.

2. Theoretical background

Modularity is a well-established design concept in many disciplines (Avlonitis and Hsuan, 2017), especially concerning product modularity (Iman, 2016). In products, modularity was widely explored, empirically and theoretically. More recently, the study of modularity has been extended to the service field (Eissens-van der Laan *et al*., 2016). Over the past decade, the research on service modularity has been attracting growing attention, due to its potential in achieving benefits (Eissens-van der Laan *et al*., 2016; Iman, 2016). To realize these benefits, an important aspect to be considered is how to modularize services (Geum *et al*., 2012).
Some authors have proposed methods of service modularization (*e.g*. Böttcher and Klingner, 2011; Geum *et al*., 2012; Peters and Leimeister 2013). These methods comprise mainly the phases of analysis of a service system for the identification of elements and interdependencies, module and interface creation, and testing (Dörbecker and Böhmann, 2015; Lubarski and Poeppelbuss, 2016). However, a limited number of methods address the testing phase (Lubarski and Poeppelbuss, 2016). Furthermore, the methods that address this phase are limited in providing a holistic view of service modularization outcomes since they are based on few evaluation criteria.
The testing phase is responsible for evaluating whether (Peters and Leimeister, 2013): (i) the modularized service is faster and cheaper than without modularization; and (ii) the modularized service works properly. The testing phase plays an essential role in modularization since a central aspect of this process is the evaluation of its effects on productivity, *i.e*., the ability to transform process inputs into outputs (Piran *et al*., 2016). In fact, modularization efforts are always dependent on its costs and benefits (Peters and Leimeister 2013), and it is necessary to assess the effect of modularization to demonstrate the improvements achieved with this process (Piran *et al*., 2016).
However, despite the importance of the testing phase for the modularization process, it is still a research gap in service modularity literature, which requires more studies (Lubarski and Poeppelbuss, 2016). Thus, this paper proposes an approach to address the evaluation of service modularization results, based on the definition of performance measures. This proposal aims to support the testing phase, which is still underdeveloped in the main modularization methods. Next section presents the research design to construct the approach proposed by this study.

3. Research design

The research design was structured in two phases and five stages as shown in Figure 1.

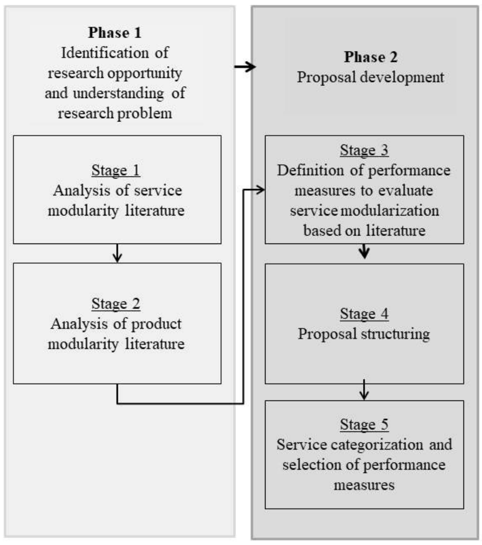

Figure 1. Research design – phases and stages

Phase I aimed to identify the research opportunity and to understand the research problem, through the analysis of modularity literature. Firstly (Stage 1), a systematic literature review on service modularity was conducted to identify the research opportunity. The study employed four relevant databases to perform the articles search (Web of Science, Scopus, Compendex, and ScienceDirect), which index papers from the engineering, science, and technology field. The search considered only publications from peer-reviewed journals (article or review type), in English language, published until 2016. The keywords "modular*" and "service*" were chosen to cover the keywords used by other reviews on the subject (*e.g*. Eissens-van der Laan *et al*., 2016; Iman, 2016), and to return the maximum number of papers.

The search yielded 5,847 publications, which after eliminating duplicates and the ones that were not aligned (*i.e*., articles that do not focus on service modularity or only mentioned the word 'modularity,' without dealing with empirical or theoretical aspects related to service modularity), 61 publications remained in the analysis. By reading the retrieved articles, some research opportunities were identified, including the one addressed by this work (assessment of service modularization results). The lack of structured modularity assessment approaches identified in Stage 1 led to the analysis of product modularity literature (Stage 2).

The product modularity literature was analyzed because it is the most developed subtopic in modularity literature (Iman, 2016), which is often used as a basis for application in service context (Geum *et al*., 2012). Stage 2 encompasses another systematic literature review, covering product modularization methods and approaches for evaluating product modularity. In this stage, the search for publications used the same databases and article selection criteria adopted in Stage 1.

A first search used the keywords "modul*" and "design" and "method" and "product architecture" or "product platform" or "product family". This first search aimed at identifying the product modularization methods that comprise an evaluation (or testing) phase. After discarding the duplicates and publications that do not present product modularization methods, 127 articles were identified and analyzed. The majority of the approaches presented in these papers applies or adapts consolidated methods of product modularity literature, as suggested by Sonego and Echeveste (2016). Therefore, to organize the material analysis, the methods were selected and grouped according to two criteria: (i) selection of the original method and exclusion of later publications that use the same principles of the original method (Sonego and Echeveste, 2016); and (ii) typical methods in industry (Holmqvist and Persson, 2003). Considering the first criteria (exclusion of similar methods), six methods were identified. Moreover, according to the second criteria (typical methods in the industry), four more methods were selected, so ten in total.

The analysis of these set of methods showed that only four encompass an evaluation phase and their scope is limited for application in services. A second search was then performed, by adding the keywords "assessment" or "evaluation" and "product architecture" or "product family" or "product platform" or "product modul*" or "modular product". This resulted in 506 publications. After discarding the duplicates and the papers that do not explicit or detail the evaluation procedures to conduct product modularity assessment, more 45 publications were taken into account. The previous stages served as a basis for the proposal development in the next phase.

In Phase 2, the development of the proposal to assess service modularization results was conducted in three stages (3 to 5). The proposal was structured in four steps and the results of this phase are presented in section 4. Firstly (Stage 3), the performance measures for the assessment of service modularization were identified and selected, based on the literature review of Stage 1. This selection considered general measures since the measures for the evaluation of modular services should be generic enough to apply to a wide range of services (Dörbecker *et al*., 2015).

After identifying the performance measures and how to measure them (based on service and product modularity), they were structured in an integrated approach (Stage 4). The systematic literature review on product modularity (Stage 2) has identified two comprehensive approaches (by Erixon, 1998 and Otto and Hölttä-Otto, 2007), which encompass several criteria in their scope that can be applied to services (*e.g*. flexibility, variety, and customer satisfaction).

Performance measures to assess the modularization was identified in the two approaches cited earlier. Erixon (1998) proposes the calculation of the ratio between the current performance measures and the target performance measures, resulting in the 'yield' of product modularization. This estimate was considered adequate since its purpose is to compare a modularized scenario with a non-modular scenario, to reveal the benefits achievable with the process. Otto and Hölttä-Otto's approach (2007) presents a prioritization of the performance measures, based on the attribution of weights, to evaluate the scores obtained for each set of measures. This prioritization was also considered suitable since the present approach aims to evaluate different service types, which have different strategies and purposes (Geum *et al*., 2012).

Furthermore, the Otto and Hölttä-Otto (2007)'s approach is based on the structure of Balanced Scorecard (BSC), for the evaluation of a product platform. BSC is a customizable approach to different service types (Praeg and Schnabel, 2006) and the literature presents some approaches that employ BSC adaptations for the evaluation of different

services, such as health services (*e.g*. Peters *et al*., 2007) and logistics (*e.g*. Rajesh *et al*., 2012). Böttcher and Klingner (2011) describe the potential benefits of service modularity based on the BSC's dimensions (*i.e*., financial, internal processes, customers, and growth and learning) from service modularity portfolio. Therefore, the BSC's dimensions were considered suitable to organize the performance measures in a table that represents the modularization results.
After structuring the proposal, the next stage was the service categorization and selection of performance measures (Stage 5). This stage seeks to support the choice of performance measures according to service characteristics since this proposal aims at evaluating different service types. The framework proposed by Carlborg and Kindström (2014) was chosen to support the service categorization, for two main reasons: (i) the framework is general and could be applied to a number of services; and (ii) the framework takes into account important aspects to be considered for evaluating a service such as complexity of the service task (process rigidity) and degree of customer participation (Geum *et al*., 2012). Next section presents the full picture of the proposal.

4. Proposal to assess the results of service modularization

The proposal is structured in four steps, which are described in the following sections.

4.1. Defining and organizing the performance measures

Table 1 presents the organization of the performance measures, followed by the next section with the step 2.

Table 1. Performance measures and way to measure them

Dimensions and measures	How to measure
Customer	
Customer satisfaction [1-3]	Questionnaires/interviews (% satisfaction)
Variety [4-6]	*Conjoint analysis*
Visibility of service [18]	Interviews (intangible)
Internal processes	
Lead time of process [7-11]	Time between the start of an activity and its completion or time from the customer request to the end of the activity (minutes)
Number of reported problems [7,12]	Total number of reported problems (number of problems/month)
Number of stages of the process [12,13]	Total number of service process steps (absolute number)
Number of employees [7]	Total number of employees involved in the process (number of employees/month)
Resource utilization rate [1,7,11,14,15]	Resources consumed (units/month)
Productivity rate [7,10,13]	Relation between outputs and inputs (% productivity)
Flexibility [3]	Company's perception of the effort to meet customer's non-routine demands [scale: 0-10] - 10 is 'no effort required for change', and 1 is the 'effort to develop a new service' [3]
Financial	
Costs per process [7,14,15]	Activity-Based Costing (ABC) ($/month) [15]
Profit [16]	The difference between gross revenue and costs ($/month)
Cost of developing new service [9,13]	Estimated cost for the development of new services ($)
Growth and learning	
Lead time to develop new service [9,3]	Time required for the development of new services (days)
Percentage of reuse of service elements [17]	Relation between modules that can be reused in other services on the total number of modules (% reusable modules)

Based on the following references: [1] Chorpita *et al*. (2005); [2] Hsiao *et al*. (2015); [3] Otto and Hölttä-Otto (2007); [4] Jiao and Tseng (2004); [5] Okudan *et al*. (2013); [6] Tuunanen and Cassab (2011); [7] Piran *et al*. (2016); [8] Meyer *et al*. (2007); [9] Erixon (1998); [10] Larsson *et al*. (2016); [11] Peters and Leimeister (2013); [12] Hyötyläinen and Möller (2007); [13] Böttcher and Klingner (2011); [14] Yan *et al*. (2012); [15] Tay and Chen (2016); [16] Moon *et al*. (2011); [17] Stryker and Jacques (2012); [18] Ulkuniemi and Pekkarinen (2011).

4.2. Service categorization and modular strategy analysis

Different service types require different modular strategies, leading to distinct desired results (Geum *et al*., 2012; Eissens van-der Laan *et al*., 2016). The framework proposed by Carlborg and Kindström (2014) was chosen to support the analysis of service characteristics and modular strategies (depicted in Figure 2 and outlined in section 2).

Service Process	**Role of the customer** **Passive**	**Active**
Rigid	Type 1 - Key issue: Internal efficiency through a high degree of standardized modules - Example: automatic gas supply - High level of process formalization - Primarily provider-driven resources -Low level of technical skills -Modular strategy: Bundled	Type 2 - Key issue: Modularizing the customer's own experience - Example: online tool - High level of process formalization - Customer-driven resources -Low level of technical skills -Modular strategy: Pre-defined bundled offerings
Fluid	Type 3 - Key issue: Interaction of modules - Example: Remote monitoring - Provider-driven resources - High level of technical skills - Modular strategy: Flexible bundling	Type 4 - Key issue: Interaction of modules and supporting resources - Example: Operator-driven reliability - Provider- and customer-driven resources - High level of technical skills - Modular strategy: Unbundled modules

Figure 2. Diagram of modular strategies and four types of service (Carlborg and Kindström, 2014)

Based on the framework analysis, there are considerations for each service type:

• For service type 1 (rigid/passive) the variety of the offer is low, and the strategic focus is on the processes standardization, cost reduction, process lead time and resources to offer a lower price.
• For service type 2 (rigid/active) the customer creates value independently of provider, and the strategic focus is on client's efficiency, ensuring low process lead time and process visibility.
• For service type 3 (fluid/passive), the process coordination is necessary, evaluating the internal processes and module integration, to the firm being able to undertake appropriate activities. Moreover, the service type 3 requires offering a higher level of variety to respond to different customer needs.
• For type 4 (fluid/active), the process coordination is essential and considering that the client actively participates in this service type, aspects such as customer satisfaction and customer relationship are also strategic.
After a brief presentation of service types and modular strategies, the following section presents the step 3.

4.3. Selection and prioritization of performance measures

The framework presented in the previous step aims to support the selection and prioritization of performance measures, which could be assessed by experts. The selection of performance measures must take into account the service characteristics as well as the modularization purpose. Modularization can pursue three primary goals (Eissens-van der Laan *et al*., 2016): (i) offering variety, (ii) cost reduction, or (iii) balancing between variety and cost reduction. Therefore, considering these goals, the measures could be selected according to consultation with experts, who must choose and assign weights to them, as suggested by Otto and Hölttä-Otto (2007). After selecting criteria and assigning weights, the calculation of the relation between the values of the current situation (modular scenario) and the integral scenario (a traditional service architecture) can proceed, as presented next.

4.4. Difference between the current and previous situation and the vector of change

This proposal aims to prove the benefits achievable with service modularization. Therefore, to demonstrate the improvements obtained with modularization, it is necessary to compare a modular scenario with an integral one. The performance measures can be calculated (according to the recommendations in step 1 for previous/integral and later/modular situations. The ratio between the current situation (modular) and previous situation (integral) values is calculated from the ratio of the value obtained from the current situation and the previous situation, based on the assessment proposed by Erixon (1998). Moreover, weights can be attributed according to expert's assessment as mentioned previously (step 3), to help in the calculation of service modularization effects, as presented next (Equation 1). Table 2 presents an evaluation chart, which can be used to assist the calculation.

Table 2. Evaluation Chart

Dimensions and indicators	Weight	Integral architecture (IA)	Modular architecture (MA)	Ratio (MA/IA)
Customer				
Customer satisfaction [1-3]				
Variety [4-6]				
Visibility of service [18]				
Internal processes				
Lead time of process [7-11]				
Number of reported problems [7, 12]				
Number of stages of the process [12,13]				
Number of employees [7]				
Resource utilization rate [1,7,11,14,15]				
Productivity rate [7,10,13]				
Flexibility [3]				
Financial				
Costs per process [7,14,15]				
Profit [16]				
Cost of developing new services [9,13]				
Growth and learning				
Lead time to develop new services [9,13]				
% Reuse of service elements [17]				

Based on the following references: [1] Chorpita *et al*. (2005); [2] Hsiao *et al*. (2015); [3] Otto and Hölttä-Otto (2007); [4] Jiao and Tseng (2004); [5] Okudan *et al*. (2013); [6] Tuunanen and Cassab (2011); [7] Piran *et al*. (2016); [8] Meyer *et al*. (2007); [9] Erixon (1998); [10] Larsson *et al*. (2016); [11] Peters and Leimeister (2013); [12] Hyötyläinen and Möller (2007); [13] Böttcher and Klingner (2011); [14] Yan *et al*. (2012); [15] Tay and Chen (2016); [16] Moon *et al*. (2011); [17] Stryker and Jacques (2012); [18] Ulkuniemi and Pekkarinen (2011).

Based on the comparison of performance measures obtained to the integral architecture and modular architecture, it is necessary to check if modularization has a positive or negative impact on each performance measure. For instance, the customer satisfaction would be expected to increase with modularization, and if the modularization decreased the value of customer satisfaction, it would be necessary to multiply the ratio value for -1. This would show that modularization has a negative impact for this measure represented by the value of the ratio. After filling in the evaluation chart (Table 2) with the performance measures, weights, and the ratio between the integral and modular scenario, the total effect of service modularization can be calculated by:

$$V = \Sigma\,(Pi \times Ri \times Ei) \qquad (1)$$

where:

V: Vector of change or total modularization effect
Pi: Weight assigned to the performance measure

Ri: Ratio between modular and integral scenarios
Ei: Effect [1 or -1]

This evaluation also depends on the organization's historical data, or even on an ideal value for comparing the current situation (modular) with the previous one (or similar integral situation). By analyzing the modular scenario compared to the previous one may indicate opportunities for improvement for the organization. After presenting the proposal, attention is turned to the conclusions of this study.

5. Conclusions

The proposed approach aims to address the gap concerning the testing phase of service modularization (the modularization phases were presented in section 2) since the literature on the assessment of modularization results is still scarce. The approach may be suitable for providing an overview of the service modularization effects, based on the analysis of performance measures. The results of this proposal may be valuable to identify improvements in the service provision and process. Conclusively, the results are useful for proving the benefits of service modularization and providing a holistic view of modularization outcomes, which may be valuable since the existing studies consider few evaluation criteria. Regarding practical contributions, the evaluation of modularization effects aims to support the development and implementation of modularity in service offerings, allowing project teams to assess whether the objectives pursued with modularization are achieved. Moreover, the results may help the practitioners in the decision-making process, demonstrating aspects that should be changed in the service offer/provision. The understanding of how to evaluate the modularization results as well as the demonstration of benefits achieved can also contribute to increasing the number of practical applications, which is also a research gap.
Similarly to any other study, this one suffers from limitations. Firstly, the proposal scope is limited to the testing phase of modularization. Thus, further studies could consider other modularization phases (analysis of a service system, module and interface creation, and testing). The purpose application is also limited since it depends on the availability of organization's historical data, or even on an ideal value for comparing the current situation (modular) with the previous one (traditional scenario). Furthermore, the proposal would also be refined by the prioritization of performance measures using multiple-criteria decision analysis (MCDM) techniques or a combination of MCDM to assign weights and rank them accordingly. Moreover, this approach aimed to be generic, but by considering the service heterogeneity, some adaptations to service characteristics of specific service types (*e.g*., health services and logistics services) must be necessary, which may improve the service assessment. Finally, this study has limitations regarding the assessment of this proposal, because it was constructed based on theory. The next step of this work is the proposal assessment by experts in addition to its application with real data of health service modularization.

Acknowledgements

The authors thank National Council for Scientific and Technological Development (CNPq) for the grant for this research project.

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