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DEVELOPING A NEW TECHNIQUE FOR DETERMINING SERVICE MODULARITY LEVEL

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Abstract. This paper addresses the existing methodological gap in assessing service modularity level. The study uses a qualitative approach and develops a technique to quickly and cost-effectively determine service modularity level. The theoretical framework builds on the principles of measurement theory, evaluation theory, and multicriteria analysis (MCA). To test the developed technique, an exploratory case study was conducted focusing on three service companies in Lithuania. Data were collected by interviewing key informants using the proposed instrument. The collected data were analysed and linked to the developed multidimensional scale for measuring the service modularity level. The obtained results support the view that qualitative evaluation can be an alternative for calculating modularity indices in the field of service modularity. The paper provides a practical tool for service modularity assessment for service industry practitioners to accelerate decision-making. The study contributes to the field of service modularity by delivering insights into assessing service modularity level. These insights are particularly important because the literature on measuring modularity level in services has been quite scarce.

Keywords: service modularity level, service modularization, decision support, qualitative evaluation, evaluation techniques, case study.

JEL Classification: C83, D81, L8.

Introduction

In the search for solutions on how to achieve service excellence in a cost-effective manner to increase customer satisfaction and gain a competitive advantage, service organizations are considering the service modularization approach (Wirtz & Zeithaml, 2018). The potential benefits of a modular system – diversity of options, complexity management, lower system operating costs, and the like – drive the application of modular principles to service delivery (Xiao & Zhang, 2021). The modularity embodies a hierarchy between system blocks or modules that are relatively independent and have a functional purpose within the system

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but are loosely coupled to act in a coordinated manner as a whole (Baldwin & Clark, 2000). When needed, modules can be easily separated and recombined to create the desired variant outcome without increasing cost. Although different in nature from physical products, services can be viewed systemically, and the principles of modular design can also be applied. Modular design for services manifests itself at various levels (Bask et al., 2011; Løkkegaard et al., 2016; Pekkarinen & Ulkuniemi, 2008; Tuunanen et al., 2012; Voss & Hsuan, 2009) – service offering, service delivery process, organizational structure of a company.

Despite the growing body of research on service modularity, practical applications of modular delivery are relatively rare (de Mattos et al., 2019) in other service contexts except reported cases in healthcare (Peters et al., 2020), logistics (Cabigiosu et al., 2015), IT (Tuunanen et al., 2022), education (Sorkun et al., 2022), legal services (Giannakis et al., 2018), and tourism (Avlonitis & Hsuan, 2017). The literature offers little in the way of decision support for planning modular service delivery and weighing the changes to be implemented. When considering service modularization, the question of current service modularity level inevitably arises. This information is needed to make management decisions and to ensure that the intended changes in the design of modular service systems are reasonable. Unfortunately, there is a significant gap in the ways to measure the modularity level in services (Dörbecker et al., 2015). The literature proposes number of tools and techniques for measuring the modularity of physical products. However, the proposals do not aid suitably for measuring service modularity because they were created based on the specifics of physical products rather than services.

To address this gap, this paper explores how the dimensions of service modularity can be empirically assessed and presents a technique for determining modularity level in services. The proposed technique is supported by theoretical approaches from measurement theory, evaluation theory, and multicriteria analysis (MCA). Its applicability was tested in three cases analyses.

The paper is structured as follows. Section 1 provides the theoretical framework for elaborating a technique for service modularity evaluation. Section 2 describes the methodology and cases. Further, we discuss the results. Finally, we outline conclusions, research limitations, and suggestions for future studies.

1. Theoretical framework

1.1. Choosing evaluation approach

Various criteria can be used to describe the modular structure and to evaluate the degree of modularity. One of the most important criteria for evaluating the degree of modularity is considered to be the component sharing or commonality, which has been studied in detail by Collier (1981), Stake (2001), Thevenot and Simpson (2008), and Windheim (2020). It is proposed to calculate different indices related to this characteristic: DCI – Degree of commonality index (Collier, 1981), TCCI – Total constant commonality index (Thevenot & Simpson, 2006, 2008), PCI – Product line commonality index (Thevenot & Simpson, 2006, 2008), % C – Percent commonality index (Thevenot & Simpson, 2006, 2008), CI© – Component part commonality index (Jiao & Tseng, 2000).

Meanwhile, Salvador (2007) offers to evaluate the degree of modularity by characteristics: component separability, component combinability, functional binding, interface standardization, and loose coupling. Fixson (2005), Fixson and Park (2008), Pimmler and Eppinger (1994) additionally propose the criteria related to interfaces: coupling intensity, reversibility of interfaces, and standardization of interfaces. It should be noted that the criteria proposed by Salvador (2007), Fixson (2005), Fixson and Park (2008), are more relevant to technical solutions in product design to develop an optimal modular structure solution. Moreover, it should be point out that the above characteristics are difficult to calculate for a complex product or a very diverse offering.

The literature (Erixon, 1998; Pugh, 1991; Windheim, 2020) also distinguishes a different approach to assessing the degree of modularity. It is suggested to focus not on the structural characteristics of modularity, but on the potential benefits of a modular structure, such as reduction of complexity, faster product manufacturing, more opportunities to create product variants, cost savings, shorter time to market, etc. These benefits of modularity can be attributed to indirect criteria that describe the modularity level.

The above presented criteria for describing modularity level are used in the context of physical products. Some of them can be adapted to services if a specific methodology for modular design of services is chosen (Poeppelbuss & Lubarski, 2018). Many of the currently known methodologies were originally developed for the modularization of physical products and transferred to services. Thus, it is potentially possible to adapt the discussed criteria to assess the modularity of services.

To assess the modularity of services, Voss and Hsuan (2009) propose the use of a Service Modularity Function (SMF). This exponential function quantitatively indicates the degree of service modularity by considering the number of unique modules, i.e., those that cannot be easily replicated and are not standardized in the industry, in the total number of service modules. The values of SMF can range from 0.0 to 1. When the SMF = 1, there is an ideal modular system in which the modules can be easily replicated, and when the SMF = 0.0, such a system consists only of unique modules that cannot be replicated in other systems. Apart from Voss and Hsuan's (2009) proposal for assessing service modularity, no other recommendations for the service domain have been found in the literature, and to the authors' knowledge, the application of SMF has been studied only in conference papers (Peters et al., 2022).

Based on the service specification documents created during service design, the number of service modules, the number of components in the service module, the number of reusable modules, the number of service variants, and other similar data required to calculate modularity indices and implicit criteria can be accurately determined. In these cases, the use of the measures presented above may well be appropriate to assess the degree of modularity of services. It should be noted, however, that service modularity may arise not only intentionally but also organically when the service organization is in the process of innovation, replication of services, development of new services, and standardization of service offerings and similar processes (Gremyr et al., 2018). In such cases, it may be difficult to compare the current level of modularity of services with the level of modularity of alternatives developed during service design if the service provider has not used procedures to document service processes in its previous activities. The provider does not have the data to calculate the modularity indices and obtaining this data would be costly and time consuming.

For the situation where the current level of service modularity needs to be assessed in a timely manner, we propose to develop an internal assessment technique that allows for relatively rapid collection of the necessary data and assessment of service modularity. Internal assessment is used when decisions need to be made about an organization's process redesign plans or to determine the adequacy of planned initiatives (Stufflebeam & Coryn, 2014) and to improve the quality of decision outcomes.

The literature on service modularity often attempts to apply the modularity of physical products to services. However, services have characteristics that prevent the modularity of physical products from being directly applied to services. The search for suitable adaptations makes the definition of service modularity even more complex, which is reinforced by the diversity of service types that bring specific characteristics. The transfer of knowledge from one context to another – from systems engineering to socio-economic context – inevitably raises problems of interpretation and connection with real phenomena. The theoretical-analytical proposals on the concept of service modularity formulated in the scientific discussion are conceptual. They do not help to identify service modularity as a phenomenon and to determine whether it is present or not in a particular service organization. For this purpose, it is necessary to develop a technique to assess the presence of service modularity and the possible qualitative levels of it.

1.2. Methodology

The integration of methodological principles from measurement theory, evaluation theory, and multicriteria analysis (MCA) was chosen to develop the technique for determining service modularity level. The field of measurement theory is concerned with the development and validation of measurement models (Bandalos, 2018). Applying strict procedural consistency requirements ensures validity (i.e., that the model measures exactly what it is supposed to measure) and reliability (i.e., that the same model produces the same results in different samples). The principles and methods used in evaluation theory help to systematically plan the evaluation process and develop an evaluation model (Stufflebeam & Coryn, 2014). Multicriteria analysis is used when decision support is needed to solve complex and poorly structured problems according to predefined criteria (Zopounidis & Pardalos, 2010). The methods used in case analysis make it possible to know in detail the real context in which the phenomenon under study exists and to add new knowledge to the research field (Eisenhardt & Graebner, 2007). According to Bandalos (2018), the use of measurement theory faces two major challenges. First, it is difficult to obtain the large sample data needed to validate measurement models. Second, the widespread use of psychometric scales in the social sciences introduces bias in socially desirable responses to data collection, making it difficult to draw reliable conclusions. It is important to understand that such measurement error is an integral part of measuring and assessing many social objects, including management sciences. Thus, in the social sciences, there is no one best way to measure or evaluate. And to find the right way, the methodological principles of different theories must be combined.

In testing the developed evaluation technique, the exploratory case study approach was adopted. Since service modularity theory is still in its infancy and many empirical studies rely on experimental case studies (de Mattos et al., 2019). The lack of more diverse research methods can be explained by the fact that the current goal is to gather evidence that service modularity can be a recognizable, understandable phenomenon for service providers and that knowledge about service modularity can be put into practice. However, the application of the case analysis method does not allow to collect enough data to confirm the validity and reliability of the proposed measurement or evaluation models and to generalize their application in different contexts through statistical-mathematical methods. Therefore, the research methodology has this limitation, which has proven to be quite common in studies of a similar nature.

Considering the rationale for this study and the procedures proposed by Churchill (1979), Netemeyer et al. (2003), Bandalos (2018), Zopounidis and Pardalos (2010), the following procedure was established for this study:

- Step 1: Specifying the content of the construct of service modularity by developing its nomological network.
- Step 2: Determining the dimensions that constitute service modularity. Identifying possible quality levels (segments) of service modularity formed by the different dimensions of the construct. Creating a linguistic description of the service modularity levels (segments).
- Step 3: Compiling a list of criteria describing the defined dimensions. Preparing an instrument for data collection.
- Step 4: Conducting a pilot study. Revising the list of criteria and the data collection instrument in consultation with experts in the field of service management.
- Step 5: Forming a group of internal experts in the studied service companies. Collecting data by interviewing the experts. Determining the consistency of the experts' opinions.
- Step 6: Calculating estimates of dimensions expressing the level of service modularity in the studied service companies.

The consistent implementation of the above steps forms the basis for the development and practical testing of the applicability of the technique for evaluating service modularity level.

1.3. Multidimensionality of service modularity construct

The term construct is used when the aim is to substantiate a theoretical concept in practice, to determine its impact on other constructs, to measure it, etc. Preparatory and applied tasks are required for reliable construct formation (Salkind, 2010): detailed analysis of theoretical aspects, verification of known interrelationships of the construct with other constructs, conducting tests with the target group to ensure that the construct field is sufficiently defined, etc. In general, constructs cannot be directly observed and evaluated (DeVellis, 2017) and are therefore considered latent variables, meaning they are not directly observable but can be evidenced by other observable variables. In order to rely on the measurement or estimation of a latent variable, the construct must be theoretically grounded by answering the questions of what constitutes a latent variable and what determines that a latent variable exists (Netemeyer et al., 2003). Cronbach and Meehl (1955) propose to refer to such an arrangement of related variables and their relationships, or a set of mutually repeating theoretical laws, as the nomological network of a construct. Bandalos (2018) emphasizes that when applying measurement theory in a social context, the formation of a nomological network remains a valuable technique to reveal the nature and content of a construct. After creating a nomological network, the content of the theory is structured and prepared for testing.

Gremyr et al. (2018) apply the definition of modularity to services provided by systems engineering and state that the modularity of a service system is characterized by the (1) architecture of the service system, how functions are assigned to (2) modules, and how modules are connected by (3) interfaces, as well as the internal characteristics of the module. Therefore, the architecture, module, and interface are considered as causal constructs in the nomological network of the construct of service modularity (Figure 1). These constructs can be evaluated based on the characteristics (criteria) that occur when service modularity exists within the service organization.

One of the clearer descriptions of architecture construct comes from Voss and Hsuan (2009): Architecture expresses the way in which the functions of a service system are decomposed into individual functional elements to ensure service delivery. For an architecture to be considered modular rather than integral, it is important that it ensures the development of service variants by assembling modules. There are three known types of modular architecture (Ulrich, 1995) that describe how a product is composed of individual modules: 1) slot, a product is composed of functional modules that have their own alternatives, and the alternatives of a given module have their own interfaces; by changing module alternatives, product variants are created; 2) bus, the product has a base (platform) to which other

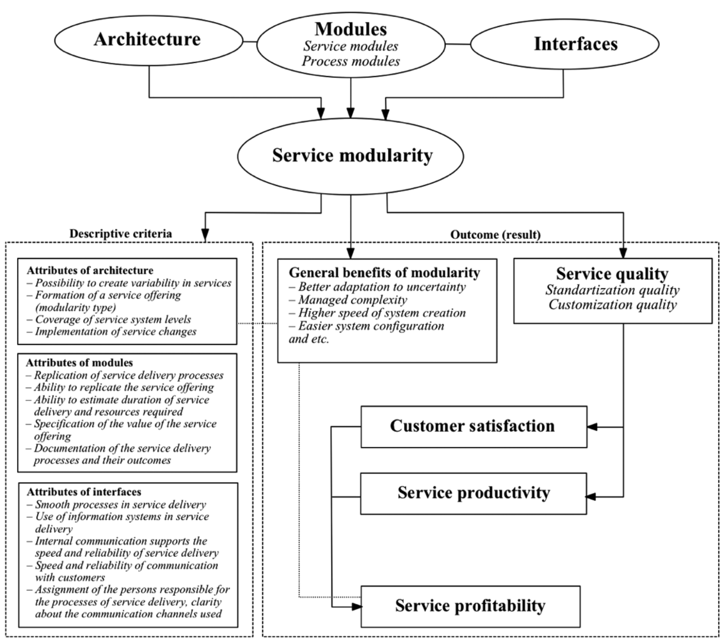

Figure 1. Nomological network of service modularity construct (source: created by authors)

functional modules are connected, creating product variants; all modules have the same interfaces; 3) sectional, the product consists of different functional modules that have the same interfaces; product alternatives do not arise in this case, which means that all intended functional modules must be combined to complete the product. The type of modular architecture implemented depends on the type of service. It is also emphasized that the architecture at any level – organization, service, processes, customer service, etc. – may or may not be modular (Pekkarinen & Ulkuniemi, 2008; Voss & Hsuan, 2009). In other words, the extent of modularity in a service organization can vary. Another feature frequently mentioned in the literature (Brax et al., 2017; Løkkegaard et al., 2016; Voss & Hsuan, 2009) that indicates the presence of a modular architecture is the introduction of agility in service systems, which enables rapid implementation of service updates, development of new services, adaptation to changes in the environment, etc.

According to de Mattos et al. (2019), there is not yet a clear description for the module construct in the context of services. Baldwin and Clark (2000) refer to a module as a block or derivative in which the structural elements are strongly connected to each other and relatively weakly connected to the elements of other blocks or subdivisions. Rajahonka (2013) defines a module as a relatively independent part of a system with a specific function and standardized interfaces. Due to the duality of service as product and process, the constructs service module and process module are distinguished. Tuunanen et al. (2012) refer to a service module as a system of components that has well-defined functionality through a well-defined interface and enables the creation, customization, personalization, and individualization of a modular service. Pekkarinen and Ulkuniemi (2008) describe the process module as an indivisible and standardized process step that, when combined with other process steps, can be used to reconfigure the process configuration and perform the functions required for service delivery. The following characteristics can be derived from such descriptions. The service as a product has a predetermined definition of the value provided and the process has some degree of standardization. Such characteristics of the construct module can be identified when: it is possible to repeat or replicate the services provided, the processes of service delivery are reused or duplicated, the resources and duration required to provide the service can be reasonably estimated, the specification of the value of the service offering exists, the processes of service delivery and their outcomes are documented.

The interface construct, adapted to the service domain, is provided by de Blok et al. (2014) and proposed as a set of rules and guidelines that ensure flexible alignment, interconnection, and interdependence of service components and service provider employees. Voss and Hsuan (2009) explain that harmonization and interconnectedness are provided by managing information content and information flows. From these descriptions, it can be concluded that the presence of the interface construct is confirmed by the smooth flow of service delivery processes, the use of information systems to deliver services, the speed and reliability of internal communication to support service delivery, the mapping of service delivery processes, and the clarity of the communication channels used. Based on Peters et al. (2018), it should be considered that there are several perspectives on the analysis of interfaces that point to their function of (1) designing a coherent service offering, (2) customizing a service offering to the needs of users, and (3) coordinating the aggregation of value from multiple, autonomous organizations in a service offering to a customer. However, more research is needed to explore in detail how interfaces manifest and how they can be addressed to improve the delivery of complex services (Peters et al., 2018).

The construct can also be evaluated by its outcome, not only by its interrelationships with other constructs. In the scientific literature, the benefits of service modularity are often associated with the general benefits of a modular system: faster adaptation to uncertainty, controlled complexity, higher speed of system development, easier system configuration, etc. These mentioned advantages reflect the existence of a modular architecture that allows flexible implementation of changes, innovations, adaptations to changes, etc. in the service organization. Although the advantages of this general modular system are frequently mentioned in the service modularity literature, only an increase in service delivery productivity due to economies of scale (Pekkarinen & Ulkuniemi, 2008) and an increase in perceived service value (satisfaction service), which creates the conditions for service customization (Rahikka et al., 2011) are confirmed by empirical studies. Research on service quality (Anderson et al., 1997; Helgesen, 2006; Heskett et al., 2008; Wirtz & Zeithaml, 2018) is based on the impact of service standardization and customization on service productivity, customer satisfaction, and service profitability. Since service standardization and customization are achieved through service modularization (Skačkauskienė & Vestertė, 2020), their impact on service performance can be considered as a consequence of service modularity.

A construct that consists of multiple aspects that are interrelated yet distinct is classified as a multidimensional construct (Netemeyer et al., 2003). This means that such constructs can be measured or assessed using multidimensional scales that describe the phenomenon under study and differentiate it according to the quality of its occurrence in one or the other case. Having created a nomological network of the construct of service modularity (Figure 1), it can be stated that this construct can be assigned to a three-dimensional construct: Architecture, Modules, and Interfaces. To describe such a three-dimensional construct, a bipolar statement, e.g., the degree of modularity is high or low, is not sufficient because it does not describe the meaning (sense) of a complex construct. Therefore, a multidimensional construct must be assessed by estimating the scales of its constituent dimensions and using them to determine a generalizing point to describe its semantic meaning (Trochim et al., 2016). In the case of the three-dimensional construct, this would mean finding a point in three-dimensional space according to the Cartesian coordinate system and describing its expression (Figure 2).

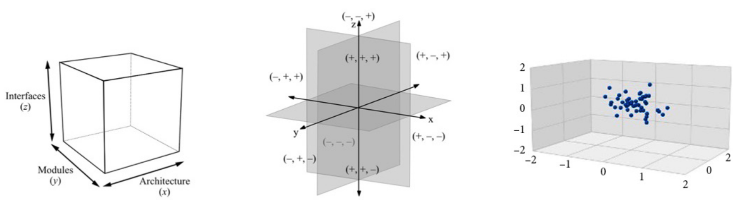

Figure 2. Formation of a multidimensional evaluation scale of the service modularity construct (source: created by authors)

This three-dimensional scale consists of an eight-segment semantic field defined by the bipolar (– ↔ +) values of the criteria describing the dimensions. The linguistic description of the three-dimensional scale – architecture, modules and interfaces – can be found in Table 1.

In assessing the modularity of services, qualitative data should be collected according to dimensional criteria. Based on the obtained estimates, a summary estimate (point) is determined, and the corresponding modularity level (segment) is assigned. Once the current service modularity level is determined, decisions can be made about changing the modularity level of services (improving the status).

2. Application of qualitative evaluation for determining service modularity level

There are studies (Lin, 2007; Liu et al., 2016; Tu et al., 2004; Worren et al., 2002) that used descriptive criteria to assess the modularity level when collecting qualitative data. Of these studies, only Liu et al. (2016) examined modularity in the context of services, while the other studies were conducted in goods-related domains. They attempted to show the relationships between modularity, organizational management structure, and productivity, i.e., service modularity was not the focus of the research, and its multidimensionality was not considered.

Table 1. Linguistic description of service modularity level (source: created by authors)

Segment	Architecture (x)	Modules (y)	Interfaces (z)	Linguistic description
I	+	+	+	The service modularity is present. The service system has well-integrated modular principles.
II	+	–	+	There is evidence of service modularity, but there is no synergy between dimensions.
III	–	+	+	There is evidence of service modularity, but there is no synergy between dimensions.
IV	–	–	+	There is no service modularity. The service system is based on integral principles.
V	+	+	–	There are signs of service modularity. The service system does not function properly.
VI	+	–	–	The service system does not function properly. Indirectly, it is difficult to determine on which principles – modular or integral – the service system is based.
VII	–	+	–	The service system does not function properly. Indirectly, it is difficult to determine on which principles – modular or integral – the service system is based.
VIII	–	–	–	There is no service modularity. The service system does not work properly and needs to be fundamentally redesigned.

2.1. Data collection instrument and sampling

In order to create the list of criteria needed to pursue the task of this research, ideas were adopted from the mentioned studies and interpretations of the constructs of architectures, modules and interfaces in services proposed by different authors (de Blok et al., 2014; Brax et al., 2017; Løkkegaard et al., 2016; de Mattos et al., 2019; Pekkarinen & Ulkuniemi, 2008; Tuunanen et al., 2012; Voss & Hsuan, 2009).

The synthesis served to combine the approaches of the above research and to develop an initial list of criteria describing the architecture, modules, and interfaces of service modularity. As an instrument for data collection, a questionnaire was elaborated in Lithuanian language and in the format of a semantic differential using a Likert scale with 7 levels of correspondence. A pilot study was then conducted to test the instrument. 3 Lithuanian experts with many years of experience in the field of service management participated in the study. The experts were asked to fill in a questionnaire and comment on the accuracy of the wording used, the relevance to services and the comprehensibility of the terms used. After in-depth discussions, the wording of the statements was corrected, and overlaps in the content of the criteria and other shortcomings were eliminated. The final version of the instrument (Appendix, Table A1), consisting of 26 questions, was prepared for data collection.

As mentioned earlier, qualitative approaches and case studies are appropriate for addressing issues with unknown variables and an incomplete theoretical foundation. Observing actual practice through case studies provides valuable insights into the subject matter. In addition, case studies are important for use in an exploratory setting where many factors are still unknown and new theory needs to be developed. Due to the limited knowledge on assessing service modularity level, three cases were used to achieve the objectives of this research. The cases were selected based on their similarities in order to conduct a replication study that can predict similar results and thus generalize beyond the units studied. Companies were selected that meet the following criteria: their activity belongs to the service sector, they operate in Lithuania, the duration of their existence is sufficient to be considered stable, they meet the characteristics of a small and medium enterprise in terms of number of employees and annual turnover. An overview of the companies selected for the case study presented in Table 2.

Table 2. Profiles of the service companies selected for the case studies (source: created by authors)

Code	Description	Year of foundation	Number of employees	Annual turnover
O-1	Lithuanian company that designs and supervise the installation of technical networks. This includes structures and equipment that provide electricity and water supply, sewage disposal, ventilation, heating, and enable the operation of residential and public buildings.	1994	20	3–5M EUR excluding VAT
O-2	Lithuanian company that provides IT solutions, security audits, analytics, quality assurance and maintenance services for organizations that are comprehensively digitizing their business processes.	1988	220	10–11M EUR excluding VAT

End of Table 2

Code	Description	Year of foundation	Number of employees	Annual turnover
O-3	Lithuanian company that provides aircraft repair solutions and comprehensive maintenance services, as well as aircraft logistics, aircraft parts supply and maintenance, engine management, ground support technology, aircraft interior and exterior modification and other related services.	2007	50	20–21M EUR excluding VAT

Expert groups were formed in selected service companies after conducting interviews with top managers about the objectives of the study. To ensure the reliability of the study, special attention was paid to the selection and quantification of experts, following recommendations in the scientific literature (Fitzpatrick et al., 2009; Stufflebeam & Coryn, 2014). In assessing service modularity level, it was considered that those selected as experts have sufficient practical experience (at least three years) in the areas of management of service delivery processes, implementation of service systems, and service development. In addition, the positions held by those selected as experts must correspond to managerial positions and they must have worked for the service organization under study for at least three years.

Another important aspect to achieve objectivity in the evaluation is to determine the number of members of the expert group. As Leavy (2017) points out, when collecting data for evaluation purposes, there are no strict rules for determining the number of respondents (in this case, experts). It all depends on the research question at hand – how much data needs to be collected to draw sound conclusions. According to Brinkmann (2013), one practical rule should be followed in data collection to get to the core of the phenomenon under consideration – interview up to 15 respondents in the case under consideration. However, it has been shown (Libby & Blashfield, 1978) that the aggregate estimates of three experts are much more accurate than the estimates of individual experts, and as the group of experts grows larger, the accuracy of the aggregate estimate increases slightly and is highest for a group of 5–9 experts. In cases where the accuracy of the evaluation of group comprising 5–9 experts is not sufficient, it is suggested not to increase the number of experts in the group, but to include more competent experts in the evaluation. The internal assessment of service modularity level within the established data collection instrument requires a wider spread of opinions to obtain a more reliable and objective reflection of the estimates of the modularity dimensions. Therefore, it was decided to consider the size of the service organization and the organizational management structure and to interview more than 5 experts for the assessment, but not more than 15, since a higher number of respondents does not increase the accuracy of the assessment but increases the time and cost of data processing.

2.2. Case study results

After interviewing the experts from the case study companies, the degree of agreement between their opinions was evaluated. The experts' opinions and approaches to the criteria describing service modularity may not only differ but also contradict each other, which would influence the decisions on further modularization of services. When more than two experts are interviewed, it is common to calculate Kendall's coefficient of concordance *W* for the consistency of experts' opinions (Salkind, 2010). The value of *W* can range from 0 to 1. When $W = 1$, it means that the experts expressed their opinions absolutely unanimously; when $W = 0$, the experts essentially disagree. If $W \geq 0.6$, then the expert opinions are sufficiently harmonized, and further decisions can be made.

Podvezko (2008) argues that the degree of agreement between expert opinions is determined not so much by Kendall's concordance coefficient W, but by its random value – the criterion χ^2. If the calculated value of χ^2 is larger than $\chi^2_{critical}$, then the expert estimates are considered consistent. If the small value of W is calculated with a large number of experts (≥7) or / and many criteria (≥7), then it is worth calculating the value of the criterion χ^2 and checking whether it is larger than $\chi^2_{critical}$. If it is higher, then the expert opinions are considered to be sufficiently harmonized despite the small value of Kendall's coefficient of concordance *W*. Once the concordance of the expert opinions was found acceptable, the collected data were processed to find the mean values of the dimensionality estimates and to determine the point (coordinates) representing the level of modularity (segment). To find this point, the collected data were first transformed from the 7-point Likert scale used to the scale of the axes of the coordinate system: 1 → (–3); 2 → (–2); 3 → (–1); 4 → 0; 5 → 1; 6 → 2; 7 → 3. Next, a table of transformed data was created from the estimates of the specific experts for the modularity dimensions and the generalized estimates of all experts were calculated using the arithmetic mean. Once a generalized estimate of the number of experts for the service modularity dimensions – one point (x, y, z) – was obtained, it was possible to determine to which of the levels (segments) listed in Table 1 the service modularity could be assigned, and recommendations could be made.

The expert groups were surveyed, and the data were collected using the survey software QuestionPro (https://www.questionpro.com/t/ASo8iZmlhw). SPSS software was used to analyze the collected data and perform the necessary calculations, and the ChartStudio plugin (www.plotly.com) was used to visualize the data.

The results of the consistency check of the expert opinions are presented in Table 3.

Table 3. Expert opinion compatibility results (source: created by authors)

Code	Number of experts	*W*	χ^2	Conclusion
O-1	8	0.583	116.653	Concurring Opinions. The value of Kendall's coefficient of concordance *W* is less than 0.6, although it is very close to the point where the opinions can be considered sufficiently harmonized. When the value of the coefficient is in the range of 0.4–0.6, as in this case, the expert opinions are considered to be moderately concordant. Since both the number of experts (8) and the number of criteria (26) are high, i.e., ≥7 the consistency of opinions is also checked using the criterion χ^2. In this case, since $\chi^2 = 116.653 > \chi^2_{critical} = 37.652$, the opinions are considered consistent.

End of Table 3

Code	Number of experts	*W*	χ^2	Conclusion
O-2	5	0.489	61.075	Concurring Opinions. The value of Kendall's coefficient of concordance *W* is less than 0.6 and falls within the range where opinions are considered moderately consistent. Since the number of criteria (26) is high (≥7), the consistency of opinions is also checked using the criterion χ^2. In this case, since $\chi^2 = 61.075 > \chi^2_{critical} = 37.652$, the opinions are considered consistent.
O-3	8	0.300	60.011	Concurring Opinions. According to the value of Kendall's coefficient of concordance *W* = 0.3, the opinions of the internal experts are considered to be not very harmonious. Since both the number of experts (8) and the number of criteria (26) are high, i.e., ≥7, the consistency of opinions is checked using the criterion χ^2. In this case, since $\chi^2 = 60.011 > \chi^2_{critical} = 37.652$, the opinions are considered consistent.

The results obtained after the calculations with the organization's O-1 data are presented in Table 4, and the visualization of the points obtained from them is shown in Figure 3. The results of the other organizations involved in the study are presented in Appendix, Tables A2, A3.

Table 4. Expert assessment of service modularity level in O-1 organization (source: created by authors)

O-1 experts	Architecture (*x*)	Modules (*y*)	Interfaces (*z*)
E1	0.375	2.111	0.889
E2	0.875	2.000	1.667
E3	0.000	1.222	1.444
E4	1.125	0.778	1.889
E5	–0.875	1.889	1.000
E6	1.375	0.889	1.000
E7	0.750	1.667	2.000
E8	0.625	1.000	0.000
Generalized assessment, point (*x*, *y*, *z*)	0.531	1.444	1.236

Based on the obtained summary points of the service modularity assessment, it is determined to which segment the company belongs, and based on the linguistic description of the segments (Table 1), the conclusion about the service modularity level for the participating companies was prepared (Table 5). The service modularity was found in all three cases.

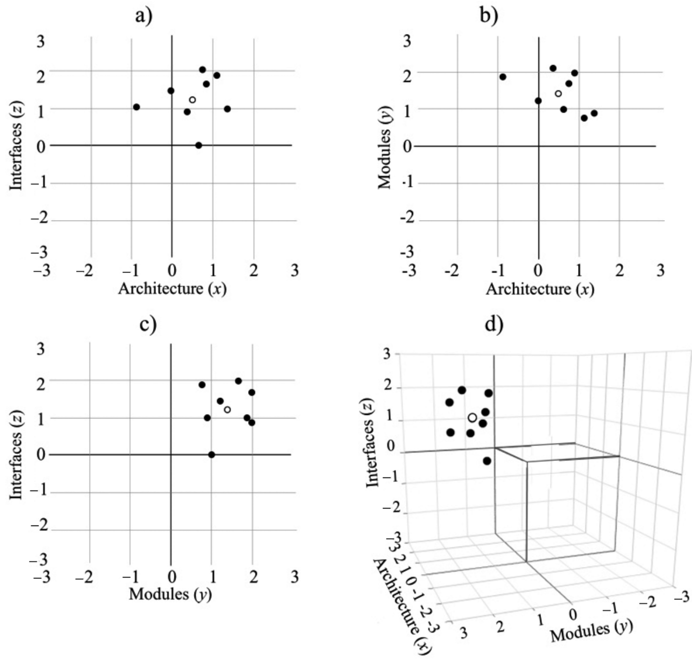

Figure 3. Expert assessment of service modularity level in the organization O-1: a) projection in the plane architecture (x) and interfaces (z); b) projection in the plane architecture (x) and modules (y); c) projection in the plane modules (y) and interfaces (z); d) arrangement of points in three-dimensional space (source: created by authors)

Table 5. Identification of service modularity level (source: created by authors)

Code	Generalized assessment (x, y, z)	Segment	Conclusion
O-1	(0.531, 1.444, 1.236)	I (+, +, +)	Service modularity is present. A low score on the architectural dimension (one expert also gave a negative score) suggests that the organization could look for ways to achieve greater synergy among the dimensions of modularity.
O-2	(1.075, 1.667, 1.733)	I (+, +, +)	Service modularity is present. The estimates of the dimensions indicate that there are synergies between the dimensions. Since the consistency of expert opinions is not very high (the ratings of some criteria are completely opposite), this organization should take additional measures to find out if the decision makers see the situation in the same way.
O-3	(0.266, 0.889, 1.042)	I (+, +, +)	Service modularity is present, but due to the low ratings of the architecture dimension and the module dimension (several experts gave negative ratings), it can be argued that there is a lack of synergy between the modularity dimensions, so the organization should analyze the individual components of the service system in more detail.

Discussion

The proposed service modularity level evaluation technique uses a qualitative approach. In this respect, it differs from SMF, which is based on a quantitative measurement. The proposed technique is suitable for cases where it is not possible to use a modularity indices in assessing service modularity level because the data for their calculation is unobtainable. Such cases usually occur when service modularity arises organically, when the service organization innovates, replicates services, develops new services, and standardizes the service offering. If a service provider has not used service process documentation procedures in its previous activities, it does not have the data to calculate the modularity indices and obtaining them would be costly and time-consuming.

Using the developed internal assessment technique, the service modularity level was determined in three service companies in Lithuania. Though it was found that modularity of services is present in all three service companies, the existing level of modularity in these companies can be further refined. Due to the different consistency indices of the experts' opinions and the different assessments of the dimensions, the conclusions of the results were revised individually for each organization – which they should consider in their further decisions.

Admission of the developed qualitative assessment methodology in service organizations allows to justify its use instead of criteria describing the modular structure. The obtained assessments of service modularity level assist for rationalization of decisions related to the modularization of services.

Although the development of the evaluation technique is based on the single-provider context, this was a deliberate move to simplify a complex problem and focus on the essentials. The application of the first-principles thinking was intended to establish the basis for measuring service modularity using a qualitative approach and then to identify the possible adaptations to the multi-provider context.

Conclusions

Assessing service modularity level is of paramount importance for decision-making related to service modularization. A clear understanding of how service modularity endorse performance management points enables consideration of necessary organizational changes. This paper contributes to service modularity level measurement literature which have been limited. The study proposes the application of a novel evaluation technique based on data collection using a multidimensional evaluation scale, which has not been considered in previous research.

The developed internal assessment technique was tested in three service companies in Lithuania. It was found that modularity of services is present in all three service companies.

Although this paper highlights the effectiveness of the proposed assessment technique in terms of cost and speed, the following limitations of the proposed approach must be considered. First, the technique does not provide an explicit assessment of modularity dimensions with high mathematical precision. The multidimensional scale developed to measure the service modularity level needs further elaboration. Second, the technique may be somewhat static when applied to large service enterprises or multi-provider context, and the characteristics of the modularity dimensions may not be fully captured by the proposed data collection tool. Therefore, to strengthen the assessment technique, its suitability for large enterprises or complex service offerings in multi-provider context needs to be reconsidered. Third, as mentioned earlier, the case study method is limited in its ability to support generalizability of findings. However, the aim of the research was not to generalize the findings, but to explore the possibilities of the elaborated technique for assessing service modularity level. Therefore, the technique needs to be further tested in subsequent research with larger samples or more case studies.

The results suggest important implications for service industry practitioners considering service modularization as an approach to solving the problem of balancing service quality and cost. We hope that some of the empirical guidelines discussed in this study will accelerate decision-making in service modularization.

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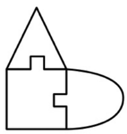
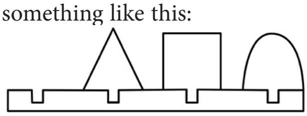
APPENDIX

Table A1. Data collection tool for assessing the level of service modularity (source: created by authors)

Code	Evaluation criteria	Bipolar (– ↔ +) values
Architecture dimension		
A1	Significant changes in our service offering and delivery are being implemented	Slow ↔ Fast
A2	Significant changes in our service offering and delivery are being implemented	Problematic ↔ Smooth
A3	Minor changes in our service offering and delivery are being implemented	Slow and problematic ↔ Fast and smooth

Continued Table A1

Code	Evaluation criteria	Bipolar (– ↔ +) values
A4	Our services are characterized	By dynamism – we adapt the offered service to various customer needs and make the necessary changes in our processes when providing the service. ↔ By stability – we adapt the provided service to the customer's preferences only within the limits defined by us and do not make any changes / exceptions in our processes when providing the service.
A5	Our services are provided by creating a service offering from individual, interconnected parts of the service. Visually, it looks something like this: 	Not like ↔ Like
A6	Our services consist of a core service to which alternative parts requested by the customer are connected. Visually, it looks something like this: 	Not like ↔ Like
A7	Our service delivery processes have elements (tasks, procedures, etc.) that are commonly used throughout our range of service offerings.	No, they have not ↔ Yes, they have
A8	Our organizational structure has the characteristics of a matrix structure.	No, it has not. ↔ Yes, it has.
	Modules dimension	
M1	When we sell services to our customers, we can clearly state what services they will receive.	No, the specifics of our services are such that it is difficult to describe them in detail when selling. ↔ Yes, we can describe future services in detail.
M2	We provide our services on time as agreed.	No, we are always late. ↔ Yes, always on time.
M3	When we sell services, we can calculate (estimate) their price quickly.	No, we take a long time to calculate (estimate) the cost of services. ↔ Yes, we can calculate (estimate) the price of services very quickly.
M4	When we sell services, it is easy for us to set deadlines for their completion.	No, it is difficult for us to predict the deadlines for services. ↔ Yes, it is easy for us to predict the deadlines for services.

End of Table A1

Code	Evaluation criteria	Bipolar (– ↔ +) values
M5	We can quickly introduce a new employee to the procedures of our service delivery.	No, it usually takes a long time to fully familiarize a new employee with procedures. ↔ Yes, we can usually quickly familiarize a new employee with the procedures.
M6	We know what typical problems customers will have when using our services.	No, we do not know that at all. There are many unforeseen problems with the service. ↔ Yes, we do know that. There are almost no unforeseen problems, and we are ready to fix typical problems quickly.
M7	We can clearly describe what processes we use to deliver our services.	No, we cannot. Most of our service processes are streamlined because we have to adapt to our customers' needs. ↔ Yes, we can. Most of the processes we provide are very clear, with possible exceptions up front.
M8	Our processes for delivering services are documented.	No, there is no process documentation. ↔ Yes, the processes are documented.
M9	The descriptions of our service delivery processes available to us are:	Not used. ↔ Used.
Interfaces dimension		
S1	Our customer data (contact information, purchase history, current orders, complaints filed, etc.) is available.	No, it is not available. The data is not reliable / not organized, it cannot be used. ↔ Yes, it is available. The data is reliable / systematized, we use it actively.
S2	When providing services, our cooperation takes place within the organization (internal communication):	Very awkward, with disagreements. ↔ Very smooth, without disagreements.
S3	We make mistakes when delivering services.	Very often. ↔ Very rarely.
S4	The processes of our services are:	Not digitized. ↔ Digitized.
S5	What is digitized is easy and effortless to use.	No, it is not. It is too complicated and there are a lot of obstacles. ↔ Yes, it can be used. Everything is simple and well-coordinated.
S6	When unforeseen events occur, decisions about service delivery are made very quickly.	No, decisions take a lot of time. ↔ Yes, decisions are made very quickly.
S7	We all have the same approach to what needs to be done to satisfy the customer (service user).	No. I have the impression that we have different views. ↔ Yes. I have the impression that we all have the same approach.
S8	We have process improvement initiatives.	No, we do not. ↔ Yes, we do.
S9	Our customers rarely complain about not receiving information about service progress (status or current stage, estimated completion dates needed to make decisions or complete customer tasks, etc.).	No, such complaints are common. ↔ Yes, such complaints are very rare.

Table A2. Expert assessment of service modularity level in O-2 organization
(source: created by authors)

O-2 experts	Architecture (*x*)	Modules (*y*)	Interfaces (*z*)
E1	1.125	1.667	1.889
E2	1.500	1.889	1.111
E3	1.000	2.222	2.222
E4	1.250	1.000	1.111
E5	0.500	1.556	2.333
Generalized assessment, point (*x*, *y*, *z*)	1.075	1.667	1.733

Table A3. Expert assessment of service modularity level in O-3 organization
(source: created by authors)

O-3 experts	Architecture (*x*)	Modules (*y*)	Interfaces (*z*)
E1	0.375	1.333	1.000
E2	–0.250	0.556	0.222
E3	–0.375	–0.333	0.444
E4	0.750	1.889	2.000
E5	1.125	0.000	0.333
E6	0.500	1.444	1.444
E7	1.000	0.889	1.333
E8	–1.000	1.333	1.556
Generalized assessment, point (*x*, *y*, *z*)	0.266	0.889	1.042