The Competitive Impact of Product Configurators in Mass Tailoring and Mass Customization Companies

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Abstract
Several researchers have advocated the role of product configurators in mass customization, especially due to their ability to stream-line the order process. This paper presents the preliminary results of a study of different competitive advantages and challenges a company which produces highly customized (tailored) products faces by introducing a product configurator system. Also, it suggests a model for evaluating whether a product configuration system should be acquired and, in case it should, what kind of system to choose. The model is developed through the use of a Norwegian wooden staircase manufacturer as a case. The staircase industry is chosen due to the inherent degree of customization in that industry. The challenges that rises when including construction and, hence, parametric variables into the core of the configuration process is discussed. The impact of this paper is not limited to the wooden staircase industry, but affects all companies that mass produce highly customized products.

Keywords: Product Configurators, Mass Customization, Mass Tailoring

1 INTRODUCTION

Kotler [1] believed already in the late 80's that the mass market is dead; referring to continuous narrowing of market segments towards the situation where individual customers are treated as a segment.

As Bourke [2] points out one decade later, customer preferences now shift overnight and they demand products with lower prices, higher quality and faster delivery, as well as products customized to match their unique needs.

The spread of both information and communication technologies as well as more flexible production technologies over the last two decades now allow many companies to bring affordable and individualized versions of products to the individual market segment [1].

The challenging situation of delivering customized products to an affordable price within a reasonable time frame has developed the research area of mass customization (MC). The term was introduced by Davis [3], where he referred to MC as the situation *"when the same large number of customers can be reached as in mass markets of the industrial economy, and simultaneously they can be treated individually as in the customized markets of pre-industrial economies*"

2 THEORETICAL FRAMEWORK

2.1 Mass Customization versus Mass Tailoring

The mass customization strategy might be an tempting alternative for companies originating from the mass production (MP) paradigm, trying to gain competitive advantage through offering more and more customized products as they moves through Da Silviera's [4] 8 different generic levels of mass customization (see Figure 1) from pure standardization (level 1) [5], through usage customization (level 2) [6, 7], packaging customization (level 3) [5, 7, 8], additional service customization (level 4) [6, 8], additional custom work customization (level 5) [6, 8] to assembly customization (level 6) [5, 6, 8]. Some of them even reach for fabrication customization (level 7) [5] and (rarely) design customization (level 8) [5, 6].

The extremes in the continuum between MP and one-of-a-kind (OKP) production are not a part of the mass customization production paradigm as they belong to their own original paradigms [9]. According to Da Silviera et al [4], the 8 generic levels are not allocated symmetrically from level 1 to level 8. Level 2-5 are allocated somewhere between Make-To-Stock (MTS) and Assemble-To-Order (ATO) [10], as indicated in Figure 1. In a manufacturing company context, we would argue that levels 2-5 have limited impact on the mass customization strategy both in order acquiring and processing and most of the operations. Hence, in this paper only level 6 and 7 are regarded as mass customization as such. This is also in line with other researchers proposals [9, 10].

Most of the literature focuses on the companies moving from MP to MC. This paper however, pays special attention to the companies that are approaching mass customization from the OKP paradigm. These companies are typically struggling to industrialize a craftsmanship (level 8) in order to achieve efficiency, and, as Duray et al [11] argue, the MC strategy is also applicable to these companies (towards level 7). As Steger-Jensen and Svensson [10] points out, these companies are facing some of the same challenges as the companies originating from the MP paradigm: Customers are no longer interested in buying standardized products or paying premium prices for customized products or product features. However, the OKP companies also differ from the former MP companies. Their market and the inherent nature of their products prevent many of them from moving further up the standardization axis than level 7. We will refer to such companies as **Mass Tailoring** (MT) companies to separate them from the more generic term of mass customization companies (see Figure 1).

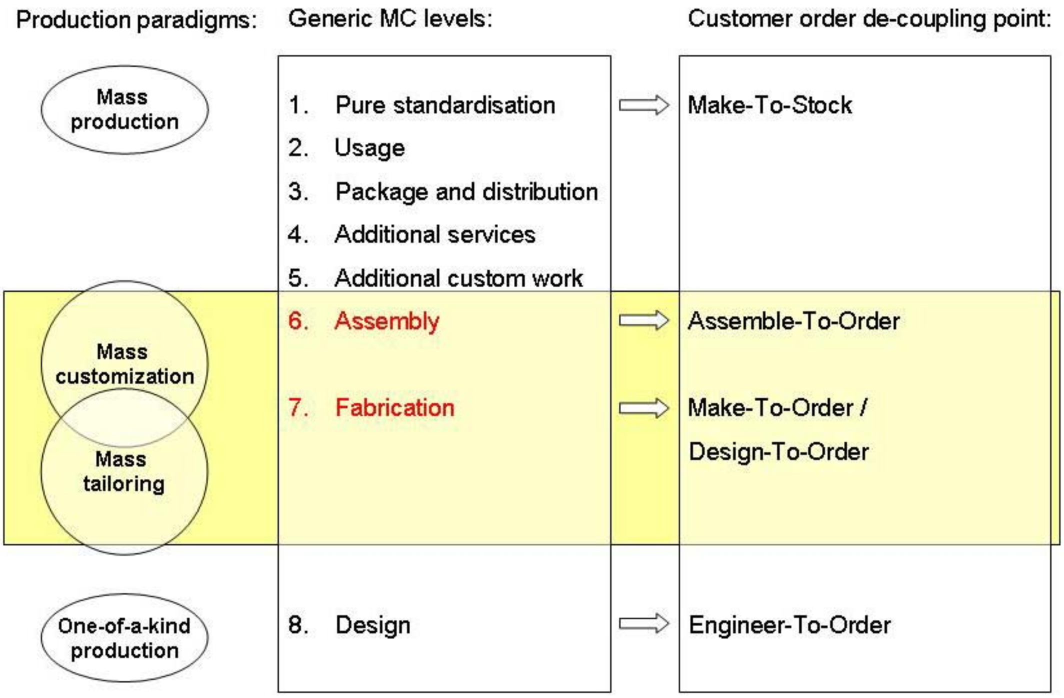

Figure 1: The relation between production paradigms, the generic MC levels according to Da Silveira et al [3] and the CODP according to [10]

2.2 Need of Product Configurators in Mass Customization and Mass Tailoring companies

One of the challenges companies face when moving from *MP towards MC* is the increase in the product variant specter, thus making the Bill of Material (BoM) more complex and the order process more vulnerable. As variety increases the need of supportive product variant software become apparent.

The *mass tailoring companies* moving from OKP production (craftsmanship) towards more industrialized production does not face the same challenge. These companies produce a unique product for each new customer, and many of them have never had a formalized product structure or a BoM as such. However, as the companies try to industrialize craftsmanship, modularizing and standardizing some of the components are necessary to gain economies of scale [12]. Thus, a more formal product structure is favorable to be able to handle order acquisition, procurement, operations and logistics more efficiently. As the degree of industrializing increases the need of a more defined product structure become apparent.

Following the arguments above, both mass customization and mass tailoring companies need some supportive software to handle the variety and defining the product structure. Such software is often referred to as *product configurators* or *configuration systems*.

2.3 Paper focus

The impact of mass customization and mass tailoring is twofold; it affects both the product-realization and the order-realization processes [13]. The product-realization process has been studied extensively over the last decade and the lessons learned include flexible manufacturing processes [14. 15], modularization and standardization [12], and efficient logistics [15, 16]. When these issues are solved, the order process becomes the bottle neck. Hence, this paper focuses on the other part – the order-realization process, and specifically towards the impact of product configurator systems.

The use of product configurators in mass customization and their impact on different business processes have been emphasized by many researchers the latest years [e.g. 2, 10, 13, 17-21]. However, most of the research has been into technical or theoretical aspects of product configurators [20]. Thus, there is a need to extend the research into more empirical work, employing a user perspective. Second, most of this literature is referring to companies customizing at the assembly level. As mass tailoring companies are facing a more extreme version of the product configurator challenge through the inclusion of construction necessity, there is a need to extend present literature to explore the competitive advantages and challenges of product configurators in such companies. Also, the amount of different software solutions covering the product configuration challenge is vast and the selection process for a company gets increasingly difficult without having a framework model and some dimensions to classify the different software into.

Based upon these observations, the present paper focuses on the possible competitive advantages and challenges gained by mass tailoring enterprises, and it develops a model useable for guidance in the decision process of acquiring a product configurator system. The perspective is from the product configurator *acquirer*, rather than from the product configurator *developer*. Hence, this paper will not go into technical details between different structures and platforms to build up a product configurator system, although this is important for the success of the implemented solution.

The rest of the paper is structured in the following way: In chapter three the methodology used is briefly described. Chapter four presents the case company used in this research including a description of their order process before the introduction of a product configurator. In chapter 5 the concept of product configurators is outlined. Chapter 6 develops the framework model based upon present literature and lessons learned from the case. The model is usable for mass tailoring and mass customization companies made for guidance in the decision process of acquiring a product configurator system. Chapter 7 rounds the paper with conclusions and suggestions for further research.

3 METHODOLOGY

The methodology in this research has been fourfold;

First, a literature review was made for acquiring the latest state- of-the-art research within the field of product configuration systems.

Second, semi-structured interviews, workshops, demonstrations and extensive discussions with the case company over a period of one year were performed in order to fully gain the insight in their existing order process and the challenges with their current ICT solution.

Third, further literature reviews were conducted in order to see whether there were existing models of how to classify and choose product configuration software.

Fourth, a web-based search for different product configurator solutions was followed up by semi-structured interviews and presentations of a selection of them in order to test the framework model.

4 THE CASE COMPANY: A WOODEN STAIRCASE MANUFACTURER

4.1 The staircase manufacturing industry

Developing from a craftsmanship, the wooden staircase industry has for centuries been making consumer specific products tailored to meet both the specific customer's taste and his or her house. The latter is of course a matter of necessity as the product cannot be used if it is not fitted to the house.

The challenge for this industry is consequently not to achieve tailoring per se, but rather to produce well designed and tailored staircases fast and affordable through economies of scale. Thus, referring to the mass customization and mass tailoring notions, the challenge is mainly in the 'mass' part of the notions – not the 'customization' or 'tailoring' part.

A second challenge the industry traditionally has faced is that the customers (at least in some markets) tend to regard the staircase as a construction unit in the house, and not as furniture. This means that the customer attention to the staircase generally was expected to be low and hence, product differentiation and company branding less effective. However, over the last few years, this has shifted and the trend is that customers tend to buy more advanced staircases, caring more about personalization, style and aesthetics. However, in some target markets, the price of the staircase is still the most important competitive advantage. Thus, this challenge is twofold; some customers need to be trained to see that the staircase is furniture and hence inspiring the customer to buy more exclusive staircases. The other group of customers demands more customized and special staircases, which challenge the industry to be able to industrialize more complicated staircases.

A third challenge for the industry is that proximity to the customer is very important because qualified personnel needs to measure the staircase room during the order process and also install and assemble the staircase on site. This challenges economies of scale, the order process and the distribution. These aspects seem to be the main reasons why the industry structure still is rather fragmented.

For a manufacturer in Western Europe the low labor costs in some of the Eastern European countries (especially Poland with its proximity to the largest European markets) also constitute a main challenge.

4.2 General company profile

The case company used in this research is one of the ten largest wooden staircase manufacturers in Europe, employing about 100 persons, spread on four production localities with different degrees of specialization and automated production equipment located in different areas of Norway. The main production line is located in the factory in Stryn and has been heavily automated and industrialized over the last decade.

Each year the company produce some 5-6,000 tailored staircases. The company serves mainly the domestic market where they enjoy a market share of about 35-40 %. They also serve the German and (recently) the Danish market. 9 % of the company's turnover is from export. Their customers are both end-users (30 % of volume) and construction firms (70%). Their distribution is direct on the domestic market and via resellers on the international market.

4.3 Product characteristics

Each staircase is individually constructed and produced to fit neatly into the house of the customer. The measures of any two staircase rooms are rarely or never the same, even in the same construction project. The staircase product consist typically of around 100 wooden components distributed between the component groups laths, handrails, sidewall strings, treads, poles and child proofing lists. Some of the components (laths, handrails, and poles) are also offered in steel or combination of steel and wood. Glass is also sometimes used instead of laths.

By the case company, the customer is offered to choose between a range of component styles in a range of wooden materials and a range of standard surface treatment for each component. Then the customer is offered to combine (in principle) any components that he or she wants to make up the staircase. During the years specific staircase designs and models have been developed, but there is still nothing that prevents the company from making quite a new and different staircase in order to meet exactly the customer requirements (within the legal framework and prevailing standards), irrespective of how strange these might be.

A study of the variant specter at the case company showed that the theoretical number of *standard* staircase components reached 5056 *tailored* variants, which could be combined in any way to form more than 150 trillion different staircases. In practice, the number is far lower due to the fact that the customer will not combine pine, ash and beech in the same staircase, nor will he combine modern laths with classic poles and traditional handrails, five different colors etc.

4.4 Configuration challenge

However, the product structure is complicated, especially when using a traditional Bill of Material (BoM). The case company had no formal system of which components that should or should not be combined with each other. However, some combination of components might not be acceptable due to geometrical limitation, technical limitations, manufacturing limitations, economical limitations, or simply that the combination disrupts the design philosophy or the company image/product brand. The lack of a formal system to organize these rules of combination implied communication challenges between different people in different departments at different locations. Typically, these challenges result in a hard-to-manufacture staircase was promised to a customer for a too low price.

The challenge is however not limited to which components that should be combined with each other. Changes in *parametric variables* of a component also might change how a staircase can be put together. This is easier explained through the use of an example:

The size of a customer's staircase room implied that one of the poles in the construction needed to be higher than a certain height. This implied that a specific material was needed in the pole in order to catch up the forces and the torques in the construction. This implied in turn that the staircase needed either to be painted (not varnished) to hide the material difference or that the complete staircase was to be made in the same material as the pole. Both situations heavily impacted the customers' choice of product (either in terms of changed color or increased price).

The challenge for the company was to find some configuration software which also could handle these kinds of configuration rules.

4.5 Order process by the case company

The order process as it was before we entered the company and before the introduction of a product configurator is outlined below.

The order process usually started with a phone inquiry or a (sometimes scarcely) specified fax from the customer. This trigged the first registration of the order and one of the company's installers was sent to the customer to measure all the lengths, depths, heights and angles in the staircase room. These data were then faxed to the company which trigged a discussion with the customer of the specification of the staircase components. Further, a coarse construction was made in specific CAD staircase software based upon pre-defined design elements. The next step was then to fax both technical and economical order confirmation sheets to the customer for review, possible change and confirmation. These data were also checked by the installer. By the reception of a confirmed customer order, the actual production of the staircase was entered into the production planning system and the inventory of raw materials and bought components was checked. The detailed construction of the staircase was then finalized and production drawings, tailored BoMs, and CNC code for the milling machines was generated by the CAD software. The components were then fabricated fast with precise and tailored sizes and angles through CNC milling.

Additionally to the process outlined above, there were non-standardized orders such as customer complaints and back orders with high priority which interrupted the process.

Bearing in mind the variety of the product, the many steps in the order process, and the fact that flow of paper constituted the main information flow, the order process was vulnerable to human error and indistinct communication between the customer and the case company.

A spot check of the orders in one week revealed that as much as 61.5 % of the orders were corrected during the order process. The main reason for these corrections was found to be the absence of a communication tool with the customer and that the delivery time was so long (4 weeks) that the staircase was ordered before the measures were certain (new buildings).

The effective order processing time and the effective coarse construction time were estimated to approximately half an hour each, thus totaling to one hour. Nevertheless, orders stayed within the order registration department for up to 1.5 weeks, a situation which challenged the detailed construction process and production which together had 2.5 weeks to fulfill the order.

5 PRODUCT CONFIGURATOR SYSTEMS

A product configurator is sometimes defined as *software that captures and manages the definition of a unique product or variant* [2]. The software is supposed to support the company in the product configuration process, by which is meant

> *"the process through which the customer's needs are translated into the product information needed for tendering and manufacturing"* [20].

This is the process that Zipkin refers to as *elicitation*, which he argues is one of the three main elements of mass customization, the other two being process flexibility and logistics [15].

One of the core ideas with a product configurator is to specify all rules and constraints for how to produce and assemble components into an 'accepted' product. This might very well be more complicated than a static component-product matrix (traditional BoM), because there might be different rules to apply in different configurations to different customers. Especially in mass tailoring companies this is highly complicated, because the rules might apply to certain dimensions of the components, that is; the rules apply to *parameters* of the components, not the components themselves. This was exemplified for the case company in Section 4.4.

The term product configurator is used on software that focuses on different aspects in the product configuration process, which makes the term confusing. From the user perspective employed in this research, there are at least four different functions that different types of product configurator software tend to focus on[1]:

1. **Logic-enabling software** that has its primary function to describe the rules and constraints of the product structure (back-office).
2. **Sales support (e-commerce) software** that has its primary function to enable the customer to buy a product through a web interface or a reseller's computer (front-office).
3. **Visualization software** that has its primary function to visualize the customers' choice of product characteristics in 2D or 3D models, encouraging him to buy (front-office).
4. **Construction (CAD) software** that has its primary function to create precise BoMs, production drawings and CNC-code for the production (back-office).

Additional to the types of software listed above there are also some software that simply describes the static product structure of components and products, not allowing any logics and complex case-specific rules to be applied. These are also called product configurators by some authors and resellers, but the more proper term is

[1] The grouping of software is made in a somewhat pragmatic way, and is not strictly academic. From a more technical point of view the software would be grouped into other categories such as rule-based reasoning, model-based reasoning, case-based reasoning etc [13]. This is however not the topic of this paper.

product structure configurators. It seems plausible to the authors that these pieces of software are simplifications or precursors for the more advanced logic-enabling software mentioned in point 1 above or a part of the solution mentioned in point 2 above, and hence we have not included them as a separate point. Some of these product structure configurators might be all that is needed for certain companies and they are found as basic components in some simple ERP software. However, for mass tailoring companies such as this paper's case company, these simplified product configurators tend not to meet the demanded functionality.

The practical problem for the company facing the different types of product configurators listed above is complicated. It is not limited to choose whatever configurator that seems to be best. He has to understand his future needs, the capabilities of the different software solutions to meet these needs and most important: How the ICT solution will run seamlessly together as *a complete* ***product configurator system*** *that elicit and transform customer requirements into product information needed for tendering and manufacturing.*

6 TOWARDS A MODEL FOR CHOOSING PRODUCT CONFIGURATOR SYSTEMS

Some of the software solutions reviewed in this research contained more than one of the functions mentioned in the last chapter. However, very few achieved high score on more than one of the functions. The challenge is that there are quite different perspectives and focus of the different types of configurators, which also challenge the comparison of them.

The model developed in this paper aims to draw up a framework and a method to support companies in the process of evaluating and choosing a product configurator system successfully. We propose a model consisting of four subsequent steps which are elaborated in the remaining parts of this chapter.

6.1 Step 1: Any need?

The first thing to really think about is whether a company is in a situation that it should consider a product configurator at all. For many companies with less complex configuration problems simple product structure configurators made in a relational database or Microsoft Excel might be good enough. Companies that only need configurators to generate lists of different articles (typically assemble-to-order) might fall into this category. One needs to analyze thoroughly whether the benefits outweigh the costs of implementing a product configuration system for a specific company. However, for mass tailoring companies, where tailored and non-standard components are the ordinary case, these systems are rarely sufficient.

There have been some scholars that have advocated the benefits of introducing a product configurator system. Reviewing this literature and adding our own experience, this paper presents a short list of the potential competitive advantages of introducing a product configurator system for a mass customization or mass tailoring company (see Table 1). The impact of the different items as well as a further detailing of the list needs to be analyzed with the focal company in mind – it cannot be done generally.

Research has shown that there are also some obstacles when introducing a product configuration system. Forza and Salvador points out (1) the possible change of personnel roles, (2) friction in the inter-functional collaboration within the company, (3) heavy workload in the introduction step and (4) the issue of software personalization [18]. They also point out the need for prioritizing resources through taking away a person from his duties so that the product model can be built [20].

Companies considering buying product configuration software should use considerable time on configuring products manually today if the investment should pay off. Also, the configuration process itself should be routine and specific so it might be automated successfully through product configuration software [22].

These obstacles, together with the price of the software and the implementation, as well as the risk for something going wrong, should be weighted against the benefits outlined in Table 1, before even thinking of acquiring a product configurator system.

Customer satisfaction
• Perceives many product options • Easier to decide what to buy • Attracted by visual interface/Inspired to buy • Increased WYSIWYG-feeling upfront • Shorter delivery time
Knowledge management and employee satisfaction
• Externalization of tacit knowledge • Less dependent of the product experts • Improved communication within departments in the company • Improved communication between customer and company • Increased and quicker understanding of new products • Frees capacity to tasks with greater additional value
Sales and order acquiring
• Automates the order process (elicitation) • Reduce necessity of checking what the customer really wants • Reduces human errors in retyping • Ease the sale process • The customer does the configuration job himself • Attracts customer due to simplicity and transparency • Trains the customer to choose added-value products • Shorter delivery time
Brand
• Retention of design conformity • Avoid claims due to bad configured combination of product • Shorter delivery time
Production
• Avoid technically difficult or impossible configurations • Increased efficiency due to less interruption caused by back orders or order changes
Financials
• Increased sales • Less costs in sales, order acquisition, construction, control and production • Avoidance of costly component combinations

Table 1: Potential benefits of introducing a product configurator system (list partially based upon [2, 10, 13, 15, 17-20, 21, 23 and 24])

Research has shown that even small enterprises (45 employees) can afford and benefit from this kind of software, obtaining both a rapid payback and a competitive advantage [20]. However, a company with less than 15 employees and a not too complex product should be resistant to jeopardize the profitability of the company through implementing expensive software systems as product configurator systems unless there are signs of considerable market (share) growth.

6.2 Step 2: What needs?

Once that Step 1 concludes that a product configurator system is needed, the next step is to specify what needs the company has.

First: Need of graphics, logic and front/back-end solution

The first thing to consider is truly the need of graphics and complex logic. If the configuration can be done purely with selecting components from a list of standard components, the output that needs to be generated is only a text string which can be handled by many simple and well established configurator systems. If the complexity of the product structure requires complex logic and/or involves interactive graphics, more advanced systems should be considered. This was the situation for the case company used in this research, hence their needs needed to be detailed further. Also, whether the need is basically front-office (elicitation and customer communication) or back-office (production and e.g. CNC-coding) or both should be determined.

Second: Apply a check list for specifying demands

The list included here (Table 2) was developed with the case company in mind, and adjusted in line with other researchers' proposals [24]. Hence, the list is not meant to be exhaustive for all applications, but acts as a starting point for specific applications. We would like to advocate that the list needs to be extended with more specific sub-points on several of the topics in order to constitute a complete specification of demands. What we would like to emphasize is the relevance of the five categories along the other axis in the matrix: "Need to have now", "Ought to have now", "Nice to have now", "Likely to be needed in the future", and "Not important".

As is the case with many investments, there is a trade-off between costs and utility, and the matrix provided in Table 2 helps to sort the real needs from the "nice to haves". We would like to highlight the importance of the "Likely to be needed in the future"-column, which helps to choose the right software not only for the short term, but also keeps the future development of the company and the industry in mind.

Third: Identify the external user(s)

In the 'User functionality' part of Table 2 some of the topics are focused on flexibility in the user interface. This trigs an analysis of the different users of the system and their different requirements. The chosen configurator system should be flexible enough to allow different kinds of user interfaces interacting with the configurator kernel. At the case company five kinds of external users were identified, all of them with distinguishing needs:

First, there was the ordinary consumer, looking for a staircase to fit his new house. As staircases have an extremely low repurchase rate the typical customer has never bought a staircase before. Hence, the customer interface to the configuration system needed to be designed as user-friendly as possible, offering an array of staircases in a graphical web environment. It needed to communicate not only the factual product combinations, but also inspiring the customer to buy through playing on the customers' emotions with text and graphics. The demands for high-quality 3D graphics were low; bandwidth-consuming construction details and high resolution were not interesting with the necessary sacrifice of speed, associated with today's technology.

Secondly, there were the resellers of the staircases which needed to show their customers the staircases from the case company. Basically, this could have been the same interface as for the consumer. However, there are two reasons why it should not. First, it should show something more than the consumer can see at his own computer through Internet. Second, the information sought is more towards pure information about the staircase, delivery time, price, graphics and 3D visualization than sales promoting text. In this case it is possible to have an application running locally on the computer, eliminating the need of bandwidth or lack of speed.

Thirdly, the customers within the major construction firms are far more professional than the ordinary consumers. They know the company, they know which and how many staircases they need, and hence, the user interface for them should be quicker, enabling them to order fast and precise.

Fourthly, in the future, one might envisage that the cooperating partners of the case company who are taking measures of the staircase rooms can type these numbers as well as other user requirements into the configuration system through a cellular handheld device.

Fifthly, in the future, one might also consider giving architects and interior designers an application to configure or even coarse construct the staircase together with the rest of the house. With increased bandwidth, this might also be available through Internet in the future.

Fourth: Identify internal user(s)

Within the case company there were also needs for separate solutions within the company.

First, there was the product expert which needed a user interface to specify all the logic, rules and constraints in the product structure. For the case company it was of great importance that this interface was user-friendly so that no programming knowledge was necessary and transparency was achieved.

Second, there was the customer service department that received the order from the customers and did the order registration, the coarse construction of the staircase, and returned the technical and economical order confirmation to the customer. These users are professional and the main focus was to automate the process as much as possible, eliminating human error and double work. Hence, the user interface needed to be fast and the data exchange between the configurator, the ERP-system and the construction software needed to be seamless and reliable.

6.3 Step 3: Analyze and classify

Through the first two steps, the specification of the company's needs should be clarified to a certain extent. However, as pointed out earlier in this paper, there is a vast range of software solutions that sorts into some kind of product configuration or at least product *structure* configuration. The clarifications made through step 1 and 2 might disqualify some suppliers, but there is still a need for sorting the different product configurator systems into different classes, so that a company's analyzing effort can be focused on a smaller group of software providers.

Topic	Need to have now	Ought to have now	Nice to have now	Likely to be important in the future	Not important	Comment
Integration						
• Integration with existing IT tools – able to *read*: o product structure o graphics o price data o production planning • Integration with existing IT tools – able to *write:* o graphics o orders o customer data						
Configuration						
• Handle configuration at parameter level • Handle configuration at component level • Dynamic configuration • High performance (speed)						
Graphics						
• CAD possibilities (3D graphics visualization with parametric values) • 3D graphics visualization without parametric values • 2D graphics visualization						
User functionality						
• Customer specific login (self-initiated) • Customer ability to track past orders • Customizability of user interface • Client-server functionality (web-based access) • Possibility to overrule configuration rules for internal users • Multilingualism • Explanation system for illegal choices • Dynamic changes when choosing illegal choices • Price calculation • Delivery time calculated from production planning system • Customer possibilities for saving half-configured products • Platform flexibility (Operating systems, web browsers, PDAs, cell phones)						
Modeller functionality						
• Easy modelling of knowledge/logic • Easy modelling of graphics • No need of programming competence • Easy to learn • Modelling speed • Maintainability						
Supplier						
• Extensive support • Extensive service • Proximity (low response time) • Industry knowledge • Stability and credibility • Necessity of new product development • Low prices of licenses and support						

Table 2: Check list for specifying demands used in the case study. (Some points taken from [24])

Hansen [24] suggests a two dimensional framework based upon the variables "Degree of knowledge modeling" and "Degree of graphics modeling". He emphasize that the classification is done in a pragmatic way to easily illustrate the differences between the groups of software, and admit that an n-dimensional theoretical space would be more correct (but also impossible to visualize).

The conclusions drawn from the study of Hansen was that there were a range of software solution that scored high on the knowledge dimension and low on the graphics dimension (e.g. traditional text-based configuration systems such as Cincom, Oracle, SSA, Firepond, ArrayTechnology). Also, there were quite few that scored high on the graphics dimension and low on the knowledge/logic dimension (e.g. traditional CAD systems such as AutoCAD, Inventor, SolidWorks). However, there were few that scored high on both dimensions (examples include VirtuBuild, IPC, Intent). The same conclusion was obtained in the search within the framework of the present study.

Using the framework of Hansen, we discovered that a third dimension should be included into the framework, namely whether the software solution is front-office oriented or back-office oriented. Some of the software were otherwise classified in the same category and would fulfill highly different purposes. An example is IPC, which is mainly back-office oriented focusing more towards construction and production purposes, whereas others, like VirtuBuild, were front-office oriented focusing more on elicitation of customer needs and the order process. These differences were utterly important when trying to understand the differences between the software systems.

Including this variable, we would propose a classification framework based upon three dimensions;

- **Degree of knowledge/logic.** From simple component/product matrixes in Microsoft Excel to complex logic, rules, and constraints that regulates which components to combine in which cases.
- **Degree of graphics.** From text-based description of the product through picture catalogue, 2D and 3D interactive visualization windows to (remote) real time construction.
- **Front-office versus back-office.** From elicitation and sales perspective towards perspectives of construction and technical production drawings and CNC milling code.

Considering the dimensions (especially the last one), there is a need to widen up the scope of the product configuration system selection process. The company has to specify where the most prominent need(s) in the three dimensional space are. Once this is done, a thorough market analysis and identification of potential suppliers should be conducted. Also, as Hansen [24] suggests, the choice between industry specific software and standard software should be dealt with, keeping in mind that specialized solution have both advantages and disadvantages.

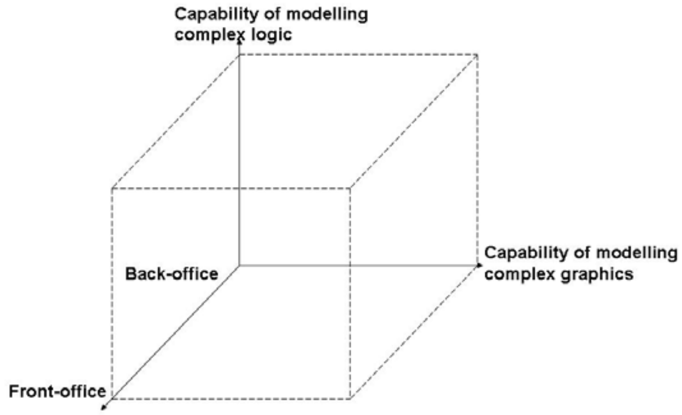

Figure 2: 3-dimensional classification tool for product configurator systems.

Using the case company as subject, they already had an industry specific CAD system, which covered the back-office need of product configuration. Their need was more into front-office purposes, elicitation and automating the order process. The need of graphics was apparent in the front-office context, but not at the highest level. In fact, a simple picture catalogue would be enough for them. A perfect 3D visualization of the staircase might be preferable, but the extra costs could not be advocated as long as the need of looking onto the back side of the sidewall strings was not anticipated to be important for the customer. The complexity in the product structure was apparent, so the product configurator system needed to be flexible enough to capture these kinds of challenges.

While focusing the further analyses on front-office configurator systems, the back-office integration was a subject to pay attention to. The chosen front-office product configuration system needed to communicate seamlessly with the CAD software in order to automate the order process and avoid human errors. In this process, one also needs to consider the possibility of having one application that covers both front-office and back-office needs. Some (especially industry specific) systems try to do this, which surely would ease or even eliminate the integration challenge. However, the case seems to be that such "all-round" software solutions are fulfilling all needs partially, but none of them completely. This tends to be especially true (due to limited resources) when software providers target niche industries such as the case industry in this paper.

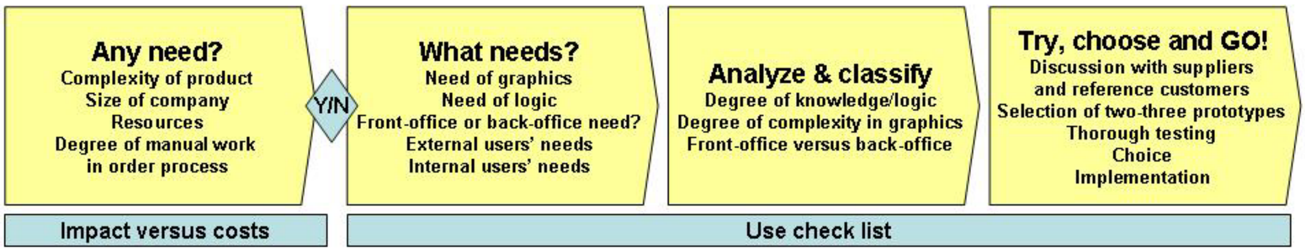

Figure 3: The four step model of choosing a product configurator system

6.4 Step 4: Try, choose and GO!

Conducting a market and suppliers analysis within the framework suggested in step 3, the rest of the screening and selection procedure is relatively standardized, e.g. comprising the following steps:

- Discussions with potential suppliers and their reference customers
- Demonstrations of potential software solutions
- Choice of two-three systems for testing (prototypes or pilot projects)
- Choice, based upon an evaluation / comparison matrix or similar tool
- Implementation

The implementation path might be long and full of pitfalls. Researchers have advocated the need for the company to set aside committed resources to take stakes in the implementation [18, 20]. Diving into the pitfalls of the implementation process is however beyond the scope of this paper.

6.5 Anticipated effects for the case company

The actual implementation of a product configurator system has not yet been completed by the case company. Thus, it is too early to draw concrete conclusions. The current status is that a self-programmed configurator solution has been launched for industrial customers. This configurator cannot be regarded as fulfilling all the needs of the company, but is more like a stepping stone towards a more professional system, using the ramp-up period to gain experience.

The main impact of the existing configurator tool has been in the order process. The feedback from the order and construction department is that the orders that come from the configurator are considerable more detailed and both easier and faster to process. Some preliminary analyses have been made of the impact of the more professional configurator, which suggest an increase in sales of 5-7% due to the visualization component. The order registration procedure is expected to be reduced to a formality, as the linkage between the configurator and the ERP-system is thought to be seamless.

The effects in production are hard to forecast, especially as there are continuously improvement work and learning also on other aspects. The delivery time is foreseen to be reduced from 4 to 3 weeks, whereas the order processing and construction is foreseen to be reduced from 1.5 week to hours for those orders specified through the use of the configurator.

7 CONCLUSIONS AND IMPLICATIONS

Based upon an applied research program with a wooden staircase manufacturer the competitive advantages by introducing a product configurator system have been discussed and a framework model for how to decide upon the right product configuration system software has been developed. The perspective is taken from a mass tailoring company where the complexity of configuration increases due to the inclusion of parametric variables (geometry) in the elicitation process. This situation becomes challenging when changed geometry of the configurable product impacts the choice of other product attributes. Although focusing on a mass tailoring case company it is the belief of the researchers that the developed model can be applied to other companies producing highly customized products as well.

There is a need to further refine and test out the suggested model. In this work empirical evidence is needed to further sort out which companies should acquire which type of product configuration software (if any). Also, there is a need to specifically classify the different software and put it into the model developed in this paper.

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