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Myrodia, Anna; Randrup, Thomas; Hvam, Lars

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Configuration Lifecycle Management – An assessment of the benefits based on maturity

Anna Myrodia[1] and **Thomas Randrup** and **Lars Hvam**

Abstract. To handle the increasing product complexity manufacturing companies of configurable products tend to utilize configurators to cover more lifecycle phases of their products. This is described as configuration lifecycle management (CLM) and it is concerned with the management of all configuration models across a product's lifecycle. However, to connect and align all configurators and IT systems to each other remains a challenging task. Apart from the technical perspective, on an operational level the integration and alignment of the IT systems also requires a structured approach and is highly related to the maturity of the organization. Therefore, this research focuses on studying the relation between the maturity level and the expected benefits from implementing CLM. It is expected that the more advanced an organization is in using product configurators in different lifecycle phases and integrating and aligning them to each other and to other IT systems, the realized benefits would be significantly higher than the sum of benefits from applying standalone configurators to support each life cycle phase. Empirical evidence from seven case studies demonstrate that there is a relation between the maturity and the realized benefits with regards to the utilization of product configurators.

Keywords: configuration lifecycle management, maturity, benefits, product configuration

1 INTRODUCTION

Configuration lifecycle management (CLM) describes the management of all configuration models and related data across all lifecycle phases of a product [1]. A CLM solution is highly relevant for manufacturing companies of configurable products, as its purpose is to provide one valid source of configuration data and models that is shared among different business units within an organization.

The utilization of product configurators comes along with various benefits. During the last decades, several researchers have performed studies to identify and measure the realized benefits of the use of a product configurator [2–4]. The identified benefits cover a wide range of aspects, from process improvements to impact on products' profitability. However, the majority of these studies are concerned with configurators that are implemented in the sales phase and some in the engineering phase [2,3] .

Therefore, the focus of this research is to identify possible gains when the utilization of a product configurator is not limited only to the sales phases, but it includes all lifecycle phases of a configurable product, such as engineering, sales, manufacturing and service. It is expected that the realized benefits would be similar but not identical in the remaining lifecycle phases and that the accumulated impact would be significantly higher than the gains on each individual lifecycle phase.

For an organization, to be able to implement and connect product configurators across all lifecycle phases and business processes is considered a rather challenging task. When it comes to the utilization of a configurator in the sales phase, there are numerous challenges identified not only by the literature but also from industrial user cases [5,6]. Resistance to change, difficulties in data acquisition and verification, valid product modeling and maintenance of the models, accurate documentation are some of the most commonly reported challenges in the utilization of product configurators in the sales phases [7,8] .

It could be assumed that similar challenges are expected to be experienced in the other lifecycle phases during the implementation and utilization of a product configurator. However, this research claims that even though some of the challenges would be faced in all lifecycle phases, there several aspects that are not addressed in them. For instance, developing a universal product model to be used by several configurators across all lifecycle phases, business units, even external organizations (e.g. suppliers, resellers, vendors) requires input from various sources and is highly related to numerous dimensions of the organization [9].

In particular, the integration of product configurators with other IT systems for data exchange, as input and/or output of each configuration step, is considered a rather challenging task, especially when it comes to IT systems that are used by several departments [10]. Apart from the technical challenge of connecting, aligning and integrating IT systems with product configurators, the operational perspective is of high importance and it should not be discarded. At an operational level, the process standardization, resources allocation, knowledge sharing and support, established ways of cross-departmental collaboration are some of the factors that are highly related to the success of utilization a CLM solution [6,7,10,11]. Additionally, on a strategic level a clear mission and vision for CLM deployment, communication to all stakeholders and engagement with specific goals for each involved department are of great importance and highly related to the level of success of the CLM solution.

All these aspects mentioned before that influence the success of a CLM solution are related to the maturity of an organization. Maturity in this context does not only describe the development of the IT systems and the possibilities of seamless integration of a universal product model for a CLM solution. Maturity also describes the process and the organizational development, from an operational, strategic and cultural point of view [12,13]. The readiness of an organization to implement and utilize a CLM solution, and the support and involvement of the stakeholders are crucial success factors for a CLM solution.

As a result, it is expected that the more mature an organization is, the higher the realized benefits would be. Therefore, this

[1] Configit A/S, Copenhagen, Denmark, email: amyrodia@configit.com

research relates the expected benefits to the maturity of the organization. The maturity is evaluated in terms of years of implementation of product configurators and the spam of lifecycle phases they cover. The expected benefits of a CLM solution are estimated to be higher than these of standalone configurators in the different lifecycle phases. Exploratory case studies are conducted to examine this proposition.

Proposition 1 The size of realized benefits when implementing a CLM solution is related to the maturity of the organization.

The remainder of the paper is structured as follows. Section 2 includes a literature review on the expected benefits from the use of product configurators in different lifecycle phases and the characteristics of maturity of an organization. Section 3 presents the empirical evidence from the case study research and discusses the results. Section 4 provides some overall conclusions regarding the connection of realized benefits and the maturity of an organization when implementing a CLM solution.

2 LITERATURE REVIEW

2.1 Benefits from implementing product configurators

This section discusses the findings from the literature regarding the expected benefits from implementing and utilizing product configurators. As this field has been examined in detail, we refer to previous work [2,3,11,14–16] and their lists of references. However, to provide an overview we present a short list of realized benefits for the different lifecycle phases (Table 1).

Table 1. Benefits per lifecycle phase

Lifecycle phase	Benefits
Sales	Reduction in quotation time
	Improve quotation accuracy
	Improve control of product portfolio
Engineering	Reduction in number of errors
	Improve quality of specification and bills-of-materials (BOMs)
Manufacturing	Improve quality of production specifications
	Improve communication with suppliers
	Reduced production costs
Service	Reduced installation and maintenance time
	Improved predictability in maintenance of products sold

The benefits are grouped under each lifecycle phase to provide a better overview when it comes to implementing a CLM solution, and they address three main factors: time, quality and cost [17]. However, it should be mentioned that that are some common benefits reported across all lifecycle phases, such as improved process efficiency, reduction of hours spent due to iterations, improved data validity, improved quality due to reduction in the number of errors.

2.2 Maturity

The maturity assessment of an organization includes several dimensions and maturity models are the tools used to perform the evaluation. Strategy, processes, IT, organizational structure, knowledge sharing and support activities are among the most widely discussed dimensions in the literature that describe most accurately all functions of an organization [12,18]. The maturity is measured in each of these dimensions; however, the maturity level does not have necessarily to be the same across all of them. This could explain why companies implementing state of the art configurators are still not able to experience all the expected benefits. This is aligned to the findings of [19] that business processes and IT alignment should fit into the organization.

The improvement of configuration management policies and tools, and the establishment of requirement engineering processes are considered top priorities of organization maturity. Seamless integration, knowledge management, monitoring, support and training activities for the users are additional aspects related to the maturity and affect the success of implementing a configuration solution [20]. Empirical studies also indicate that the maturity of IT processes is connected to the gap between organizational targets and processes' aims [21].

Challenges in realizing expected benefits are identified in the sales and planning process [22–24] and are connected to the need of horizontal reorganizational of the structure to include customer and supply chain stakeholders [25]. The current vertical organization structure is a source of delays, increased costs and challenges of managing subcontractors [20]. This is also supported by [26] who claim that when the manufacturing company is in control of the entire supply chain and it is able to coordinate internal and external processes, then it is more mature and can gain a competitive advantage [27,28].

One aspect of knowledge management related to the maturity of an organization is the lack of overview of the product portfolio, which is due to increased complexity. Keeping external variety high to satisfy personalized customer needs to be induced by controlled internal variety and product standardization to avoid increasing costs and complexity [28].

According to [12], the maturity of an organization is increasing based on the level of standardization. That includes both standardization of products and processes. Consequently, this would have direct impact of the realized benefits by utilizing a product configurator, even more when it comes to CLM. However, this alignment and standardization is a task that requires time as it comes along with numerous changes in the organization [6,29]. It is expected that the higher the maturity of an organization is, the higher the gains form the realized benefits would be by the use of product configurators, especially across all lifecycle phases. This is identified as an area not explored by the existing literature.

Even though the research from [12] focuses on the ETO companies, the underlying principles can be extrapolated and used for manufacturers of standard but complex products too, such as the examined case studies. Therefore, this research aims at contributing to this field by providing some empirical evidence to test the developed proposition.

3 EMPIRICAL EVIDENCE

To examine the suggested proposition, case research is selected as the research method. The main reason for selecting case research is that allows for comparison of the results across different case companies, where the analysis has been conducted under the same settings and followed a research protocol. In this study, 7 companies are used as cases. Through the case research the under

examination phenomenon is studied in its natural settings and it allows for deeper understanding of phenomena that are not fully examined [30–32]. In this research, the under investigation phenomenon is the one described in the proposition; the relation between the size of realized benefits and the maturity of an organization with regards to the implementation of CLM. The following section provides an introduction to the companies and the set-up of the research, presents and
analyzes the results.

3.1 Background

For this study 7 manufacturing companies (A – G) were contacted. All of them are designing, selling, producing and servicing highly engineered and complex products. All the companies have been utilizing product configurators to support at least one lifecycle phase of their products. Furthermore, all 7 companies are large organizations, employing more than 1000 people, and they are operating globally, in terms of market, production facilities and suppliers. They have been utilizing product configurators for at least 2 years before the research was conducted. Table 2 provides an overview of the selected cases regarding their main characteristics and the lifecycle phases they are utilizing a product configurator.

Table 2. Overview of the case studies

Case company	Industrial sector	Lifecycle phase	No. of years utilizing product configurators
A	IE&M (Mechanical)	Sales	3
B	IE&M (Mechanical)	Sales	2
C	IE&M (Medical)	Sales	5
D	IE&M (Mechanical)	Sales	6
E	Automotive	Sales, Engineering	7
F	IE&M (Agriculture)	Sales, Engineering	7
G	IE&M (Electrical)	Sales, Engineering	3

3.2 Results

In each of the case companies' data collection included interviews with managers and head of departments that have been using a product configurator. The form of the interviews was semi-structured, to ensure that the relevant data were collected and to allow for some discussions regarding future directions and initiatives towards a CLM solution. All managers were asked the same set of questions to provide information regarding the use of configurators, the lifecycle phases they cover, and the realized benefits they have been experiencing or measuring. The benefits were predefined, based on the results of the literature review. To ensure the validity of the results, two persons from each company we interviewed separately.

During the interviews, the different maturity dimensions were discussed. Since this is an exploratory study, the focus was given on process standardization and cross-organizational collaboration. Process standardization is assessed based on the following two criteria; the number of manual tasks that need to be performed on top of the use of the product configurator, and the generated documentation following the actual configuration process. Cross-organizational collaboration is assessed based on the number of teams from different departments that are using the product configurator or providing input when setting up the configuration models. In addition to these findings, the research team took into account the number of years that each company has been using configurators and the number lifecycle phase they cover, to assess the maturity of each case company. The assigned maturity level varies among low-medium-high. Table 3 presents the results of the analysis.

As it can be seen from Table 3, the number of realized benefits is increasing along with the maturity of the organization. In detail, case companies E, F and G are ranked with medium maturity level due to the fact that they have cross-organizational implementation of product configurators. Even though case company G has been using product configurators for 3 years, which is relatively lower than cases C and D, its level of maturity is still considered to be medium, due to the fact that it has fully standardized and automated processes, and minimum manual work required on top of the use of the configurators across the sales and the engineering teams. In all these three cases, when setting up the product models in the configurator teams from both the sales and the engineering departments were involved. Teams from these two departments also undertake the maintenance and the update of product related data in the configurator, while at the same time product related data for the sales and the engineering phases are handled via the configurator. The realized benefits reported are related to the process standardization, control of complexity, knowledge management and data validity.

Case companies A, B, C and D are utilizing a configurator in the sales phase, therefore the reported benefits are related to cost estimation, quotation and sales efficiency. It should also be mentioned that case company C was the only one able to provide quantitative data regarding the realized benefits. Company C reported that it has managed to reduce the hours used for preparing quotations by 50% (from days to hours). Due to the reduction of errors in the specifications in the sales phase, they have managed to reduce the costs of poor quality in production with 80% due to more accurate production specification.

By summarizing the results can be concluded that there is a relation to the maturity level of an organization and the size of realized benefits. This confirms the under investigation proposition in this study.

3.3 Discussion

The benefits identified in the case studies are aligned to the findings from the literature. On a high level it can be concluded that all the benefits can be grouped under the three categories suggested in the literature; time, quality and cost [17]. This conclusion can be used for assigning key performance indicators (KPIs) to monitor and measure the performance of different factors that have a direct impact on these three categories. The KPIs should both cover the lifecycle management aspects of the configurable products and the configuration process itself (detailed examples of KPIs can be found at [33]). By providing quantitative data the companies would have a more accurate assessment of the improvements they have established due to the use of the product configuration.

Furthermore, the results from the case studies indicate that process standardization is a cornerstone for a successful implementation of configurators. Case company G is such an example; even though the implementation of the configurator s relatively new (3 years) by standardizing the sales and the engineering processes, they managed to achieve the highest number of benefits across the examined cases. This is because by standardizing the processes, the management of configuration models can be improved [34], and the knowledge encapsulated within these models can be used in different lifecycle phase by different users [35]. In the sales phase, the utilization of the configurator is more mature and is usually where the companies are starting. This can be explained by [6] as sales configurators are proven tools and the most popular solutions both in the industry and in academic research.

However, the findings show that several gains can be experienced in the engineering phase. These benefits might be identical to the ones from the sales phase, such as improved efficiency, quality and lead time, but are also phase specific, such as scalability of product models, product platform design and BOM validation.

Nevertheless, the results cannot be generalized to all lifecycle phases based on this case study, as none of there were no empirical evidence from the manufacturing and service phase in these cases. It can be argued, that in a similar way as in the sales and engineering phase, benefits can be gained across all lifecycle phase of a configurable product. It can also be assumed that the more phases the configurators cover, the higher the degree of process standardization and knowledge sharing across the organization.

4 CONCLUSION

The scope of this study is to examine the relationship between the realized benefits from the use of product configurators across all lifecycle phase of a product and the maturity level of the organization. The developed proposition is tested in 7 case companies and the study reveals a direct relation between these two variables.

This is an exploratory study. The main limitation of this research is the generalizability of the results, which can be improved by having a more in depth investigation of the phenomenon.

Future research will include more cases that are using product configurators in the manufacturing and service phase. This will be examined in relation to the maturity of the organization, not only in terms of product and process standardization, but also strategic initiatives, knowledge sharing and support, degree of integration of IT systems. Finally, another factor that should be examined is the complexity of the configuration process, regarding the size of the models, the number of features, rules, and the number of users. This could also provide some insight regarding the implementation strategy that would improve the user-friendliness and the acceptance rate of the new system by its users.

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Table 3. Realized benefits per case company

Benefits	Company	A	B	C	D	E	F	G
	Maturity (L=Low, M=Medium)	L	L	L	L	M	M	M
Sales	Improve quality - Reduction of number of errors			X	X	X	X	X
	Improved technology management						X	X
	Increase productivity	X					X	X
	Increased sales							X
	Improve competitiveness							X
	Reduction in printing costs and distribution of catalogues							X
	Improve process efficiency	X					X	
	Reduce cost of IT systems and maintenance					X	X	X
	Improve functionality of integrated IT systems	X						
	Reduction of complexity						X	
	Reduced quotation time	X	X	X	X			X
	Improve accuracy of quotation	X		X				
	Support different market/regions/language/currencies		X			X		
	Improve guided-selling		X				X	
	Increased customer orders				X			
	Improved dealer management						X	
	Increase number of quotes through dealers							
	Improved ordering process and customer self-service						X	X
	Improved validity of configuration data					X		
Engineering	Improve efficiency and scalability of product modeling					X		
	Bill of material validation					X		X
	Component optimization					X		
	Improve quality - Reduction of number of errors					X	X	X
	Improved technology management						X	X
	Increase productivity						X	X
	Increased sales							X
	Improve competitiveness							X
	Reduction in printing costs and distribution of catalogues							X
	Improve process efficiency						X	
	Reduce cost of IT systems and maintenance					X	X	X
	Improve functionality of integrated IT systems							
	Reduction of complexity						X	
	Reduced quotation time							X
No. of benefits per case		5	3	3	3	9	15	18