Industrial Application of Configurators: From Motivations to Realized Benefits

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INDUSTRIAL APPLICATION OF CONFIGURATORS: FROM MOTIVATIONS TO REALIZED BENEFITS

Manufacturing companies are increasingly seeking to gain the benefits from mass customization strategies as a response to increased customers' demand for customized products. To automate the process of generating products' specifications and guide the sales process, configurators are commonly used to support companies applying mass customization strategies. This articles analysis the relationship between the initial motivations manufacturing companies have for implementing configurators and the realized benefits from the application of configurators. The results presented in this paper are based on a survey followed with interviews in 22 industrial companies. The findings show that the main motivations can be grouped into seven categories, where the successfulness of achieving the targeted benefits varies between the individual categories. Furthermore, the results highlights that substantial benefits can be achieved when applying configurators in manufacturing companies.

Keywords: Configurators, Process optimization, Information systems, Product and process designs

1. INTRODUCTION

The ability to provide customized products has become more important across industries over the past years (Salvador & Forza 2004). In order to cope up with increasing demand for customized products, mass customization strategies have received greater attention both from practitioners and researches over the years. Mass customization outlines how companies can make customized products and services, which fit every customer through flexibility and integrations with a cost similar to mass-produced products (Pine 1999). Configurators are one of the key enablers of mass customization strategies (Pine II *et al*,. 1993)(Piller & Blazek, 2014) and one of the most successful systems of artificial intelligence (Blecke*r et al*., 2004). Configurators are used to guide the communication with the customer and automate the generation of the product specifications, where product variants are defined within the chosen scope of variety (Forza & Salvador, 2008). Such systems utilize formally expressed product architectures, i.e. knowledge bases, consisting of a set of components, their relationships, and constrains to prevent infeasible designs (Felfernig *et al*., 2000).

The literature describes the various benefits that can be achieved from utilizing configurators. However, the motivation behind the implementation and how successful companies are in achieving the benefits that can be related to the initial motivations has not been addressed to great extent in the literature. Besides, the majority of the literature describes the motivations and the realized benefits based on single case company, which makes it difficult to generalize.

This paper aims to capture that research opportunity by analysing the relationship between the actual motivations for implementing configurators and how successful companies are in achieving the benefits in relation with the initial motivations. In addition, the results provides insight in to the main challenges companies face in the process of providing customized products and how those challenges can be addressed by implementation of configurators. Aligned with the focus of the study the following research questions were developed:

RQ. 1. What are the main motivations manufacturing companies consider for implementing configurators to support their design and specifications processes?

RQ. 2. How successful are manufacturing companies in achieving benefits associated with the initial motivations described prior to the implementation of the configurators?

The research method adopted in this paper is based on survey followed with interviews with 22 companies, which can be categorized as manufacturing companies providing customized or engineered products and use configurators to support the generation of the products´ specifications in the sales and design processes. The survey consisted both of open and closed questions, to capture both the qualitative nature of the main motivations and to quantify to what degree companies agree with achieving the main benefits described in the literature. Based on the answers gathered from the companies the motivations were grouped into seven categorizes. The pre-defined benefits were then grouped according to the identified categorizes of motivations to provide insight weather companies expressing certain motivation were more likely to achieve the related benefits.

2. LITTERATURE REVIEW

The focus of the literature review is on the motivations and the benefits described in the literature in relation with configurators.

Aldanondo et al. (2000) describe how configurators can be used in industries providing highly customized products, where there are iterative steps resulting in long cycle time, risk of wasted time and money if the customer rejects the solution, risk of the proposed solution to be unfeasible, and finally the inaccurate cost estimation. To address these challenges, configurators can be used to limit the numbers of iterations as they support knowledge gathering and error avoidance in the process.

Ardissono et al. (2003) propose a configurators services to support diverse customers in open market environment and to be able to intergrade with suppliers providing configurable sub-products. Standard configurator software is proposed that provides personalized and adaptive user interfaces and communications across the supply chain. The system is capable of automatic exchange of orders, publishing product catalogs, or supporting billing transactions across the supply chain.

Ariano & Dagnino (1996) present a case study based on a manufacturing furniture company. The main objectives of the implementation of the system are described in terms of providing a system that enables the employees to enter an order in quick and accurate manner, provide the mechanism to check the product configuration and finally generation of BOM and drawings. The main benefits from implementing the system are aligned with objectives for the implementation or organized way to structure the company's product line, more efficient way to enter orders that can be verified for correctness and alignment with the company's product offerings, generation of the dynamic BOM that enables more accurate price estimations, and reduction in duplicated information.

Barker et al. (1989) present a case where the initial purpose of the configurator was to help employees in the manufacturing to validate the technical correctness before production. Since then the system has expended to address the business needs to greater extent. The main benefits are described in overall net return of $40 million per year. These savings can be traced to incomplete orders can not get through the process, optimization of the system performance, more efficient processes when releasing new products, increased manufacturing flexibility, the technical quality of the orders entering the manufacturing has been significantly improved and therefore time consuming testing process and re-work in the manufacturing can be eliminated.

Fleischanderl et al. (1998) present a case where a configurator is applied in complex domain of telephone switching systems. The system supports number of stages of the products' life cycle that includes sales, engineering, manufacturing, assemble and maintenance. It is claimed that the system has archived positive return of investment in the first year. In addition, benefits are described in terms of the quality of the configuration and elimination of error-prone manual editing of parameters. Furthermore, the implementation of the configurator has enabled training of new employees to be done in more structured way and help to make the knowledge more accessible to wider range of employees.

Forza & Salvador (2002) present a case study where the introduction of the configurator has positively affected the sales, design, engineering and manufacturing processes at the company. The benefits of using the configurator are described in terms of errors generated in the sales processes are almost eliminated as a result to an automatic validity and completeness check performed by the configurator along with the time for generating proposal and consequently the man-hours are significantly reduces. The technical productivity has also been increased as a result of automation of simpler technical configurations. Finally, in the production the correctness of the BOM generated by the configurator has made it possible to avoid production stoppages leading to delivery delays. In another study, Forza & Salvador (2002) introduce a case company faced with challenges regarding performance of correctness check of the products' specifications without increasing the control cost and reducing product variety. To address these challenges a configurator is implemented were the main benefits are described in terms of reduced man-hours and lead-time (5-6 days to 1 day) and the correctness of product information generated are close to 100%. Furthermore, the ability to deliver on time is also increased as a result to improved correctness and fewer errors identified in the assembly process. Finally, the configurator helps to drive the customer towards a solution within the company's preferred product range. In the third study Forza et al. (2006) present a company that implemented a configurator and by implemented a different product strategy that involved postponement of product differentiation. The benefits from that are described in term of enabled communications about the product assortment, fast and easy way to explore the company's product solutions, more accurate offers that can be generated within less time as there is not need to consult consistently with the the technical offices, and finally the configurator supports accurate production of products code, BOM and production cycle.

Haug et al. (2011) presents a study where fourteen companies are analyzed in order to evaluate the impact from implementing a configurator on the lead-time for generating quotes and detailed products' specifications. For the generation of the quotes the average lead-time reduction is stated to be 83.7% while the average savings in man-hours is 78.4%. In terms of detailed product specifications the average lead-time reduction is 83.5% as a result to the implementation of the system.

Heatley et al. (1995) present a study where configurator is used to support operational tasks at a company. Initially the system was implemented to support the ordering process, where errors were generating that caused delays, threatened the overall quality, cost and the customers' satisfaction. By implementing the configurator, the correctness and completeness of the orders was significantly improved. Furthermore, the time required for validation and cost of re-work as a result to inaccurate specifications when entering the manufacturing has been eliminated. In addition, the average selection time per unit has been reduced from 2 hours to 6 minutes, the throughput cycle has been reduced from 6 days to 1 day, the orders feasible for manufacturing was increased from 40% to 100%, and finally orders containing pricing errors have been reduced from 80% to 0%. Finally it is stated that due to increased efficiency a sales person that on average sold equipment for $2 million can now sell for $4 million.

Heiskala et al. (2005) performed a study to analyze the benefits and challenges of mass customization, configurable products, and configurators with a special focus on services. The main benefits are described in terms of suppliers and customers. In terms of suppliers benefits are described in terms of reduction errors and man-hours, shorter lead-time where irritations can be reduced enabling generation of more quotations without increasing the number of employees, supporting the sales and R&D of more complex products, standardization of specifications, enables less skilled employees or even customers to perform configuration, reduce the need for technical experts in checking consistency, improved ability to make cost and delivery time estimations, improved ability to maintain and manage the configuration knowledge, and finally supporting communication of up-to-date configuration knowledge. In terms of benefits for the customers the ability to explore alternatives solutions and the impact, customers can be provided with access so the can generate the specifications, price and delivery time to immediately calculate and finally the configurator can help to explain customer why some alternative choices are not compatible.

Hvam et al. (2004) present a case study where a company is faced with changed market environment, and increased pressure to deliver in shorter time, with lower cost and improved overall performance. To respond to those challenges a configurator was implemented to support the overall design and generation of the products' specifications in the sales process. The main benefits were described in terms of reduction in lead-time for generating quotations (15-25 days to 1-2 days), improved quality of the quotations, the ability to optimize plant performance, and finally, reduction in engineering hours for making quotations (5 man-weeks to 1-2 man-days). In another study, Hvam (2006) performed at the same case company, where the company aims to increase efficiency in the sales and engineering processes by implementing configurator. The main benefits described in terms of 50% reduction of manned activities for generating in the sale process, improved quality and more homogenous budget quotations, by determination of default values a quotation can be generated based on limited input from the customer, different solutions can be simulated, optimization of the plant, improved communication with customer, and increased knowledge sharing. Finally, Hvam et al. (2013) present a study where they describe the observed benefits from applying configurators in four industrial companies. The result presented shows that lead-time has been reduced by 94-99%, on-time delivery is improved to be 95-100% and resources for making the specifications have been reduced by 50-95%.

Furthermore, by using configurators companies has achieved increased sales, decrease in the number of products and product variants, improved ability to introduce new products, finally and cost reductions.

Petersen (2007) focus on the benefits in engineering companies from implementing a configurator. The benefits are described in terms of reduction of lead-time and resources for generating quotations, the risk of errors in the sales process are reduced as result to the knowledge to be embedded in the system and automation in the workflow.

Sviokla (1990) presents the case where, the required demand for flexibility, constant new product development, great number of possible configurations the company was lacking overview resulting in number of errors. In order to guarantee quality of the products a time consuming, the final assembly and test was performed before shipping the product to the customer. To address these challenges a configurator was implemented where the benefits are described in terms of, elimination of the testing process, which was estimated to result in $15 million savings for the company. Other benefits are described in terms of increased correctness (65-90% to 95-98%), increased order volumes and shorter cycle time in the assembly process (10-13 weeks to 2-3 weeks).

Tiihonen et al. (1996) present a study based on a survey carried out in 10 companies to study the actual problems in the configuration process. In that study the main motivations for implementing a configurators are described in terms of being able to transfer up-to-date information to the sales units and enable them to use it in the right ways, and by increasing atomization by use of configurators the numbers of errors should be reduced leading to improved quality.

Trentin et al. (2012) explore the impact from using configurators on products quality. The results presented are based on response from 176 manufacturing plants from three industries and six countries. The findings of the survey confirm that use of configurators supports higher product quality. Furthermore, it is stated that use of configurator affects compatibility between product variety and product quality that can be improved by using a configurator.

Finally, Yu & Skovgaard (1998) present a study of a configurator tool where the aim are to guarantee the correctness of the configurations, ensuring consistency, handling constrains, overcome limitations with regards to maintainability and finally to support the use of configuration application in user-friendly manners.

The literature describes the various benefits that can be achieved in industrial settings from implementing a configurator. In few of the research the initial motivations for the implementation of the configurators are addressed. However, the literature does not provide an evidence of the initial motivations and the realized benefits from implementing configurators based on more than single case study. This paper aims to capture that research opportunity and explore to greater extent the main motivations or the drivers' industrial companies providing customized products have when implementing configurators and how successful they are in archiving the benefits associated with those motivations.

3. RESEARCH METHOOD

3.1 Population and sampling

The criteria for selecting the company for the research was based on being manufacturing companies providing customized or engineered solution, and finally having experience from using configurators to support their specification processes. In total of 26 companies were contacted that all fulfilled the selection criteria. The resulted presented in this article are based on the samples of 22 as those companies were able to provide the required answers. The sample used was aimed to represent manufacturing companies providing customized and engineered solutions. The companies represent small, medium and large sized companies, where the level of customization and the complexity of the offered products can vary greatly as the companies' offerings includes everything from complete plants, equipment and components.

3.2 Design of the questionnaire

Aligned with the focus of the research, the aim is to explore the main motivations manufacturing companies have for implementing configurators and measure how successful companies are in achieving the benefits associated with the motivations. The questionnaire was designed to capture both qualitative explanations and measurements of the degree companies agreed with achieving pre-defined benefits in relation with usages of configurators. The pre-defined motivations were determined based on the literature in the field and experiences from working with configurators, 22 benefits associated with configurators were identified. The respondents were therefore asked the following questions for the purpose of this research:

1. What are the main motivations for the implementation of the configurator?
   [Open question]
2. To what extent you agree that the company has obtained the following benefits from using the configurator?
   [On a 5-point scale where, 1 represent completely disagree, 2 disagree, 3 neither agree nor disagree, 4 agree, 5 completely agree and finally represent 0 that the respondent did not know or to what extent the use of the configurator had on the benefit]

3.3 Data collection and analysis

The data collection phase is divided into two steps, or pre-study and the actual interviewing phase. The pre-study phase was aimed at establishing an external validation of the questionnaire and to make sure that the respondents had the right understanding of the questions. For these reasons, three pilot interviews were conducted. Thereafter, the questionnaires were e-mailed to the all the identified companies along with a description of the purpose of the study, the interview procedure, and a follow up notification. Finally, appointments were made for phone interviews. The interviewing phase was done through structured phone interviews conducted as a walk-through of the questionnaire. The interview process left room for clarification and elaboration of questions to ensure a correct and consistent interpretation of the questions and for the interviewer to gain a holistic understanding of the empirical setting at the companies.

In the analysis phase, interviews were entered into an MS Access database, cross-checked for data entry errors, and the answers were analyzed. Based on the answers provided by the companies, they were grouped according to key words and the final grouping was discussed among the research team in order to provide consistency in the result presented. Thereafter, the pre-defined benefits were grouped according to categorizes of the motivations in order to see how successful the companies were in achieving the described motivations. The grouping of the benefits was also discussed by the research team and key words from the motivations were used.

4. RESULTS

In this chapter first each of the identified motivations categories will be explained in more detail based on the answers provided by the companies. Thereafter, the predefined benefits that were grouped according to the motivations categories are presented. The benefits were defined based on the literature and experience. To measure to what degree companies achieved those benefits they were measured on a five point scale, which represent to what degree companies agree with individual benefit being realized as a result to implementation and usages of the configurators. First, the percentages of companies' ratings for each of the benefits associated with the motivation are presented. Thereafter, to evaluate whether companies that expressed a motivation in the category were more likely to achieve the benefits the average rating, which is calculated based on all the benefits in the category, are presented.

4.1 General competitiveness

Inc**r**eased general competitiveness was identified as one of the motivation in 6 out of the 22 companies, or by 27% of the total companies. In terms of general competitiveness, two of the companies described that a use of a configurator was market condition as they would not be in the market if not they are not able to deliver customized products efficiently. In another company, it was mentioned that the development of the configurator was supposed to enable greater automation of the sales and order process and thereby the company hoped to improve competitiveness. In addition one of the companies aimed that by developing a configurator to get ahead in the market competition. Furthermore, it was described that the configurator were designed to help the companies to reach more customers along with reducing the numbers of orders that do not turn into actual sale. Finally, it was expressed that by implementing a configurator, it was hoped to minimize the overall cost. In Table 2, the benefits associated with the general competiveness are presented along with the degree the companies agreed with the benefits to be realized in relation with the configurator.

Table 1. Benefits related to general competiveness

	Disagree (1-2)		**Neither (3)**	**Agree (4-5)**		**NA (0)**
	Completely disagree	Disagree	Neither disagree nor agree	Agree	Completely agree	No answer
1. Increased sales revenues for the products included in the configurator	**5%**		**27%**	**64%**		**5%**
	5%	0%	27%	23%	41%	5%
2. Increased gross margin for the products included in the configurator	**0%**		**23%**	**68%**		**9%**
	0%	0%	23%	36%	32%	9%
10. More sales quote result in actual orders	**10%**		**32%**	**32%**		**27%**
	5%	5%	32%	14%	18%	27%
11. More on time delivery result in increased number of orders	**10%**		**41%**	**41%**		**9%**
	5%	5%	41%	14%	27%	9%
20. Larger share of products that meet the quality objectives	**0%**		**32%**	**64%**		**5%**
	0%	0%	32%	32%	32%	5%
3. Increased customers satisfaction when the configurator is used	**5%**		**14%**	**77%**		**5%**
	5%	0%	14%	41%	36%	5%
4. Increased employees satisfaction	**5%**		**18%**	**72%**		**5%**
	5%	0%	18%	45%	27%	5%
The average score for the companies expressing general competiveness as main motivation (27% of total companies)	**3%**		**14%**	**79%**		**5%**
	0%	3%	14%	31%	48%	5%
The average score for the companies <u>not</u> expressing general competiveness as main motivation (73% of total companies)	**5%**		**31%**	**53%**		**11%**
	4%	1%	31%	29%	24%	11%

4.2 Knowledge management

Improved knowledge management was identified as one of the motivation in 8 out of the 22 companies, or by 36% % of the total companies. In terms of knowledge management it was mentioned that preserving the knowledge within the companies is vital so they could be less exposed when experienced employees leave. It was also described that by implementing a configurator it should enable increased learning and knowledge sharing. In this context, it was also described that knowledge hold by few experts at the companies should become available to an increased number of employees. Furthermore, it was mentioned that it should help the company to expand as the product knowledge become more accessible and therefore the company is not constraint by limited number of employees with specific product knowledge. Finally, by storing the knowledge and the product information, it is hoped to enable better knowledge flow and documentation base, which is easier to maintain. In Table 2, the benefits associated with the knowledge management are presented along with the degree the companies agreed with these benefits being realized in relation with the configurator.

Table 2. Benefits related to knowledge management

	Disagree (1-2)		**Neither (3)**	**Agree (4-5)**		**NA (0)**
	Completely disagree	Disagree	Neither disagree nor agree	Agree	Completely agree	No answer
6. Better documentation and maintenance of knowledge	**0%**		**32%**	**64%**		**5%**
	0%	0%	32%	9%	55%	5%
21. Reduction of redundant information	**0%**		**32%**	**64%**		**5%**

	0%	0%	32%	32%	32%	5%
22. Better accessibility of knowledge about product variants and product specifications	**5%**		**23%**	**73%**		**0%**
	0%	5%	23%	32%	41%	0%
The average score for the companies expressing knowledge management as main motivation (36% of total companies)	**4%**		**21%**	**67%**		**8%**
	0%	4%	21%	21%	46%	8%
The average score for the companies not expressing knowledge management as main motivation (64% of total companies)	**0%**		**33%**	**66%**		**0%**
	0%	0%	33%	26%	40%	0%

4.3 Efficiency in the sales and order processes

Increased efficiency in the sales and order processes was identified as motivation in 10 out of the 22 companies, or by 45% of the total companies. In this relation it was mention that the sales person should be able to handle all product configurations even for the complex products through the configurator and at the same time being able to focus on being a good seller. Furthermore, the companies described how they aimed to use the configurators as a tool, which should enable employees to make a configurator and at the same time provide flexibility in options without compromising quality. Another aspect was related to improve the ability to capture all of the customers' requirements in efficient manners and based on that finding the optimal solution. It was also expressed that the configurator should be able to guide the sales process towards selling the right products based on the standard offerings and at the same time finding the optimal fit for the customers. Finally, by automating the sales and the order processes to greater extent, it is hoped to increase speed and consequently reducing routine work and the lead-time for the order fulfillment. In Table 3, the benefits associated with the efficiency in the sales and order process are presented along with to what degree the companies agreed with them being a realized benefits in relation with the configurator.

Table 3. Benefits related to efficiency in the sales and order process

	Disagree (1-2)		**Neither (3)**	**Agree (4-5)**		**NA (0)**
	Completely disagree	Disagree	Neither disagree nor agree	Agree	Completely agree	No answer
5. Reduction of routine work	**5%**		**5%**	**87%**		**5%**
	0%	5%	5%	32%	55%	5%
7. Fewer transfers of responsibility and errors when generating the proposals and specifications	**0%**		**9%**	**87%**		**5%**
	0%	0%	9%	32%	55%	5%
9. Shorter time to generate proposals	**5%**		**5%**	**87%**		**5%**
	0%	5%	5%	14%	73%	5%
12. Reduction of cost when of preparing proposals and specifications	**5%**		**14%**	**77%**		**5%**
	5%	0%	14%	45%	32%	5%
The average score for the companies expressing efficiency in the sales and order processes as main motivation (45% of total companies)	**8%**		**10%**	**78%**		**5%**
	3%	5%	10%	35%	43%	5%
The average score for the companies not expressing efficiency in the sales and order processes as main motivation (55% of total companies)	**0%**		**6%**	**90%**		**4%**
	0%	0%	6%	27%	63%	4%

4.4 Efficiency in the production process

Increased efficiency in the production process was identified as one of the main motivation in 6 out of the 22 companies, or by 27% of the total companies. In this relation it was mentioned that it was hoped that the configurator would improve the overview of the different products variants and their connections and their effects on the production. Furthermore, in this relation it is hoped that the configurator can streamline the process of generating BOM, the production specifications, and thereby increase the speed and reduce errors. Finally, it was described that due to the variety of templates and different standards for generating the production specifications, which resulted in errors in the production, it is hoped to make the specifications more homogenous by the implementation of the configurator. In Table 4, the benefits associated with the efficiency in the production process are presented along with to what degree the companies agreed with them being a realized benefit gained in relation with the configurator.

Table 4. Benefits related to efficiency in the production

	Disagree (1-2)		**Neither (3)**	**Agree (4-5)**		**NA (0)**
	Completely disagree	Disagree	Neither disagree nor agree	Agree	Completely agree	No answer
13. Reduction of cost in relation with construction and production preparation	**5%**		**14%**	**77%**		**5%**
	5%	0%	14%	27%	50%	5%
14. Reduction of cost in relation with production and procurement of materials	**5%**		**45%**	**46%**		**5%**
	0%	5%	45%	32%	14%	5%
The average score for the companies expressing efficiency in the production process as main motivation (27% of total companies)	**0%**		**17%**	**83%**		**0%**
	0%	0%	17%	33%	50%	0%
The average score for the companies not expressing efficiency in the production process as main motivation (73% of total companies)	**6%**		**34%**	**53%**		**6%**
	3%	3%	34%	28%	25%	6%

4.5 Accuracy of the products' specifications

Improved accuracy of the product' specifications and the documentation associated with the product configuration was identified as one of the motivations in 9 out of the 22 companies or 41% of total. The companies explicitly explained that they aimed to eliminate errors and thereby improving the quality of the specifications. In this context, one of companies expressed that they aimed to achieve increased uniformity of the generated quotations, as the sales persons had different routines and preferences that lead to lack of uniformity and

errors in the quotations sent out to customers. In another company, it is described that by validating and ensuring that the accurate information are incorporated in the configurator, the number of errors should subsequently be reduced. Furthermore, it was expressed that the implementation of the configurator should enable improved overview of the different products' parameters, the relationship between the different parameters and why certain combinations are not feasibly, to reduce errors. Finally, when errors are discovered it is easier to communicate and correct them, as it only has to be changed in one place or in the configurator, and therefore the same errors should not repeatedly occur. In Table 5 the benefits associated with the accuracy of the products' specifications are presented along with to what degree the companies agreed with them being a benefit gained in relation with the configurator.

Table 5. Benefits related to accuracy of the specifications

	Disagree (1-2)		**Neither (3)**	**Agree (4-5)**		**NA (0)**
	Completely disagree	Disagree	Neither disagree nor agree	Agree	Completely agree	No answer
8. Improved quality of the response to customer request	**0%**		**9%**	**86%**		**5%**
	0%	0%	9%	36%	50%	5%
15. Reduction in the number of orders where there are deviations between the estimated and the actual cost	**5%**		**18%**	**59%**		**18%**
	5%	0%	18%	23%	36%	18%
16. Less deviation (in percentages) between the estimated and the actual cost	**5%**		**23%**	**54%**		**18%**
	5%	0%	23%	27%	27%	18%
The average score for the companies expressing accuracy of the products' specifications as main motivation (41% of total companies)	**0%**		**4%**	**71%**		**26%**
	0%	0%	4%	30%	41%	26%
The average score for the companies not expressing accuracy of the products' specifications as main motivation (59% of total companies)	**5%**		**26%**	**64%**		**5%**
	5%	0%	26%	28%	36%	5%

4.6 Management of products variants and complexity

Improved management of variants and complexity was identified as one of the motivations in 5 out of the 22 companies, or by 23% of the total companies. In this relation, it was expressed that the configurator should help in the process of managing complex products' portfolio and the associated cost. In the other company, it was expressed that by use of a configurator it is hoped to minimize the number of items and structured BOMs. This should result in reduced variant handling associated with long descriptions with large number of different SKUs. Furthermore, it was expressed that by use of the configurator it was hoped to standardize the way of offering individualized (customized) products and thereby reducing the overall cost. Finally improved product overview, standardization of the product portfolio, and consistent configurations from time to time was to be achieved by the implementation of configurators. In Table 6, the benefits associated with the management of product variant and complexity are presented along with to what degree the companies agreed with them being a benefit gained in relation with the configurator.

Table 6. Benefits related to management of product variants and complexity

	Disagree (1-2)		**Neither (3)**	**Agree (4-5)**		**NA (0)**
	Completely disagree	Disagree	Neither disagree nor agree	Agree	Completely agree	No answer
17. Easier to identify and manage product variants	**0%**		**9%**	**91%**		**0%**
	0%	0%	9%	32%	59%	0%
18. Decreased number of product variants	**41%**		**27%**	**32%**		**0%**
	23%	18%	27%	18%	14%	0%
19. Increased use of standard modules / components	**5%**		**14%**	**82%**		**0%**
	5%	0%	14%	32%	50%	0%
The average score for the companies expressing Management of products variants and complexity as main motivation (23% of total companies)	**27%**		**13%**	**50%**		**0%**
	7%	20%	13%	13%	47%	0%
The average score for the companies not expressing Management of products variants and complexity as main motivation (77% of total companies)	**12%**		**18%**	**70%**		**0%**
	10%	2%	18%	31%	39%	0%

4.7 Other motivations

In term other motivations answers from 5 out of the 21 companies, or 24% of the total companies where grouped in this category. This includes improved visualization, security, innovation and uniformity. In addition one of the companies explained that the ERP system used at the company that included variant management but not financial management, which meant that it was not possible to calculate the production cost, which motivates them to use configurators. In terms of other motivations no specific benefits could be grouped to the motivations listed in this category as they are to company specific. Therefore, it cannot be determined how successful the companies were achieving them.

6. DISCUSSIONS

Seven main categorize were identified based on the motivations given by the companies, where two of categorizes the are efficiency in the sales and order processes and the accuracy of the products' specifications are the most mentioned motivations, or by 45% and 41% consequently. Knowledge management was mentioned by 36% of the companies as the third most mentioned motivations, and finally the remaining motivations categorizes were expressed less frequently or by 27-23% companies.

In the first motivation category *general competiveness,* seven benefits were grouped, which are (1) increased sales revenues for the products included in the configurator, (2) increased gross margin for the products included in the configurator, (3) more sales quote result in actual orders, (4) more on time delivery result in increased number of orders, (5) larger share of products that meet the quality

objectives, (6) increased customer satisfaction, and finally (7) increased employee satisfaction. Out of these benefits, 77% and 72% of the companies agreed with increased customer and employees' satisfaction consequently being realized benefits from using the configurators, while only 32% of the companies agreed with more sales quotes resulting in actual orders. For the other benefits 68% - 41% of the companies agreed that those were benefits associated with the configurator. In this category significant difference of the companies that expressed a motivation in this category can be seen as 79% on average agreed with those benefits while for companies not expressing a motivation grouped into the category 53% agreed.

The second motivation category *knowledge management* three benefits were grouped, which are (8) better documentation and maintenance of knowledge, (9) reduction of redundant information, and finally (10) better accessibility of knowledge about product variants and product specifications. Out of these benefits, better accessibility of knowledge about product variants and product specifications was the most recognized benefit or by 73% of the companies, while better documentation and maintenance of knowledge, and reduction of redundant information were both recognized by in both cases by 64% of the companies. However, not significant difference can be found between companies expressing a motivation in this category and the ones not expressing a motivation in this category, as the number of the companies agreeing to the benefits on average or 67% and 66% consequently.

The third motivation category efficiency in the sales and order processes four benefits were grouped, which are (11) reduction of routine work, (12) fewer transfers of responsibility and errors when generating the proposals and the specifications, (13) shorter time to generate proposals, and finally (14) reduction of cost when of preparing proposals and specifications. Out of these benefits 87% of the companies agreed with reduction of routine work, fewer transfers of responsibility and errors when generating the proposals and specifications, and shorter time to generate proposals being a benefit, while 77% agreed with reduction of cost when of preparing proposals and specifications. However, an interesting finding is that on average 90% of the companies, which did not express a motivation in this category agreed with those benefits while 78% of the companies expressing a motivation in the category agreed on average. Therefore, higher percentages of companies not expressing a motivation grouped in the category agreed with achieving the associated benefits.

The fourth motivation category *efficiency in the production processes* two benefits were grouped, which are (15) reduction of cost in relation with construction and production, and (16) reduction of cost in relation with production and procurement of materials. Out of those two benefits 77% of the companies agreed with reduction of cost in relation with construction and production being a benefit while 46% of the companies agreed with reduction of cost in relation with production and procurement of materials. In terms of companies that expressed a motivation grouped into this category a significant different was found. On average from the companies expressing a challenge in this category 83% agreed with this being a realized benefit, while only 53% of companies not expressing a motivation in the category agreed on average with this benefit.

The fifth motivation category *accuracy of the products' specifications* three benefits were grouped, which are (17) improved quality of the response to customer request, (18) Reduction in the number of orders where there are deviations between the estimated and the actual cost, and (19) less deviation (in percentages) between the estimated and the actual cost. Out of those benefits most companies agreed with improved quality of the response to customer request or 86% of the companies, while 59% and 54% agreed with reduction in the number of orders where there are deviations between the estimated and the actual cost, and less deviation (in percentages) between the estimated and the actual cost consequently. In terms of companies that expressed a motivation grouped into this category a significant different was found as 71% on average agreed that those three benefits were realized from using the system while 64% of companies not expressing a motivation in the category agreed on average.

The sixth motivation category *management of products variants and complexity* three benefits were grouped, which are (20) easier to identify and manage product variants, (21) decreased number of product variants, and (22) increased use of standard modules / components. In relation with the benefit easier to identify and manage product variants 91% of the companies agreed, which makes the benefit that the most companies agree with out of all the benefits. The benefit increased use of standard modules / components also was agreed by the majority of the companies or 82% while only 32% agreed with decreased number of product variants being a benefits associated with using the configurator. An interesting finding is that on average 70% of the companies, which did not express a motivation in this category agreed with those benefits while only 50% of the companies expressing a motivation in the category agreed on average. Therefore, higher percentages of companies not expressing a motivation grouped in the category agreed with achieving the associated benefits.

The implementation of configurators often involves that companies also improve their product designs with special focus and increased standardization and predefined product architectures. The above mention benefits from the application of the configurators also includes these aspects and therefore the benefits are not only gained from implementing the configurators but also as the companies are more in charge of the their product designs.

CONCLUSIONS

The aim of the study was to provide further insight into the relationship between the initial motivations manufacturing companies have for implementing configurators and the associate realized benefits. To address this two research questions were developed.

The first research question aims to identify the main motivations for the implementation of the configurators. The main motivations were grouped into seven categories, which are to improve general competitiveness, knowledge management, efficiency in the sales and order processes, efficiency in the production processes, accuracy of the products' specifications, management of products variants and complexity and finally other motivations.

The second research question aimed to express how successful companies were in achieving the benefits associated with the motivations prior to the implementation. For the motivation categorizes, general competiveness, efficiency in the production process and accuracy of the products' specifications, companies that expressed a motivation grouped into these categories agreed to greater extent with the associated benefits being realized in their companies. That means that companies that have plans from the beginning to achieve those goals are more likely to accomplish them. For the motivation categories efficiency in the sales and order processes and

management or product variants the companies that expressed a motivation grouped in to these categories, agreed to less extent than the companies not expressing a motivation into the category that this was a realized benefit. Finally, for the motivation category known as knowledge management now significant difference could be determined between the companies expressing a motivation in the category and not in terms of the to what degree companies agreed of the associated benefits being realized benefits associated with the usage of the configurator.

The findings presented in this study also raise further questions regarding what is the relation between the planned benefits prior to the implementation of the configurator and the side benefits that are achieved without be planned. Further, studies will therefore explore this relationship to greater extent.

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