Towards a decision support framework for service modularisation

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Abstract

Purpose – The theory of modular systems proves useful in its application to services. The benefits of service modularity include cost-effective differentiation to better meet customer needs, requirements, and expectations; effective management of complex service systems; resilience to disruption; and the like. However, when implementing service modularization, there is a lack of clear understanding of what should be expected as overall benefits. To address this inconsistency, this paper aims to explore the nature of context and propose a direction for a management decision support framework that ensures rationality in service modularisation decision making.

Design/methodology/approach – The paper is a part of an ongoing research. It uses a conceptual approach and focuses on exploring existing service management research and modular systems theory.

Findings – The paper presents insights for a decision support framework consisting of four interrelated and complementary domains. It also identifies problem areas related to the lack of methodological options for management decision support and offers guidelines for addressing these problems.

Research limitations/implications – This work is exploratory in nature and is intended to provide a possible starting point for further theoretical refinement and empirical validation.

Practical implications – This paper helps the management of service organisations to better understand the implications of service modularisation. It also suggests considering the use of a decision support framework to speed up the planning process and expect a more beneficial outcome.

Originality/value – The article contributes to the field of service modularity by providing insights into decision support for service modularisation, which has not been addressed in previous research.

Keywords Modular systems theory, Service modularity, Service modularisation planning, Management decision support.

Paper type Conceptual paper

Introduction

In the pursuit to seek solutions on how to achieve service excellence in a way that increases customer satisfaction cost-effectively and gain competitive advantage, the service organisations consider the service modularisation approach. The potential benefits of a modular system – the variety of options, complexity management, lower system operating costs, and similar – drives the application of modular design to services.

Application of modular design principles allows creating a modularity in a system. It embodies a hierarchy between system blocks or modules that are relatively independent and have a functional purpose within the system but are loosely coupled to act in a coordinated manner as a whole (Baldwin & Clark, 2000). If required, modules can be easily separated and combined anew, creating the desired outcome variant without increasing costs.

Though being different in nature from goods, services can be viewed systemically, and modular design principles can be applied as well. Modular design for services manifests at various levels (Bask, Lipponen, Rajahonka, & Tinnilä, 2011; Løkkegaard, Mortensen, & McAloone, 2016; Pekkarinen & Ulkuniemi, 2008; Tuunanen, Bask, & Merisalo-Rantanen, 2012; Voss & Hsuan, 2009) – product, process, organisation. By applying modular design at the service-offering (product) level, the service acquires the modularity property. This property translates as the standardisation of service-offering elements and service delivery processes and the forethought of their flexible interconnections for increasing the possibilities of customisation during service delivery at economical costs (Skačkauskienė & Vestertė, 2019).

However, despite the growing body of research in service modularity, practical applications are relatively rare (de Mattos, Fettermann, & Cauchick-Miguel, 2019). Going deeper and analysing the empirical cases presented, one can observe that there is a tendency to streamline service sub-processes through their standardisation, however, not achieving service flexibility or, in other words, it is not possible to customize services flexibly in the occurrence of such need. If focusing solely on streamlining processes, a provider runs the risk of not hearing customer voice that determines service satisfaction. Conversely, focusing solely on a customer, who cannot pinpoint what (s)he needs exactly, may unreasonably increase costs in response to service delivery efficiency. Thus, modularity – the breakdown of the system into independent modules that can be flexibly reconfigured as needed and the creation of the necessary variability without cost increase – is not likely achieved in most of the attempts to transform the service system.

The possible reason for this issue lies in management decisions not considering the totality of the service modularization premises. For a modular service design to be executed suitably, it is necessary to formulate the conditions for the service designers properly. These conditions can be formulated when the service modularisation objectives correspond to the service provider's organisational objectives, the expected results are clearly stated, the managers understand what to look for when evaluating the presented service modularisation alternatives, etc. In other words, there is a need for managerial decision-making framework, which would ensure that the service modularisation initiative balances these opposites – service customisation and standardisation – and allows to achieve the overall modularity benefit – increased service competitiveness for profitability and growth.

Management decision support domains in service modularisation

The term *decision support* is used in various contexts related to decision-making processes (Bohanec, 2003). Although intuitive, its content is constantly evolving due to rapid changes in technology, but the essence remains the same: decision support is aimed at decision makers (humans, not machines with artificial intelligence) to improve and rationalise their decision making. According to Teng and Ramamurthy (1993), decision support can exhibit itself by supporting the decision *process*, influencing the decision flow, and supporting the *content* of the problem to be solved by proposing tools for modelling and evaluation. The methods and tools needed for decision support are used from different interdisciplinary fields: Operations Research, Decision Analysis, Decision Support Systems Engineering, Computerized Collaboration (Bohanec, 2003; Hillier & Lieberman, 2015; Howard & Abbas, 2016; Kaklauskas & Zavadskas, 2010). It should be noted that regardless of the object of decision support (process or content), semi-structured and unstructured decision making is a particularly information-intensive and multi-stage process, in which decision support manifests itself through various actions with information (identification, collection, processing and structuring of necessary information, also clear presentation, effective communication and the like).

To understand the type of support required for service modularisation management decisions, it is appropriate to discuss the essential elements of decision making. The phases of the rational decision making model distinguish the following main elements: a decision maker, a problem to be solved, constraints, solution evaluation criteria, solution alternatives, solution selection, and outcome (Borges, Marques, & Castro, 2020).

Management decisions related to service modularisation should typically involve a group of people, since modern organisations often entrust groups rather than individuals with important decisions (redesigning a service system involves such decisions). The problem they address stems from the question of *what is expected from service modularisation*. When a group pursues for answers, there is a growing notion of what is being sought, what is the nature of the problems, and how it should be addressed, and etc. According to Grünig and Kühn (2005), decision makers may have many conflicting objectives and be unable to clearly define them. Therefore, it is possible to identify the first domain of decision support – *assistance in structuring objectives* related to service modularisation (Figure 1, Item 1), which would allow to diagnose the current problematic situation of service delivery and describe the desired state in the future. Then, from the structure of the set objectives, the decision criteria should be formulated, which would allow to evaluate the possible alternatives of service modularisation from the management point of view.

There are several constraints in developing alternative solutions in the context of service modularisation. Restrictions such as available material resources, human capital, mastered

technologies, existing processes, etc. influence the solution development. Since service design is a field that also requires expert knowledge, there may also be specific constraints on the development of alternatives that take into account the specifics of services and the expected service prospects in the market. However, in service modularisation planning, it is not the technical aspects that are most important to management decision makers. Managers are primarily interested in *determining the potential value or benefits* of the service modularisation solution. This requires appropriate support (Figure 1, Item 2) that provides clear, objectively structured decision criteria for evaluating alternatives.

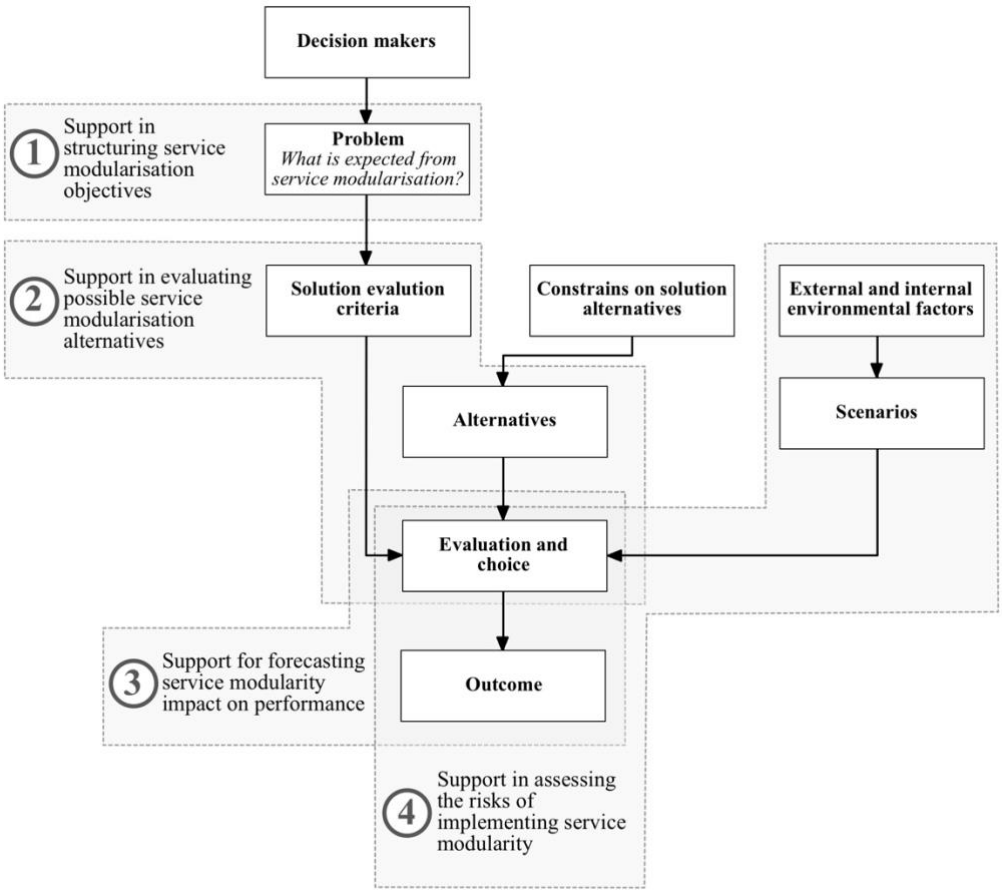

Figure 1. Identification of management decision support domains in service modularisation, created by authors

By modularising services, service providers expect the best outcome that is closest to the set objectives. However, the future is always not entirely clear, and decision support is needed to predict the impact of service modularity on performance (Figure 1, Item 3) and reduce uncertainty about the future.

Every decision is also influenced by external and internal environmental factors that may be important for future outcomes (Grünig & Kühn, 2005). These factors affect the implementation of service modularisation and create conditions for the occurrence of different situations in the future that evolve over time into possible sequences or collisions, such as various scenarios. Therefore, to improve the quality of management decisions, alternative solutions should also be considered in relation to different scenarios and the associated risks should be assessed (Figure 1, Item 4).

The four identified domains of management decision support relate to the problem content. However, it should be recalled that the decision-making process in service modularisation involves a group of people who may come from different levels of management. In such a case, as Windheim (2020) points out, the problem of coordinating decision-making between different stakeholders becomes particularly acute and requires support as a process. Carrascosa (2018) highlights another problem of group decision-making, namely reaching a common best agreement (consensus) between group members with different opinions, interests, and perceptions. To this end, different models of consensus building and methods to promote cooperation in decision making are used. Windheim (2020)

also proposes to improve the group decision-making process by actively integrating various visualisation techniques into it that enable group members to competently interpret information about modularisation and make better quality decisions. Based on sources that study group decision-making (Carrascosa, 2018; Teng & Ramamurthy, 1993; Windheim, 2020), it can be argued that the smooth running of the group decision-making process is closely related to the information systems of a service organisation. Since the development of such systems for group decision support is not the focus of this study, these aspects will not be further analysed from a methodological perspective. However, this is an important subject that should not be underestimated in the practical implementation of service modularisation.

Furthermore, we will explore the methodological options for identified decision support domains for service modularisation objectives and evaluation of modularisation alternatives with the aim of identifying the existing gaps.

Support in structuring service modularisation objectives

The support in structuring service modularisation objectives requires a clear translation of the service modularity ascendants into organisational objectives. According to Skačkauskienė and Vestertė (2020), service modularisation present both service customisation and standardisation qualities if embodied suitably.

Customisation actions during service delivery produce customisation quality. A provider considers the possibility of these actions in advance when designing services on modular principles. Service designers, considering customer participation in service delivery process, decouple services into modules in such a way as to create variants of service offering and delivery that are meaningful to customers and provide specific benefits. They also achieve service standardisation during service design by refining service offering, reducing its vagueness, designing delivery processes that correspond to the service offering elements and standardising the interfaces connecting them. Properly adapted modular design for services must increase customisation quality and standardisation quality, both of them constituting overall service quality. Engineering decisions made during the service design phase must ensure this.

According to Heskett, Jones, Loveman, Sasser, and Schlesinger (2008), there is an indirect relationship between service quality and service profitability. They introduce the service-profit chain model which describes the series of related factors. Customer loyalty is one of the main drivers of service profitability. The most crucial factor of customer loyalty is customer satisfaction, which is determined by customer value or in other words, customer perceived quality of service (customisation quality). Customer value is created by satisfied, loyal, and productive employees. Smooth internal processes of the organization, effective technologies, compelling internal communication and similar ensure internal quality (standardisation quality) that defines employee satisfaction. Thus, by launching service modularisation initiative, a provider seeks to improve service quality through customisation and standardisation activities (Figure 2).

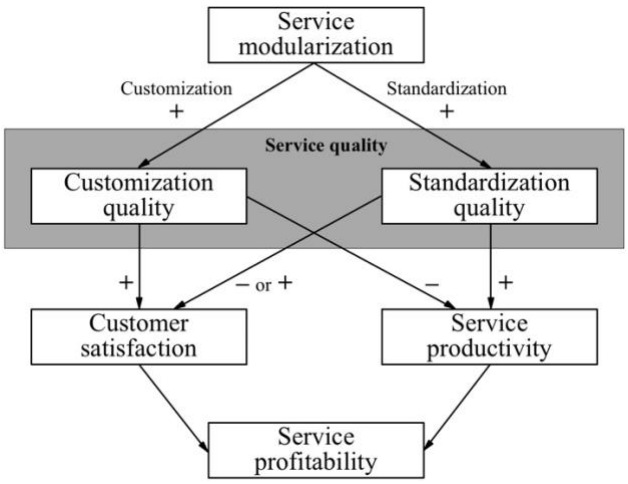

Figure 2. Interconnection of service modularization premises, source Skačkauskienė and Vestertė (2020)

During service design, the engineering decisions should pursue to consolidate the effects of service customisation and standardisation qualities so that customer satisfaction would improve simultaneously generating higher revenues, and productivity would increase or remain unchanged. The provider needs to discover a balance between customisation that improves customer satisfaction and demand, and standardisation that helps streamline processes, avoid errors, and reduce costs, and follow that service profitability increases, or at least remains unchanged. If these conditions are met, service modularisation can be considered justified.

Having service modularity antecedents translated into organisational objectives leads to better further decisions. Skačkauskienė and Vestertė (2021) proposes the possible form for this which uses the Balanced Scorecard methodology steps by preparing the Strategic Linkage Model and selecting the appropriate performance indicators for measuring results. The authors state that the existing methodological potential for forming a set of indicators reflecting the achievement of organisational goals related to service modularisation is sufficient.

Support in evaluating service modularisation alternative

As claimed earlier, managers are primarily interested in *determining the potential value or benefits* of the service modularisation solution. During service design phase, service engineers may come up with alternative solutions for modularisation. Evaluating the potential value or benefits requires decision support, as has been stated.

Scriven (2007) describes evaluation as the process of determining the strengths, value, and significance of an object of evaluation. During evaluation, the value attributed to the object is formalised quantitatively and/or qualitatively. Foglieni, Villari, and Maffei (2018) states that in structuring the evaluation of alternatives as a component of decision support, it is important to distinguish: 1) the purpose of the evaluation; 2) objects of the evaluation; 3) evaluation criteria; and 4) methods of obtaining (calculating) the values of the evaluation criteria.

The purpose of the evaluation is reflected in the answer to the question of what the evaluation is intended to achieve. In view of service modularisation solution, evaluation is performed to decide: in one case, to implement service modularisation or not, and in another case, when several alternatives to service modularisation are proposed, to select the best one.

As mentioned earlier, the main prerequisite for applying the principles of modular design to services is to find a balance between customisation and standardisation intending to create service variety that meets the needs, requirements and expectations of customers and is rational in terms of the provider's activities. Such formulation of the aim of service modularisation provides possible objects of evaluation. In evaluating the proposed alternatives, it is necessary to find out to what extent the proposed alternative meets the expectations and needs of customers and to what extent it is rational in terms of cost for the service provider. In other words, both the customer's (user's) and the service provider's parameters must be included in the evaluation. This view is supported by Dörbecker, Böhm, and Böhmann (2015), who were one of the first to address the problem of evaluating the benefits of service modularisation during decision making. By selecting different contexts (networks, goods, software, services) and using a systematic literature review, the authors identified, classified, and compared criteria that can be used to evaluate the modular structure of the product and the benefits of modularity. They also noted that in the context of services, the evaluation of modularity is not developed. However, they suggest that the evaluation criteria should be cost-oriented and endorse the desired level of customization.

In situations where the proposed alternative solutions are similar in terms of meeting customer needs and expectations (customisation) and cost rationale (standardisation), it is appropriate to introduce a third set of evaluation parameters to ensure certainty in decision making. These should regard the characteristics of a modular system – structural features, complexity and estimated costs and risks of its implementation.

The scientific literature on the problems of managing the complexity of socio-economic systems (Blecker & Abdelkafi, 2006; Ethiraj & Levinthal, 2004; Ng & Andreu, 2012; Simon, 1962) raises issues of variety management. The literature on the methodological aspects of product and production variety management (Medini, Moujahid, Boucher, & Bernard, 2018; Windheim, 2020) proposes to study variety by distinguishing between the concepts of external and internal variety. External variety refers to the variety of product offerings perceived by customers, i.e., product variety

refers to the number of options available to meet different customer needs. Increasing external variety requires greater product-market fit while increasing the value of the service organisation itself. In other words, increasing external variety is desirable. Internal variety is created to represent and sustain external variety and includes diversity of processes, components, resources, etc. Internal variety usually increases the complexity and cost of the overall system, so it should be avoided or attempted to be minimized. Service variety, which results from the application of the modularity principles to service design, can be considered as the equivalent of external variety. It presupposes the customisation of the service. While the variety of a service as a product (external variety) increases, the variety within the organisation (internal variety) increases with the number of supporting delivery processes and components used in service delivery. In the wake of service modularisation, the goal must be to exploit opportunities to reduce internal variety through the features of modular design – compatibility of modules, commonality of modules, reuse of internal components, standardisation of interfaces, etc. In other words, perform standardisation activities. Following this logic, it can be argued that the evaluation of the properties of modularity of the product structure goes hand in hand with the evaluation of the properties of product standardisation, which, as mentioned above, are also evaluated by the criteria of cost-effectiveness.

After defining the evaluation objects – external variety and internal variety – and their components, and based on the principles of multi-criteria decision analysis, the criteria groups of the evaluated solution alternative are structured hierarchically (Figure 2).

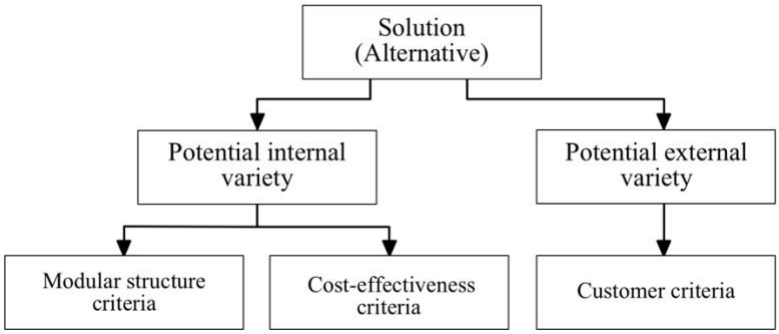

Figure 3. Hierarchical structuring of solution evaluation objects

Further, we will discuss the possible options for choosing appropriate criteria for modular structure, cost-effectiveness and customer sets en route to evaluate service modularisation solutions and make decisions.

Discussion

From an engineering viewpoint, the modularity of the product structure is understood as a feature – the ability to create considerable product variants by changing the components in the final product. According to Stake (2001), this characteristic can be evaluated by *component sharing* or *commonality* in the product structure. The concept of commonality is quite widely researched in academic literature (Collier, 1981; Stake, 2001; Thevenot & Simpson, 2008; Windheim, 2020). It is considered as one of the main criteria reflecting the modularity of the product structure.

It should be noted that in the case of a complex product or a very diverse assortment, the criteria proposed in the literature are difficult to calculate. Therefore, Salvador (2007) proposes to describe the modularity of the product structure by 2 characteristics – *component combinability* and *component separability*. According to him, the structure of the product can have some degree of sharing of components, but in order to be considered modular, it is necessary that the components can be separated and connected (combined). The proposals of other authors (Fixson, 2005; Fixson & Park, 2008; Pimmler & Eppinger, 1994) provide various criteria related to the interfaces of the modular structure (*coupling intensity*, *reversibility of interfaces*, *standardisation of interfaces*).

It should be acclaimed that the criteria proposed by the above authors are more relevant for engineering decisions during product design, when the goal is to develop an optimal solution in terms of modular structure. For management decisions during service modularisation, such criteria are not

quite appropriate, as they address a different type of problem. Management decisions aim at finding a balance between standardisation and customisation in the pursuit of organisational goals.

In the literature (Erixon, 1998; Pugh, 1991; Windheim, 2020) that formulates questions about product modularisation, a different approach to evaluating modularity can be identified. It is suggested that rather than focusing on the structural features of product modularity, the focus should be on the potential benefits arising from the modular structure, such as reduced complexity, faster product assembly, increased ability to create product variants, cost savings, faster time to market, etc.

The criteria discussed above for accessing the modular structure are presented in the context of goods. Some of them can be adapted to services if a specific methodology for service modularisation is chosen (Poeppelbuss & Lubarski, 2018). Many of the currently known service modularisation methodologies were originally developed for the modularisation of goods and applied to services, so adapting the criteria describing modularity to services is potentially possible.

With the exception of Voss and Hsuan (2009) proposal for assessing service modularity in terms of unique and standard service nodes, there are currently no other proposals in the literature that exclusively assess service modularity. This is probably because any criteria for describing modularity require, in particular, a very clear and sufficiently detailed structuring of the content of the service offering. This is in many cases a laborious activity of analysis, concretization and documentation of the service concept and service delivery processes. If there is no clear structuring of the service offering, other methods of assessing service modularity must be sought.

Since the service provider's performance after service modularisation must meet the set financial goals, it is necessary to determine the future costs of providing the service and the costs of implementing the solution before implementing service modularisation. For this purpose, the methods for determining the potential costs are selected that are appropriate for the cost accounting methods used by the service organisation. In the context of management decisions to modularise services, not only are monetary cost estimates needed, but also aggregate and relative criteria that allow decision makers to compare alternative solutions. Such criteria need to describe the potential economic benefits of the proposed services, relate to expected revenues, profits, time to market, market segment suitability, and provider willingness to provide the services, etc.

It is important to emphasise that in addition to the cost of providing the future modularised service and the cost of implementing the solution (budget of the service modularization project), it is worthwhile to include aggregate and relative criteria to evaluate the effectiveness of the solution in terms of the expected profitability of the service. The use of such additional criteria allows for a more prudent comparison of multiple solutions. The choice of specific aggregate and relative criteria to assess the reasonableness of costs is related to the service modularization methodology used.

By increasing the diversity of service offerings, the service provider can expect that the service offered will better meet the needs of the customer. However, the variety of service offerings must be carefully evaluated and selected to meet market demand and generate a sufficient level of revenue for the service provider. Too much variety in service offerings can have a negative impact on the service provider by increasing unit costs and operational complexity in service delivery. It is important to emphasise that the criteria for meeting customer needs and expectations must be known in advance, i.e., before service development begins, so that engineers can properly integrate them into solutions. When evaluating the fulfilment of customer needs, requirements, and expectations, it is important to determine the extent to which these requirements are successfully implemented in the solution.

It should be clear that the specific criteria for meeting customer needs are determined by the specifics of the service itself. Furthermore, these criteria are constantly evolving due to ever-changing customer needs, and service providers must constantly monitor changes in the environment. Nevertheless, it should not be difficult for a provider who has a good knowledge of the specifics of the services offered to distinguish criteria or requirements to meet customer needs. The methods presented in the literature (Holtta-Otto & Otto, 2006; Maritan, 2015; Robertson & Ulrich, 1998) propose a combination of qualitative and multi-criteria methods to aggregate these criteria, obtain numerical estimates, and evaluate how the designed solutions meet customers' needs, requirements, and expectations.

Conclusion

The study identified four main domains of management decision support for service modularisation: 1) support in structuring service modularisation objectives; 2) support in evaluating service modularisation alternatives; 3) support in forecasting the impact of service modularisation on performance; 4) support in assessing the risks of implementing service modularisation. The first two domains were detailed in the paper.

It was found that the biggest problem is to find the appropriate methodological potential for management decision support related to the evaluation criteria of the modular service structure. It can be argued that there are not many criteria that are suitable for use in service modularisation. Criteria that describe a modular structure through its inherent structural characteristics are difficult to calculate for services because they require a very rigid structuring of service offering, which is difficult to achieve for services. Moreover, these criteria are more meaningful for engineering decisions aimed at optimising system performance, but not for management decisions during service modularisation where the goal is to increase service quality without increasing costs and thus creating revenue growth.

Proposals to evaluate a modular structure indirectly through its benefits are closer to service modularisation, which focuses on achieving the appropriate benefits (increased customer satisfaction, increased revenue, increased productivity). When deciding to apply a certain methodology of service modularisation, it is possible to include in the set of criteria describing the modular structure the proposed criteria evaluating the complexity of the system, the time of assembly of modules, the flexibility of variants. In the absence of a clear and detailed structuring of the service offering, indirect evaluation of service modularity should be considered.

References

Baldwin, C. Y., & Clark, K. B. (2000). *Design rules: The power of modularity* (4 ed. Vol. 1). Cambridge, MA: The MIT Press.

Bask, A., Lipponen, M., Rajahonka, M., & Tinnilä, M. (2011). Framework for modularity and customization: Service perspective. *Journal of Business & Industrial Marketing, 26*(5), 306–319. doi:https://doi.org/10.1108/08858621111144370

Blecker, T., & Abdelkafi, N. (2006). Complexity and variety in mass customization systems: Analysis and recommendations. *Management Decision, 44*(7), 908–929. doi:https://doi.org/10.1108/00251740610680596

Bohanec, M. (2003). Decision support. In D. Mladenic, N. Lavrac, M. Bohanec, & S. Moyle (Eds.), *Data mining and decision support: Integration and collaboration*. New York, NY: Springer Science+Business Media.

Borges, M., Marques, J. L., & Castro, E. A. (2020). Decision-making as a socio-cognitive process. In V. Chkoniya, A. O. Madsen, & P. Bukhrashvili (Eds.), *Anthropological approaches to understanding consumption patterns and consumer behavior*.

Carrascosa, I. P. (2018). *Large group decision making: Creating decision support approaches at scale*. Cham, Switzerland: Springer.

Collier, D. A. (1981). The measurement and operating benefits of component part commonality. *Decision Sciences, 12*(1), 85–96. doi:https://doi.org/10.1111/j.1540-5915.1981.tb00063.x

Dörbecker, R., Böhm, D., & Böhmann, T. (2015). *Measuring modularity and related effects for services, products, networks, and software – A comparative literature review and a research agenda for service modularity.* Paper presented at the 48th Hawaii International Conference on System Sciences, Waikoloa, USA.

Erixon, G. (1998). *Modular function deployment – A method for product modularisation.* (Doctoral Dissertation). The Royal Institute of Technology, Stockholm, Sweden.

Ethiraj, S. K., & Levinthal, D. (2004). Modularity and Innovation in Complex Systems. *Management Science, 50*(2), 159–173. doi:https://doi.org/10.1287/mnsc.1030.0145

Fixson, S. K. (2005). Product architecture assessment: A tool to link product, process, and supply chain design decisions. *Journal of Operations Management, 23*(3–4), 345–369. doi:https://doi.org/10.1016/j.jom.2004.08.006

Fixson, S. K., & Park, J. K. (2008). The power of integrality: Linkages between product architecture, innovation, and industry structure. *Research Policy, 37*(8), 1296–1316. doi:https://doi.org/10.1016/j.respol.2008.04.026

Foglieni, F., Villari, B., & Maffei, S. (2018). *Designing better services: A strategic approach from design to evaluation*. Cham, Switzerland: Springer.

Grünig, R., & Kühn, R. (2005). *Successful decision-making: A systematic approach to complex problems*. Berlin: Springer.

Heskett, J. L., Jones, T. O., Loveman, G. W., Sasser, E., & Schlesinger, L. A. (2008). Putting the Service-Profit Chain to Work. *Harvard Business Review, 2008*(July–August). Retrieved from https://hbr.org/2008/07/putting-the-service-profit-chain-to-work

Hillier, F. S., & Lieberman, G. J. (2015). *Introduction to Operations Research* (10 ed.). New York, NY: McGraw-Hill Education.

Holtta-Otto, K., & Otto, K. (2006). Platform concept evaluation: Making the case for product platforms. In T. W. Simpson, Z. Siddique, & J. Jiao (Eds.), *Product platform and product family design: Methods and applications* (pp. 49–72). New York, NY: Springer.

Howard, R. A., & Abbas, A. E. (2016). *Foundations of Decision Analysis*. Essex, UK: Pearson Education Limited

Kaklauskas, A., & Zavadskas, E. K. (2010). *Intelektinė ir biometrinė sprendimų parama: monografija*. Vilnius: Technika.

Løkkegaard, M., Mortensen, N. H., & McAloone, T. C. (2016). Towards a framework for modular service design synthesis. *Research in Engineering Design, 27*(3), 237–249. doi:https://doi.org/10.1007/s00163-016-0215-6

Maritan, D. (2015). *Practical Manual of Quality Function Deployment*. Cham, Switzerland: Springer.

de Mattos, C. S., Fettermann, D. C., & Cauchick-Miguel, P. A. (2019). Service modularity: Literature overview of concepts, effects, enablers, and methods. *The Service Industries Journal*. doi:https://doi.org/10.1080/02642069.2019.1572117

Medini, K., Moujahid, A., Boucher, X., & Bernard, A. (2018). Product and service variety versus internal performance: Towards new balances.

Ng, I., & Andreu, L. (2012). Special Issue: Research perspectives in the management of complex service systems. *European Management Journal, 30*(5), 405-409. doi:10.1016/j.emj.2012.06.003

Pekkarinen, S., & Ulkuniemi, P. (2008). Modularity in developing business services by platform approach. *The International Journal of Logistics Management, 19*(1), 84–103. doi:https://doi.org/10.1108/09574090810872613

Pimmler, T. U., & Eppinger, S. D. (1994). *Integration analysis of product decompositions.* Paper presented at the ASME Design Theory and Methodology Conference, Minneapolis, MN.

Poeppelbuss, J., & Lubarski, A. (2018). A classification framework for service modularization methods. *Enterprise Modelling and Information Systems Architectures-an International Journal, 13*. doi:https://doi.org/10.18417/emisa.13.14

Pugh, S. (1991). *Total design: Integrated methods for successful product engineering*. Harlow, England: Addison-Wesley Pub. Co.

Robertson, D., & Ulrich, K. (1998). Planning for Product Platforms. *Sloan Management Review, 39*(4), 19–31. Retrieved from https://sloanreview.mit.edu/article/planning-for-product-platforms/

Salvador, F. (2007). Toward a product system modularity construct: Literature review and reconceptualization. *IEEE Transactions on Engineering Management, 54*(2), 219–240. doi:https://doi.org/10.1109/TEM.2007.893996

Scriven, M. (2007, June 6-9, 2007). *The logic of evaluation.* Paper presented at the 7th OSSA Conference: Dissensus & the Search for Common Ground, Windsor, Canada.

Simon, H. A. (1962). The architecture of complexity. *Proceedings of the American Philosophical Society, 106*(6), 467–482. Retrieved from https://www.jstor.org/stable/985254

Skačkauskienė, I., & Vestertė, J. (2019). Modulinio projektavimo taikymo paslaugoms problematika [Problematic of service modularisation]. *Mokslas – Lietuvos ateitis / Science – Future of Lithuania, 11*, 1–9. doi:https://doi.org/10.3846/mla.2019.9195

Skačkauskienė, I., & Vestertė, J. (2020). Tasks for service modularization planning. *Business: Theory and Practice, 21*(2), 813–819. doi:https://doi.org/10.3846/btp.2020.12776

Skačkauskienė, I., & Vestertė, J. (2021, May 13–14). *Service modularisation compatibility to organisational objectives.* Paper presented at the International Scientific Conference "Contemporary Issues in Business, Management and Economics Engineering'2021", Vilnius, Lithuania.

Stake, R. B. (2001). A framework for evaluating commonality. In A. Riitahuhta & A. Pulkkinen (Eds.), *Design for configuration: A debate based on the 5th WDK workshop on product structuring* (pp. 169–184). Berlin, DE: Springer-Verlag Berlin Heidelberg GmbH.

Teng, J. T. C., & Ramamurthy, K. (1993). Group decision support systems: Clarifying the concept and establishing a functional taxonomy. *INFOR: Information Systems and Operational Research, 31*(3), 166–185. doi:https://doi.org/10.1080/03155986.1993.11732225

Thevenot, H. J., & Simpson, T. W. (2008). A comprehensive metric for evaluating component commonality in a product family. *Journal of Engineering Design, 18*(6), 577–598. doi:https://doi.org/10.1080/09544820601020014

Tuunanen, T., Bask, A., & Merisalo-Rantanen, H. (2012). Typology for modular service design: Review of literature. *International Journal of Service Science, Management, Engineering, and Technology, 3*(3), 99–112. doi:https://doi.org/10.4018/jssmet.2012070107

Voss, C. A., & Hsuan, J. (2009). Service architecture and modularity. *Decision Sciences, 40*(3), 541–569. doi:https://doi.org/10.1111/j.1540-5915.2009.00241.x

Windheim, M. (2020). *Cooperative decision-making in modular product family design*. Berlin, Germany: Springer Vieweg.