

# An empirical study on product configurators' application: Implications, challenges and opportunities

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**Abstract.** As computer systems, product configurators have been widely applied in practice for configuring a right amount of product variety. While studies have been reported to shed light on how product configurators' application achieves time reduction and quality improvement in fulfilling customer orders, empirical investigations addressing the implications of product configurators' application for companies' business activities are very limited. However, understanding the implications is very important for companies because with such an understanding, they can better plan actions and make changes to embrace the implementation of product configurators. Thus, based on a survey, this study investigates the implications of product configurators' application. The results indicate (i) how product configurators' application affects companies' business activities, (ii) the difficulties in designing, developing, and using product configurators, and (iii) the potential barriers preventing companies from effectively applying product configurators in the future. With the results, we further highlight several improvement areas for companies to investigate in order to reap, to the largest extent, the benefits of implementing product configurators.

## 1 INTRODUCTION

Since the early 90's, product configurators have been receiving continuous interests and investigations from both the academia and industrial alike. Resulting from these efforts, countless articles have been published to present solutions to diverse configurator related issues. Many of these articles address configuration knowledge representation and modeling, methods and approaches for product configurator design from a theoretical point of view (e.g., Haug, 2010; Pitiot et al., 2013; 2013; Zhang et al., 2013). In comparison, a relatively small number of articles deal with the practical issues related to product configurators' application. Among them, some articles empirically investigate how product configurators achieve lead-time reduction and quality improvement (Trentin et al., 2011 & 2012; Haug et al., 2011); some articles use single cases to show (i) how product configurators' development can be facilitated (Haug et al., 2010; Hvam et al., 2003; Hvam & Ladeby, 2007), (ii) how product configurators contribute to variety management (Forza & Salvador, 2002), and (iii) the suitable product configurator development strategies (Haug et al., 2012). Due to the relatively less investigation, several important issues related to configurators' application are unclear. They include (i) how product configurators' applications affect companies' business activities, (ii) the difficulties in designing, developing/maintaining, and using product configurators, and (iii) the barriers potentially preventing companies

from effectively using configurators in the future. However, it is important to have a clear understanding of all these issues. This is because such an understanding can help companies better plan actions for optimally applying product configurators, thus realizing the benefits of product configurators' application to the largest extent.

This study tries to fill this gap by investigating the implications of product configurators' application. It is done using a quantitative research method, as described in the next section. Based on the data collected, we present, in Section 3, the results and analysis. The results are discussed with respect to (i) how product configurators' application affects companies' business activities, (ii) the difficulties in designing, developing/maintaining, and using product configurators, and (iii) the potential barriers influencing the effective application of product configurators in the future. Built upon the insights in Section 3, we further discuss the possible changes and improvements that companies may undertake.

## 2 METHODS

As the aim of this study is to identify the implications of product configurators' application for companies' business activities, an empirical study was performed. In doing so, a questionnaire was developed for collecting data. The collected data was computed and analyzed for revealing the application implications and for identifying the related opportunities as well.

In designing the questionnaire, we included such questions like the functions that product configurators perform, the business process and IT system changes caused by product configurators' application, the difficulties in implementing product configurator projects, the potential barriers preventing the effective application of product configurators in the future, and the performance improvements resulting from product configurators' application. Besides these questions, there are also general questions such as position titles, the application time of configurators. By considering the explorative nature of this study, we used nominal scales by presenting alternative choices for each question. The alternatives were determined based on the literature and our experiences of working with companies, where product configurators are applied. Besides alternatives, we included the opportunity for respondents to choose "Other" and give details. In this way, we avoid the possibility of missing potential alternatives. To verify the initial questionnaire with respect to the sufficiency and appropriateness of questions, we pretested it in 5 companies, with which we have collaborations. In

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the pretest, 5 company representatives filled up the questionnaire and provided comments. In addition, we made phone contacts for clarifications of the comments and additional remarks. Based on the feedback, some questions were revised, leading to the finalized questionnaire. (Appendix A summarizes the questionnaire.)

With the finalized questionnaire, survey was conducted in a research panel involving managers responsible for IT investments in US companies in October and November 2013. These companies were mainly from the computer, telecommunication system, and industrial machinery industries. Panel members were invited by a commercial research data collection company: EMPanel Online. Data was collected by sending invitation by email and using an on-line survey tool. To ensure that the respondents know about configurators and were responsible for configurator projects, a qualifying question was asked. In addition, another two questions regarding industry type and company size were asked. By considering these questions, we obtained and analyzed 64 completed questionnaires, which had balanced distributions with respect to the company size, industry, and time duration (in year) of product configurators' application.

In analyzing the data, we computed the total occurrence of each alternative, which was selected by the respondents, and the corresponding percentage. In this regard, we analyzed the distribution of the selected alternatives.

### 3 RESULTS

In accordance with the questionnaire, the collected data is analyzed with respect to (i) how the application of product configurators affects companies' business activities, (ii) the difficulties in designing, developing/maintaining, and using product configurators, and (iii) the issues potentially influencing the effective application of product configurators in the future.

#### 3.1 How product configurators' application affects companies' business activities

In studying how companies' business activities are affected by the application of product configurators, it is essential to understand the major tasks that product configurators perform. This is because these tasks contribute to many of companies' activities for designing, producing, and delivering products. It is equally important to understand the major users of product configurators. In accordance with the configurators' tasks and users, there might be changes to companies' business processes, functional units, IT systems, the number of employees, and performances.

##### 3.1.1 Major tasks and users of product configurators

Being consistent with the literature, the survey results suggest that a configurator performs multiple tasks and has multiple users. As shown in Fig. 1(a), configurators in 60% of the respondents (i.e., the responding companies) perform sales order processing, such as quotation preparation, sales order specification, and product specification; configurators in 29% and 11% of the respondents carry out product documentation: BOM and drawing generation and manufacturing documentation: routing and process plan generation, respectively. (Note that these figures were calculated based on the

total number of tasks, instead of that of companies. In this regard, they are not mutually exclusive with respect to companies. This is the same with the calculation of all the rest figures.) Consistent with the tasks that configurators perform, the major users include sales staff (in 46% of the respondents), designers (in 25% of the respondents), customers (in 15% of the respondents), and production planners (in 14% of the respondents), as shown in Fig. 1(b). While published articles provide anecdotal evidences, there is no study presenting such a complete distribution of configurators' functions and users.

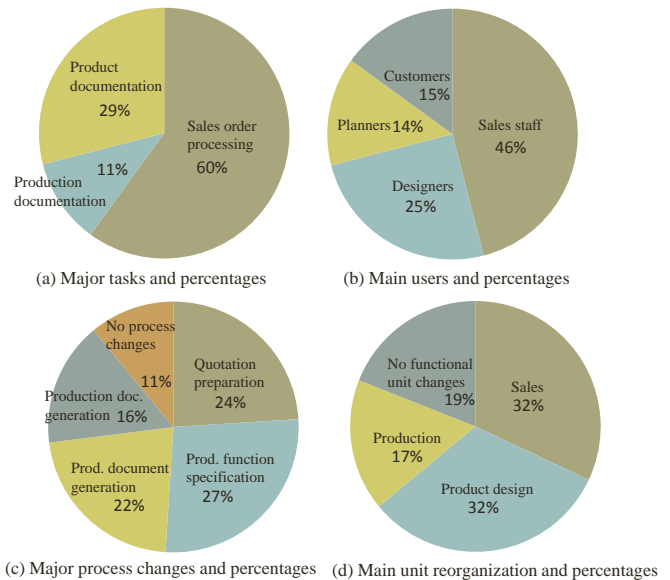


Figure 1: Some results

##### 3.1.2 Functional units reorganized

While product configurators take over tasks, which are performed previously in different functional units, their application does not bring many changes to the functional units. As shown in Fig. 1(c), both the sales and product design/development units in only 32% of the respondents are affected, thus reorganized; the production unit in 17% of the respondents is reorganized. It is interesting to see that product configurator application does not bring any changes to the functional units in 19% of the respondents. Our experiences of working with companies show that this might happen in the situations, where customers are the major users of product configurators. However, this needs to be further confirmed in the future investigations.

##### 3.1.3 Business process changes

As product configurators automatically perform many activities, which are carried out manually in the past, their application might incur business process changes as well. In the survey, many respondents indicate that their business processes have been changed. These changes include (i) the original manual quotation preparation is done automatically (in 24% of the respondents), (ii) the sales unit is responsible for the task of specifying product functions (in 27% of the respondents), (iii) product technical details, e.g., BOMs, drawings, are dealt with automatically (in 22% of the respondents), (iv) manufacturing documents are generated automatically (in 16% of the respondents), as shown in Fig. 1(d). It

is worth mentioning: as pointed out by 11% of respondents, that product configurators' application does not bring changes to their business processes. This seems consistent with what we have found above: 19% of respondents indicate that product configurators' application does not cause changes to the functional units. When there are no changes to companies' functional units, there may not be the changes to the business processes. However, this needs to be further tested in the future.

### 3.1.4 *Changes to companies' legacy systems*

In performing tasks, product configurators interact with companies' other IT systems for receiving inputs and/or sending outputs. Consequently, product configurators' application may cause changes to companies' legacy systems. The results confirm this. As shown in the results, (i) design systems are modified to be linked with configurators (in 33% of the respondents), (ii) production systems, such as product planning and control systems and material resources planning systems, are modified to be linked with product configurators (in 48% of the respondents), and (iii) accounting systems are modified to be linked with product configurators (in 9% of the respondents). At last, 10% of the respondents indicate that there are no changes to their legacy systems. When product configurators are built-in modules of ERP systems, it might be possible that companies do not need to modify their legacy systems.

### 3.1.5 *Changes to the number of employees*

As product configurators perform automatically many activities, which are performed manually in the past, intuitively, product configurators' application should reduce the number of full time employees. However, it is surprising to see that 63% of the respondents hire full time employees, whereas only 6% indicate that they lay off employees. 31% point out that there are no changes to the number of their employees. As indicated in the following results (Subsections 3.2 and 3.3), companies do not have sufficient good IT system designers and developers. In this regard, the application of product configurators may lead to the recruitment of new employees.

### 3.1.6 *Performance improvements*

The available literature reports diverse performance improvements resulting from the application of product configurators. This study finds similar results, thus supporting the literature. For all the respondents, the improvements include (i) increased sales volume, (ii) increased correct sales orders, (iii) reduced production rework, (iv) increased customer orders, (v) reduced order processing time, and (vi) reduced sales delivery time. As indicated by the results, 47%/44%/ 44%/31% of respondents achieve 30%-50% increase of sales volume/increased correct sales orders/reduced production rework/increased customer orders accepted, respectively. Seen from the results, it is difficult for companies to achieve higher improvements in these performance measures. For example, only 3% of the respondents achieve 80% increase of sales volume. It is interesting to see that companies reduce much order processing time, whereas they do not achieve equivalent improvement in the sales delivery lead time. (50% of the respondents indicate higher than 50% reduced order processing time; 30% and 22% of the respondents

achieve 0-30% and 30%-50% delivery lead time reduction, respectively.) This might be caused by the fact that there are more interactions among different functional units in the entire cycle of delivering sales orders. These interactions may result in lower improvements in sales delivery lead time.

## 3.2 **Difficulties in designing, developing/maintaining, and using product configurators**

As shown in the results, most companies experience difficulties in designing, developing/maintaining, and using product configurators. 50% of the respondents indicate that it is rather difficult for them to design product configurators. The two major reasons are (i) the lack of IT system designers (in 50% of the respondents) and (ii) IT system designers and product designers cannot communicate well (in 45% of the respondents). With our experiences of working with companies and based on the literature, these results are understandable. Manufacturing companies normally hire IT engineers for maintaining systems in support of their core business activities: design and production. In this regard, the IT engineers may not possess sufficient skills and capabilities for designing product configurators. The early literature points out that due to the differences in communication languages, configurator designers and product experts have difficulties in making effective communications (Haug et al., 2010). The results found in this study are consistent with the literature.

Similarly, most respondents have difficulties in developing/maintaining product configurators. The biggest challenge for companies to develop/maintain product configurators is the high complexity of product configurators, as supported by 52% of the respondents. The other two main difficulties include (i) the lack of good IT system developers (in 24% of the respondents) and (ii) the continuous evolution of products and the resulting high product complexity (in 24% of the respondents). While product complexities do not appear as a main difficulty in designing configurators, they do cause difficulties in developing and maintaining product configurators. This is because in accordance with product complexities, the product configurator design is complex too. It is understandable that complex product configurators are difficult to develop.

In using product configurators, companies also have difficulties. These are caused by (i) un-user friendly interfaces (in 44% of the respondents), (ii) the inefficient communications for getting required inputs (in 31% of the respondents), (iii) the high complexity of product configurators (in 12.5% of the respondents), and (iv) the lack of sufficient training (in 12.5% of the respondents). In processing customer orders, configuring products, and generating product/manufacturing documents, configurators require diverse inputs. These inputs are from customers, sales staff, designers, etc. In many cases, the input providers are from different offices or even different companies. This location dispersion may hinder the effective communications for required inputs. In addition, even in the situation where the input providers are in the same location, due to, e.g., other tasks that they need to deal with, the input providers may not be able to supply required inputs on-time. In our view, the other three difficulties are interconnected with one another. First, complex product configurators may have many interrelated modules and procedures. More training is required to understand and use these modules and procedures. However, companies are busy with dealing with daily operations activities and may not give enough

training time to users. As shown in practice, e.g., the fail of SAP project in Avon (<http://blogs.wsj.com/cio/2013/12/11/avons-failed-sap-implementation-reflects-rise-of-usability/>), caused by design difficulties, complex IT systems tend to have un-user friendly interfaces. In this regard, the un-user friendly interfaces may be, at least, partially related to product configurator complexities.

### 3.3 Issues potentially influencing the effective application of product configurators

One question in the questionnaire asked respondents for the barriers, which may potentially prevent them from effectively applying product configurators in the future. The results here are consistent with these discussed earlier. The earlier results show that companies have difficulties in designing and developing product configurators because of the lack of technical IT staff. Similarly, the lack of IT staff also appears to be a major barrier for companies to effectively use product configurators in the future. The fact that products keep evolving is one of the three difficulties in using product configurators is also acknowledged as one barrier for future use. Two additional barriers, including (i) the unclear customer requirements and (ii) the unsafe feeling of employees, are brought up. Due to the linguistic origins, customer requirements are normally imprecise and ambiguous (Jiao & Zhang, 2005). In addition, they often conflict with one another. As product configurators need articulated customer requirements, the ambiguous and conflicting requirements will negatively affect the effective application of product configurators. As a matter of fact, during the initial questionnaire pretest, some of the 5 company representatives indicated this. As product configurators execute activities, which are carried out earlier by the employees, the affected employees perceive product configurators as a menace to their positions inside the companies (Forza & Salvador, 2002). In this regard, the unsafe feeling of employees may become an obstacle for the effective application of product configurators in the future.

In summary, the largest barrier is the continuous evolution of products, as pointed out by 75% of the respondents. The other barriers include (i) the lack of technical IT staff for maintaining the configurators (seen by 47% of the respondents), (ii) the unclear customer requirements (perceived by 47% of the respondents), and (iii) the unsafe feeling from the employees because of the possibilities of losing jobs (agreed by 34% of the respondents).

## 4 DISCUSSIONS

Along with the benefits achieved, product configurators' application brings many additional requirements and changes to companies' existing way of doing business, as shown in this study. While the changes and requirements may not be perceived beneficial, they open up opportunities for companies to improve the new way of doing business, which involves product configurators. Based on data analysis and results, this study highlights three areas for investigation: (i) IT capacity and capability enhancement, (ii) organization redesign, and (iii) top down support and company-wide engagement.

*IT capacity and capability enhancement.* Product configurators are basically IT systems. The optimal design and development of these systems will bring many advantages to companies, such as the configuration of optimal products, the cut-down of configuration

time, the reduction of configuration errors, the easy application, the reduction of training time, etc (Haug et al., 2012). Such design and development demands sufficient system designers and developers with high skills and experiences. However, the results indicate that many companies do not have sufficient good designers and developers. In this regard, it will be beneficial to companies, especially these that design and develop configurators in house, for having sufficient well-trained system designers and developers. These designers and developers bring companies additional IT capacities and capabilities. Developing such IT capacities and capabilities can be also justified by other issues. The fact that products keep evolving necessitates continuous maintenance and upgrading to be performed (Section 3.2). Caused by its complexity, configurator maintenance and upgrading are not easy tasks and difficult to perform. In addition, if they are not well performed on-time, companies may delay product configuration, production, and delivery. This may, in turn, cause companies to lose customers. In this regard, sufficient, well-trained system designers and developers can also contribute to configurators' continuous maintenance and upgrading.

*Organizational redesign.* Product configurators' application brings many changes to companies existing activities, processes, and functional units (Sections 3.1.2 & 3.1.3). While simply reorganizing the affected units, as what the practice does (Section 3.1.2), may to certain degree facilitate product configurators' application, it is insufficient for companies to realize the full benefits of product configurators (Salvador & Forza, 2004). In fact, the communication difficulties (Section 3.2) lend themselves to this point. In accordance with the tasks and functions that product configurators perform, companies should reorganize their business processes and structures by reallocating the responsibilities of each individual employee and functional unit. The reorganization should be performed such that each employee has a clear vision for his activities, tasks, and responsibilities. This is the same for functional units. Besides, information exchange protocol and procedures need to be (re)designed such that communication difficulties in applying product configurators can be eliminated. At last, as one of the potential barriers for effective configurator application in the future lies in unclear customer requirements, some efforts in organization redesign may be directed to the suitable tools, techniques, systems, etc and the related issues for obtaining clear customer requirements.

*Top-down support and company-wide engagement.* As with the implementation of any new technologies, the implementation of product configurators needs continuous support and commitment from all levels, especially the top management level, in a company. The support and commitment is very important for completing the necessary organization changes (see above) and for successfully implementing product configurator projects. The literature shows that the lack of long-term commitment is one of the main reasons for the failure of many technology implementation projects (Bergey et al., 1999). As the employees including the middle management level have a tendency to resist changes (Paper & Chang, 2005), regular encouragement and incentives from the top management level are required to remove employees' hostile attitude towards the application of product configurators. Once the employees positively look at product configurators' application, they are willing to accept and implement organization changes. Perceived by companies, the employees' unsafe feeling for losing jobs is one of the important barriers potentially preventing companies from effectively applying configurators in the future (Section 3.3). To encourage the employees and remove their unsafe feelings, the top management



level may create more training activities. With these training activities, the employees may master additional skills. They may also involve employees in company's important meetings, share with employees company's daily or weekly news and development, etc. All these supports may help employees regain their confidence and develop correct attitudes towards configurators' application.

## 5 CONCLUSIONS

In view of the lasting interests that product configurators receive, this study set out to investigate the implications of product configurators' application for companies' business activities. The belief is that it is beneficial for companies to understand the difficulties and challenges before embarking upon a product configurator project. As shown in the results, product configurators' application brings many changes and difficulties along with performance improvements. The changes together with the difficulties highlight a number of areas to be investigated if companies want to achieve the optimal benefits from using product configurators.

In conducting the survey, we used nominal scales by considering the explorative nature of this study. While the nominal scale permits an easy understandable questionnaire, it makes analysis less exact than a Likert scale. In another words, it may not be able to identify the causal relationships among the interesting elements involved in the implications of configurators' application. In this regard, this study highlights an interesting future research topic. An extended quantitative method involving data analysis based on Likert scales might be conducted to reveal these causal relationships. In addition, as an initial study, the survey treated configurator development and maintenance as one issue, instead of two. As computer system development and maintenance are two different projects, the extended future study might take this into consideration. Moreover, the survey results reveal that many interesting questions need to be investigated in the future, such as in accordance with the major configurator tasks, who should be responsible for a configurator project and how they can better lead such a project, what are the configurator maintenance tasks and how can these tasks be better performed. At last, while the initial results in this study show some trends, further work is needed to investigate differences between small and large companies and between business-to-business companies and business-to-consumer companies.

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Appendix: A summary of the questionnaire

General issues:

- 1: How long have the configurator been in use.
2. How many types of products are the configurator used for.

Product configurator applications:

1. Which tasks are performed by the configurator.
2. Who are the users.
3. Which functional units were reorganized.
4. Which business process were changed.
5. Which changes were made to other computer systems.
6. Did you layoff/hire full time employees.

Performance of product configurator applications:

1. The percentage of increased sales volume.
2. The percentage of increased correct sales orders.
3. The percentage of reduced production rework.
4. The percentage of increased customer orders accepted.
5. The percentage of reduced order processing time.
6. The percentage of reduced sales delivery time.

Difficulties in implementing product configurator project:

1. The difficulties in designing the product configurator.
2. The difficulties in developing/maintaining the configurator.
3. The difficulties in using the product configurator.

Barriers preventing companies from continuously applying product configurator:

1. The continuous evolution of products.
2. The lack of technical staff for maintaining the configurator.
3. Customer requirements are rather unclear.
4. The unsafe feeling from the employees because of the possibility of losing jobs.