



**MCPC-090-2007**

**The state of art of mass customization practices in Finnish technology industries  
– Preliminary results of multiple case study of 40 companies**

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Mass customization literature has grown a great deal in recent years and today it covers a wide range of topics ranging from customer integration to modular product architectures. However, extant literature is biased; it seems to concentrate on business-to-consumer commerce and is more concerning theoretical development than empirical studies. This paper seeks to tackle this issue by presenting preliminary results from business-to-business case study conducted in 40 Finnish companies. Results suggest that although the mass customization as a term was not always identified by companies, mass customization strategies and practices are utilized widely in Finnish industry. Mass customization fits well with Finnish industry where traditional mode of production is customer specific production and short production series. In the current state, the product qualities and its production is managed well, but cross-functional cooperation, product configurators and integration of different information systems is still providing challenges.

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Abstract. Mass customization literature has grown a great deal in recent years and today it covers a wide range of topics ranging from customer integration to modular product architectures. However, extant literature is biased; it seems to concentrate on business-to-consumer commerce and is more concerning theoretical development than empirical studies. This paper seeks to tackle this issue by presenting preliminary results from business-to-business case study conducted in 40 Finnish companies. Results suggest that although the mass customization as a term was not always identified by companies, mass customization strategies and practices are utilized widely in Finnish industry. Mass customization fits well with Finnish industry where traditional mode of production is customer specific production and short production series. In the current state, the product qualities and its production is managed well, but cross-functional cooperation, product configurators and integration of different information systems is still providing challenges.

## MASS CUSTOMISATION IN B-TO-B CONTEXT

Mass customization was envisioned as a production method of the future as early as 1970 (Tofler, 1970), and this development was given a name in 1987 (Davis, 1987). However, it was only after Pine (1993) wrote his best-seller book on this subject in 1993 that mass customization strategies began to form a part of corporate business strategies on a large scale. Part of the reason for this was the strong development during the 1990s in the information and communications technologies, which - to a great extent - are what have made the cost-effective adoption of various customer-focused mass customization strategies possible.

The significance of mass customization for the economy of the future has even been characterized as a revolutionary, which is comparable to the change from craft-type production strategies to mass production at the dawn of the 1900s. Whether true or not, the significance of mass customization should not be underestimated, since as the change progresses it will have an increasingly large impact on the competitiveness of most of the companies and business sectors. This development is above all an opportunity for countries with high production costs and distant location from markets, since a product tailored to the customer produces unique added value, in which case the primary factor in the product purchasing will no longer necessarily be the price. On the other hand, by using mass customization strategies this added value can be produced both cost-effectively and with a rapid delivery time (Salvador and Forza, 2004). In addition, the adoption of mass customization strategies often require a high technology production environment, which favors advanced industrial cultures such as Finnish technology industries.

This paper seeks to tackle two main biases in extant mass customization literature that is, too few empirical studies and lack of business-to-business focus (Da Silveira et al., 2001; Åhlström & Westbrook, 1999). Multiple case study of 40 companies was conducted as a

part of a larger research and development project, concentrating on ICT-enabled mass customization opportunities in Finnish technology industries. Overall, the Finnish technology industries are characterized by short production series, product customization and advanced production technologies. Industry is also characterized with high labor and production cost, small internal market size and remote distance from biggest markets. These qualities make the Finnish technology industries an interesting context of research for mass customization possibilities and potential in highly developed industrial countries.

The preliminary results suggest that although the mass customization as a term was not always identified by the firms themselves, mass customization strategies and practices are utilized widely in Finnish technology industries. The need for mass customization is mainly rising from difficulties to manage product variations and the pressure to shorten the delivery times and to decrease costs. As contradictory to most of the mass customization literature, mass customization was mainly approached from custom manufacturing side, and not from mass production side. However, exceptions were present. This is why the main benefits were also seen differently. The main continuing challenges found were the cross-functional cooperation, product configurators and integration of different information systems.

The rest of the paper is divided to sections as follows. In Section 2, the research setting is described. In Section 3, key steps in a way toward mass customization approach are described, as identified in the case companies. In Section 4, the overall state-of-art of mass customization strategies in Finnish technology industries is described. Section 6 concludes the paper with discussion, conclusions and future research recommendations.

Research settings

Research context

The multiple case study reported in this paper is conducted as a part of a both publicly and privately funded research and development project concentrating on mass customization opportunities utilizing information and communication technologies in Finnish technology industry. At the time of writing, the study is still ongoing and no final results have achieved. However, a level of saturation was evaluated to be breached and thus some tentative results can be addressed.

The Finnish technology industry is extremely important as a research context in Finnish settings. It was selected as the development of competitiveness is particularly important in the technology industry, whose future development will also have a significant impact on the entire national economy, both directly and indirectly. The technology industry is not only the Finland's largest industrial sector, accounting for 59 % of exports, but also counts for no less than 84 % of all research and development investments in Finland.

Objective of the study was to outline the development paths of the Finnish technology industries focusing in to find out the state of art in mass customization practices in each company. The purpose of the interview study is also to use this information base in identifying general development challenges, problem areas and development potential, in

order to create a roadmap for the development of mass customization strategies in the technology industry.

## Research method

Multiple case study method was selected because it has many advantages in this kind of research context. One of the reasons was that mass customization is still an emerging concept unfamiliar to most of the companies. A survey as a research method would have produced very distinct results difficult to interpret. In this kind of research settings only case study method can produce sensible results. This is because in the interview situation researcher can interact with interviewed person(s) about subject and used concepts and a common understanding can be created. Multiple case study method (Cunningham, 1997; Eisenhardt, 1989) was required to be able to extend our knowledge among individual cases and create an outline of situation in technology industries. Furthermore, results from multiple case study are considered to be more convincing than from single case study (Yin 1984).

At the time of writing, empirical data of the study was collected from 34 Finnish companies. The target level of interviews was set to 40 in the beginning of the study, but saturation level was evaluated to have reached after about 30 cases. The study reported in this paper consist 34 in-depth company visits, interviews and related documents with 70-80 directors or managers. Company theme interviews were done between October 2006 and April 2007. Typically the representatives of these companies were production managers, product development managers, product managers and/or sales managers, in most cases more than one of the before mentioned managers at the same interview. The enterprises selected the persons internally after the phone/email contact from researchers.

The interviewed companies were selected by research team. A representative sample of companies was first listed by researchers, altogether about 40-50 companies. Experts of Technology industries of Finland screened the list to check the comprehensiveness and appropriateness. Then the companies were orderly contacted to get permission for an interview. With only a few exceptions almost all companies agreed for an interview. Both large enterprises and SMEs were included in the study as well as both brand owners and sub-contractors. The volume of production varied from 10 units to 8,000,000 units per year. Some companies applied built-to-order production; some manufactured finished or semi-finished products to stock.

Case companies were selected by using theoretical sampling. According to Eisenhardt (1989) theoretical sampling can be used, when researcher wants to replicate study, expand created theory or when researcher wants to fill theoretical categories or to give examples of polar types. The companies were selected to fill different categories of product types and production volumes. For each selected company a counterpart with similar product/volume features was selected to find out possible differences and similarities in mass customization practices.

The process of conducting interviews

After initial contact and agreement for interview, an outline of topics covered in interview were sent via email for interviewees few days in earlier for mental preparation. This outline of topics was carefully planned by research team to cover all the most important topics of mass customization. The objective was to be able to sketch a blueprint of mass customization practices and variations of practices in different environments from interview data. In the actual interview session the outline was not followed slavishly; the aim was to let the discussion roll on its own to get the richest description possible and to get a company specific development story. However, researchers guided the discussion a little bit in order to cover all items listed in interview outline. Items included structured, semi-structured and open-ended like of issues.

In practice, all of the interviews were done during company visits. Most of the interviewees were from middle management, although both members of top management and product/process owners were also present. From 1 to 4 managers were present per company and most commonly there were 2 managers present. Altogether 70-80 managers were interviewed in this point.

All interviews were recorded to be able to recall the content of discussion in later phases of research. Despite of the recording, interviewees were very open in sharing information and discussing about their operations, strengths and weaknesses and even to show around the factory floor. Open yet confidential discussions were possible because among interviewees existed a strong trust for researcher not to misuse the interview material, which was attributable for good reputation of research institutions among companies.

In all interviews a minimum of two researchers were present to ensure validity of interpretations. In addition, the interview reports were sent to interviewees to double-check for misinterpretations and correction of clear mistakes. Also, a total anonymity was guaranteed for companies so that only aggregate results would be published straightforwardly.

## ROADMAP TOWARDS MC

### Roots in industrial history of companies

In this point of study, some tentative analyses can already be presented, although analyzes of data are still continuing. The data show that there seems to be some typical features in development of mass customization practices in Finnish business-to-business environment. The primary observation in different company interviews concerning their MC practices is the tight connection into company's industrial history and roots of production development. Only a few of the interviewed company managers had constructed themselves a total framework of advantageous MC utilization and realized the demanding production solutions it takes. In some cases the process was ongoing, but the bottleneck was i.e. in commitment of top management to change the business concept.

On the steps towards MC utilization, the key question of development path seems obviously to be, whether a company has its roots in customer oriented individual

production or in mass production (Duray et al., 2000). In Figure 1, some of the business solutions targeting the effective utilization of MC are described and the paths and elements towards the goal according to collected data.

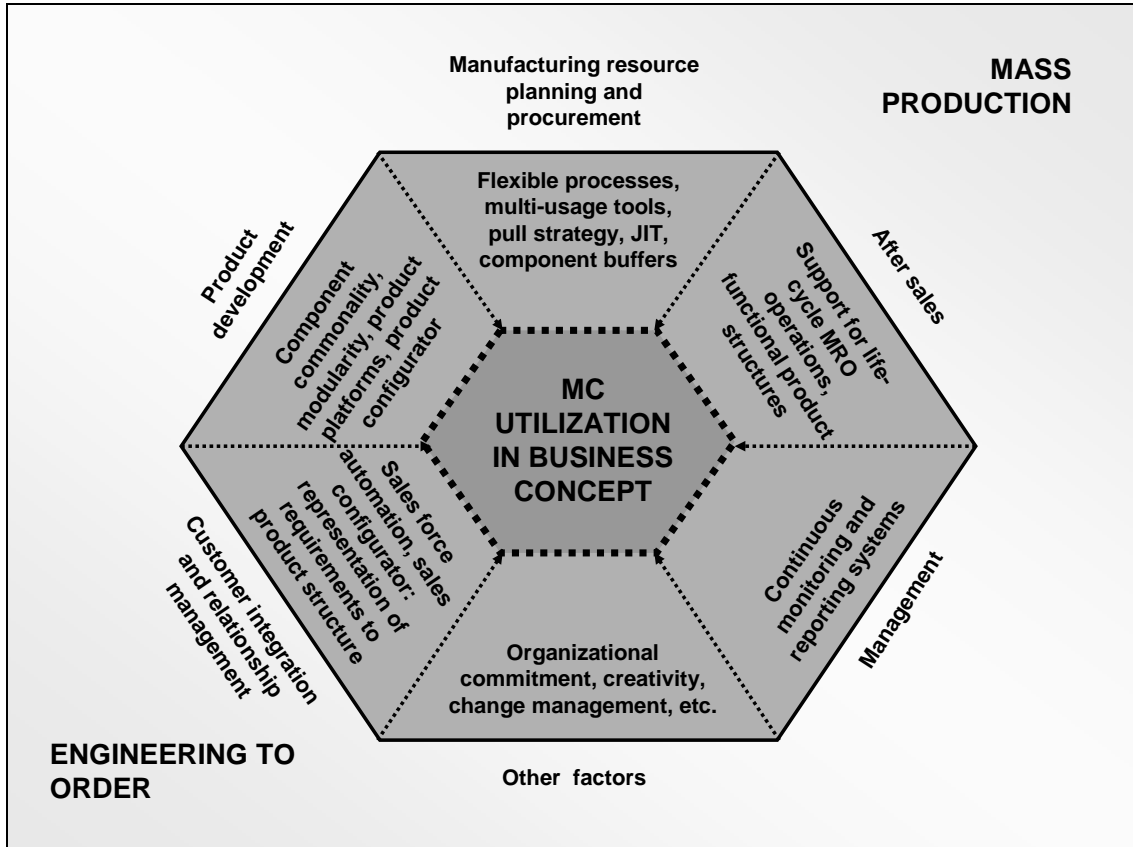


Figure 1: Elements of mass customization.

In next subsections 3.2 – 3.4 the major challenges and development paths of interviewed companies toward MC are analyzed closer. Also, some practical examples are given about solutions the companies have developed in their way toward MC from either a mass production or an engineering-to-order production background.

### FROM ENGINEERING TO ORDER PRODUCTION TO MC

In companies with background in unique engineering-to-order production and trend in growing volumes and demands by their customers, the question of make-or-buy capacity becomes acute quite quickly. Also, in global business environment one of the major tasks in keeping competitive positions is concerned with decrease of delivery time between business agreements to conveyance of commissioned investment. In engineering-to-order environment this development can be put forward with the parameterization of earlier design solution and building of information banks.

This approach can make the engineering work faster as the re-use of old designs is improved, but it still misses the best benefits of a true mass customization approach. In order to introduce new products and product families, development must start from new product development to create a coherent product structure from the start. Modules interfaces need to be defined clearly so that subcontractors can produce parts and modules relatively independently. An ability to formulate specified demands of purchased components is a classical primary task in outsourcing process, too.

Product development can later integrate new products upon parameterized interfaces basing information bank. Later on there can be build component and production families and also create standardized component libraries. Without information bank and parameterized component specs can a company meet serious trouble in delivery time and network management. Hence; many of the companies have already invested in 3D-dimension software in order to utilize their earlier created and functionally solutions to decrease delivery time and cost level of future coming customer needs. On the same time the parameterized information bank seems also to be one of most successful knowledge collection methods. In too many companies the intangible assets of know-how, like successful solutions, are kept by the most expert personnel themselves. In personnel changing situations this has even turned up into massive information losses, if the core competence is not shared or it is not at all documented.

Another typical challenge among engineering-to-order basing start is to get awareness of cost structure in volume and net sales growing situation. The realistic cost structure i.e. cost information of work hours, investments, raw materials and components; either they are produced by the company oneself or purchased; as well as pricing strategy should be integrated into sale configuration system and manufacturing resource planning. Only a minority of interviewed companies in Finland are yet so far. In too many companies either the sale department can give too tight promises comparing to production resources or the production gives too long delivery times 'for sure'. This was called 'victimizing' by interviewed; either a production or a sale department inside the same company felt themselves in a victim position because of each others unrealistic promises or too tight limits.

The other challenges starting form engineering-to-order bases into MC are concerning typically in creating or developing flexible production lines by moving from cell units into line production or by reorganizing stock policy, like using just-in-time buffers or pull-input stocks. Total reorganization of company's manufacturing streamlines with incoming raw material and out going products is one of the most commitment needed and demanded challenge in practice. For that kind of investment into MC production are needed both the well done preconceptions of market situation and good capacity in accounting by company management and other interest groups.

Without well based information and the needed investment into MC, the delivery time and unit cost challenges can turn up too dangerous for company in growing turn up situation. If the customer satisfaction is decreasing because of too long delivery times and

demanded but not existing capacity, there was seen a great danger of loosing backlog of orders, especially in growing market tendency.

## FROM MASS PRODUCTION TO MC

On the other hand; if a company has its roots in mass production, they have had usually the main difficulties in variation management and unit cost accounting, when they have moved their production into MC. In earlier times unique solutions were not as common as they are today. For customer needed demands can be done too many tools or components that can not be utilized in any other cases. In the beginning of MC production it seemed to be natural to loose some investments in these unique solutions.

Hereby, the profitability can have losses and i.e. a value of component or unaccomplished storage can grow too high in company's balance sheet. In order to assist these companies, the cost analyze is needed beside maybe new solutions in stock management and in network cooperation. Anyhow, the company should learn from its earlier mistakes and develop more flexible way of production.

The management of different variations should also be based in target oriented consumer procurement and also in parameterized component library. Custom made solutions by successful companies were usually produced in quite light format by using product and component family strategies. This was possible when the production platform was carefully planned beforehand. Most of the required custom accessories could be integrated into a product, but also pricing policies were used to manage the too wide variation of complexity.

So far, the business potential included in lifecycle services doesn't seem to be utilized very well. Depending upon the product, the role of maintenance, repair, and operation (MRO) planning is increasing. The phenomena was already well known by many interviewed managers, but after sale service development in company's strategies were quite often still in development process. One problem with MRO-operations was that product data was stored from production's point-of-view, not from functional point-of-view that repairers needed.

## FINE TUNING OF MC CONCEPT

The difference between products and needs of customers even in business-to-business environment can be produced when the different it-systems of company are adequately integrated to support entity. Just the configuration system building between different kind of company's information software and data basis seem to be the major challenges of the most developed companies in adapting MC in their business concept.

In most of the cases, the sales configurator was at least planned to be implemented in near future. However, this wasn't seen as a non-problematic development. According to interview data, the basic reason for difficulties was to match customer needs to functional requirements and then to product qualities as the relation from one to another is hardly ever simple. In many cases the linkage between different it-systems was build by using

MS Excel –software or other basic tools. Use of this kind of basic tools was a sort of surprise as markets are full of really well operating ERP, PDM, CRM systems. The integration of different systems and different data sets was found to be one of the biggest challenges among developed utilizers of MC too.

Beside the need of company’s it-system development there is another challenge quite equal for most developed MC users; it is to get the network management operating in a way supporting the MC operations. The entire delivery time of the end production is subordinated by the weakest link in supplement chain. Therefore; there are strong interests to develop the MC business concept ideology together with network concept in the next coming years.

## THE STATE OF ART IN MASS CUSTOMIZATION PRACTICES

### Characteristics of the study population

After 34 case interviews some overall yet tentative results can be addressed as the major tendencies seems to have emerged. Characteristic for interviewed companies was their clear orientation in customer specific production (28 out of 32 classified). The custom-made orientation of the study population was not known beforehand when the research group selected the companies asked to join the study. Neither is it known, how well the study population represents the total population of Finnish business-to-business manufacturers. However, it must be acknowledged that practices used to deliver this custom-made orientation varied. Most of the companies analyzed in this paper utilized at least some mass customization principles, but some of them could better be characterized as engineering-to-order manufacturers.

The yearly volume of production varied from 10 to 8 000 000 units delivered. The unit price was reversely interdependent on amount of volume, although some variance appeared. Also, most of the companies operated under their own brand and controlled the total process while only a minority classified themselves as component suppliers. Four companies had their core business in design operations together with either component manufacturing or project management responsibilities (see table 1).

Brand owner		Volume		Custom-made		Role of operations	
Yes	21	1-1 000	9	0% - 25%	2	Design+	4
No	9	1 000-10 000	11	26% - 50%	1	Component manuf.	5
Both	3	10 000-100 000	4	51% - 75%	1	Assembly	5
		> 100 000	7	76% - 100%	28	Entirety	19
N/A	1	N/A	3	N/A	2	N/A	1

Table 1: Characteristics of interviewed companies, n=34

Changes in business environment

Most of the interviewed companies were also asked about the major changes in business environment. According to the collected data the most important changes in business environment mentioned are the increasing demand level of customers and the shortened cycle of changes in customer needs. Customers also in business-to-business context are nowadays felt to behave more actively than before. To respond to this demand the companies in this study are in principle willing to produce more customized solutions. In this questionnaire set was asked also, if the life-cycle of single products has shortened remarkably. The answers were polarized almost half and half, just a tight majority disagreed on research question and minority agreed on it (see table 2).

Research questions	Yes	No	Don't know
Customer needs are changing faster than before	17	5	2
Customers are more demanding	19	3	2
Demand of customized products has grown	16	5	3
Company will seek to increase customizability of products	15	6	3
Life-cycle of products is shorter	10	13	1

Figure 2: Identified changes in business environment, n=24

The expected advantages from implementation of MC

The most important reason to apply mass customization practices was the purpose to shorten both throughput and delivery time. A very tight competition together with an extra transaction time caused by long distance from markets was very often mentioned among the main factors in utilizing MC production. The gap between Finland's geopolitical position in Northern Europe and the growing markets of South-East Asia and in South America is strongly pushing Finnish industry into modern solutions. About half of the study population was pointing out the chance to shorten the delivery time of products when they were asked about their companies' keenest interest in MC utilization (see table 3).

Pursued benefits from mass customization (n=34)	
Shortening the delivery/throughput time	18
Variation management	12
Cost reduction	9
Flexibility/efficiency of production	9
Operational control	8
Customer intimacy	7
Automation / speed-up of design	6

Table 3: Pursued benefits from mass customization (n=34)

The number two on the list of the expected advantages was a need to control and manage the great number of custom variations. About one third of interviewees mentioned this factor. It was typical for the companies producing capital investments with guaranteed spare part deliveries and after sale services for entire life cycle of the product, which could span over next 10 or 20 years.

The other purposes mentioned by interviewees were closer to each other in frequency. The other expected advantages were decreasing unit costs, increasing flexibility and efficiency of production, and operational control. Interestingly, increasing custom intimacy didn't appear in the top of the list, perhaps a result of long production tradition close to customer. Also, the objective of speeding-up and increasing the automation level of engineering work is mentioned; an objective more important to companies doing heavy custom production.

#### Current state in mass customization practices

Blecker & Abdelkafi (2006) identified seven design practices to manage the complexity and variety: component families, component commonality and process commonality as a required steps before product and process modularity, product platforms and finally delayed differentiation. First three steps were largely in use in the study group, the following product and process modularity were somewhat utilized but product platforms and delayed differentiation were scarcely used.

Compared to craft customization approach, interviewed companies have a clear goal towards standardization of components and modules but at the same time, toward better management of product structures and data (see table 4). However, the importance of delayed differentiation remains somewhat unclear. Many of the interviewed companies have managed to shorten the throughput time enough to make delayed differentiation unnecessary.

	Component families	Component commonality	Process commonality	Product modularity	Process modularity	Product platform	Delayed differentiation
Yes	21	19	21	15	11	5	4
Partly	6	8	5	8	9	7	10
No	6	6	7	10	13	21	19

Table 4: How companies utilize variation management methods, n=33

#### Utilization of configurators in sales

The utilization of configurators varied significantly within the research sample (n = 32). Exactly half of the companies were using configurator to acquire the customer

requirements. The main factors affecting the possibilities of configurator utilization seem to be the product and process characteristics and production volume. The 12 companies that have never utilized nor even planned to utilize a sales configurator, mostly produce non-modular, simple products that can not easily be configured with selectable, distinct options. Also if the production mode still falls into the craft customization category, any utilization of configurators is rare. Interestingly, only one company has reportedly given up on configurator utilization after once having tested it. All the other companies (16 from 32) that have once taken a configurator in use are still utilizing it at least as one of several ordering practices.

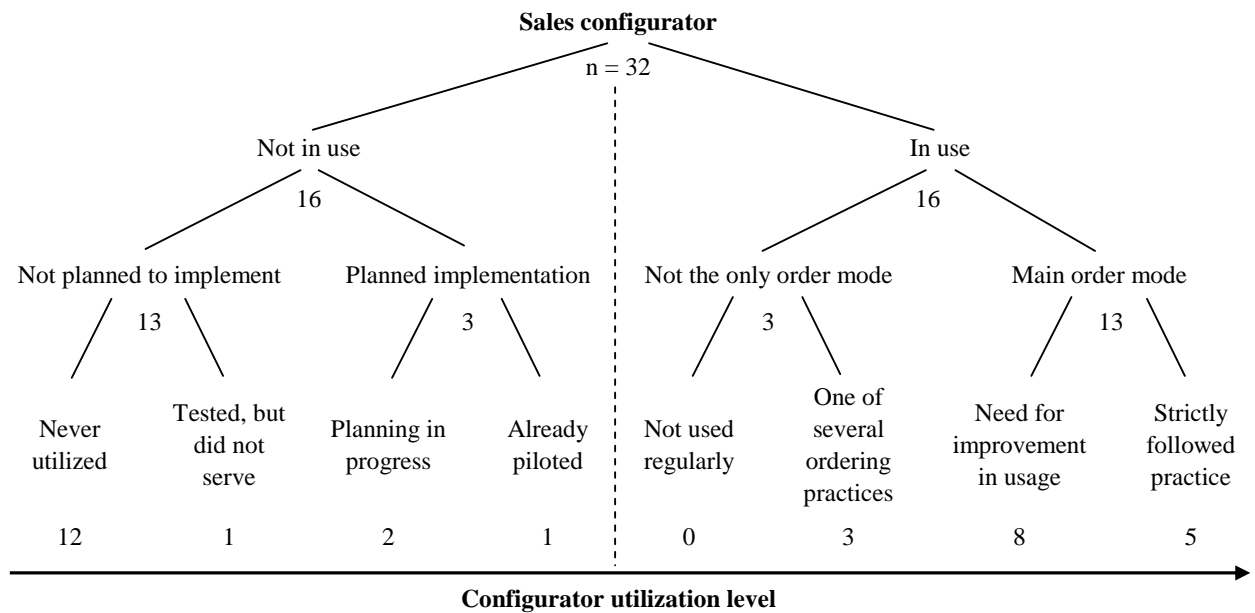


Figure 2: The utilization of sales configurators in companies.

The configuration process was conducted together with customer and sales person, never the customer on its own. However, the role of the sales person varied from entering the customer requirements into the system to creative problem solving of product expert. The configuration process characteristics depended on the complexity of the product but also about how well the rules of configurations were defined. The biggest problem (8 out of 16 users) with configurators was that rules are not followed or the rules are defined too loosely. The free input fields in configurations caused most of the problems. Only 5 companies had succeeded in implementing configurator with such clearly defined rules that they were followed without exceptions.

Well defined configurator was seen to be a clear advantage in applying companies. By representing a limited number of options the product definition process with customer is quite fluent. The customer requirements are matched with product features and options and the order is placed according to this information. Customer requirements are smoothly transformed to product structure, production order and with good IT-integration

all the way to suppliers. Fundamental is the management of product data and well defined product structure with modules/components and their interfaces.

## CONCLUSIONS

One of the primary findings was that although the majority of the interviewed companies utilize typical mass customization solutions in their operations, the concept of mass customization itself is not yet very well-known. The interviewed managers were more familiar with terms like modularity, customer specific production and such. Also, the development of mass customization practices had started in production or product development, but management of wholeness was lacking behind.

The major results are also promising in order to develop systematic in mass customization development program in general. According to the interview results, there seems to be equal steps in adapting mass customization in production. By giving special kind of support for each of the step, there seems to be even faster in productivity development comparing to learning-by-doing path of companies. This is also a promising result for our next and now continuing stage of pilot case development study.

The major results are also promising in order to develop systematic mass customization development program in general. According to the interview results, there seems to be equal steps in adapting mass customization in production. By giving special kind of support for each of the step, there seems to be even faster development paths to productivity gains than learning-by-doing path of companies. The education of business management in national level especially in management of wholeness is needed.

These tentative results describe the state-of-art of mass customization practices in Finnish technology industry. Future research should concentrate more on detailed information how companies can be helped to develop their MC operations in different situations.

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