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Mass Customization as Aided Value Tool in New Product Development Process

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ABSTRACT: Nowadays, intensive market competition brings new strategies of manufacturers and retailers as is mass customization, or the indvidualizing of standard products and services to meet the specific needs of each customer. Mass Customization (MC) is the result of a more self-aware type of customer who demands more choice and more involvment. Small and medium enterprices , through their flexibility advantages and closeness to customers, potentially can increase their sales volume in economic downtourns. Smaller firms and those producing made-to-order products were most likely to have realized increased sales volume. Small and medium enterprises competitiveness is based more on working closely with customer to produce fully customized products.

KEYWORDS: Mass Customization, Customized Products, Configurators, New Product Development.

I. INTRODUCTION

With the increasing competition in the global market, the manufacturing industry has been facing the challenge of increasing customer value. Mass Customization is the result of a more self-aware type of customer who demands more choice and more involvement. Companies operating in a demanding environment may need to react by providing flexible manufacturing systems, but these systems exclusively are not enough to offer variety without compromising on profitability [1]. Customer co-design and integration is the key to mass customization [2]. This is the core element that differentiates mass customization from other strategies like lean management or agile manufacturing [3]. With today's information technology, mass customization customers can be included into the value creation chain by defining, configuring or modifying an individual order. Though an interactive website customers can configure specifications of the product or service, packaging and even delivery options. The use of build-to-order methods, where an item is not constructed until an order is received, is an important factor in minimizing the cost of a customized product. Mass customization is a reality because it is an attractive strategy for both manufacturers and customers. Producers are able to reduce their inventories and manufacturing overhead costs, eliminate waste in their supply chains, and obtain more accurate information about demand [4]. Including the customer in the product design also establishes an individual contact between the manufacturer and customer, which offers possibilities for building up a lasting relationship [5]. Mass customization technologies make it possible for companies to create a cost efficient value chain, while increasing flexibility towards answering customers' needs from heterogeneous market demands. In this way, companies pay more attention in delivering products and services, and, instead of focusing just on acquiring new customers, they concentrate on building lasting relationships with the existing customers. Involving customers into the company's value creation process increases their sense of contribution in the end product and brings real first hand customer knowledge.

Small and medium enterprises through their flexibility advantages and closeness to customers potentially can increase their sales volume in economic downturns. They comprise most of the world's manufacturing sector. Small and medium enterprises competitiveness is based more on working closely with customer to produce fully customized products. In addition to feeling intense pressure from low-cost international competitors, these organizations have to deal with rising raw material cost, customers demanding high quality service, support, and product variety. In addition

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an overview of the mass customization concept is given, as well as explanation of the implementation of some aspects of mass customization strategy in small and medium enterprises, on the example of a furniture producer.

II. BACKGROUND - CONCEPT OF MASS CUSTOMIZATION IN SMALL AND MEDIUM ENTERPRISES

Mass customization can be achieved through product line rationalization, modularity and part standardization, using internet catalogues and order entry, supply chain design; even lean manufacturing can be an entry in mass customization. In today's world of business where the customer is most important and business products and services are more likely to be customized to fit the needs of the customers, it is highly critical that even small businesses learn to adapt and include customization in their offerings.

Small and medium enterprises, are already adopting variations of the mass customization concept. In order to analyse SMEs from the angle of mass customization we must determine the scope of these companies and what we mean when we say small or medium company. Many countries in Europe have their own definition. However there are recommendations from the European Commission used to determine the size of the company. By these recommendations [6] there is also a subcategory of small companies called micro enterprises consisting of 10 or less employees (Table 1). Enterprises qualify as micro, small and medium-sized enterprises (SMEs) if they fulfil the criteria laid down in the Recommendation which are summarized in the table below. In addition to the staff headcount ceiling, an enterprise qualifies as an SME if it meets either the turnover ceiling or the balance sheet ceiling, but not necessarily both. All enterprises whose headcount, turnover or balance sheet total exceed these numbers are referred to as large enterprises.

Table 1: Micro, small and medium enterprises as given in recommendations of EU Commission [6]

Enterprise category	Headcount	Turnover	Balance sheet total
medium sized	< 250	≤ €50 million	≤ €43million
small	< 50	≤ €10 million	≤ €10million
micro	< 10	≤ €2 million	≤ €2million

Due to the highly competitive marketplace, small businesses may need to develop a niche strategy such as customization, which may become even more important in small and medium businesses than larger ones. Also, in many cases, the smaller businesses can more easily adapt and make changes to effectively implement the customization concept. The strategy of customization seems to offer small businesses a niche and a competitive edge in the marketplace. Even some larger companies are repositioning themselves as small business units so as to effectively benefit from the implementation of customization in their companies [7].

In today's markets, small companies are better suited and more quickly able to implement customization to meet their many fickle-minded customers who possess increasing control and are looking for endless options. It is easier for the small and medium enterprises to contact with their customers and build a good relationship with them. Because of that, these enterprises can produce customized products including their customers as co -designers.

Using some of the mass customization strategies like using internet catalogues and order entry, small and medium enterprises are competitive manufacturers on the market. Their main goal is satisfying customer needs and increasing their profit. Table 2 shows some advantages and disadvantages of SMEs in implementing mass customization.

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Table 2: Advantages and disadvantages of SMEs

	Advantages	Disadvantages
SMEs	Adaptability to trends	Limited resources
	Adaptability to change in demand	Difficulties to develop specific competence for low to medium technology
	Close customer interaction	

Besides direct advantages in MC, SMEs also have their advantages in economic, social and environmental spheres of business like relationships with customers, cultural identity, aesthetic awareness, etc. SMEs are able to exploit local niches and maintain diversity in available products, understand local tastes that foster craftsmanship, create greater social equity that humanizes relationships in buying and selling (building community), provide culturally sensitive options that empower marginalized groups, and from the environmental aspect, having shorter transport distances, they reduce pollution, as well as human risk. Maybe some of these advantages will be the reason that SMEs will be the future of the Mass Customization. In today's competitive business environment, where the customer is the most important, and products and services are more likely to be customized to fit the needs of the customers, it is highly critical that small and medium businesses learn to adapt and include customization in their offerings.

What do SMEs need to do if they want to become mass customize? Some of the next steps could be taken [9]:
1) Development of product configurator that can be a sales configurator or back end configurator, which is used with the mediation of an expert;
2) Increased automation – in the phases where it is purposeful;
3) Dealing with solution space – defining the production program that can be successfully produced with existing production equipment;
4) Increase in production volume - introducing new technologies in manufacturing and organization of production;
5) Replacing particular technology systems with CNC systems;
6) Introduction of IT systems for the successful management of data - PDM or PLM;
7) Developing of product platform and product families.
Aware of the existence of limited resources to implement MC, comparing to large enterprises, SMEs improve the three capabilities necessary for MC (solution space development, robust process design and choice navigation), by strategically focusing their resources on the capability where an investment would have the greatest effect on overall competitiveness, without trying to lift all three on the highest level. Capitalizing on economies of scope (the expansion of new business activities with current customers) instead of economies of scale (the expansion of current business activities in the marketplace) will allow a small organization to implement and benefit from mass customization [10].

III. PRSENTATION OF THE MAIN CONTRIBUTION OF THE RESEARCH

This research is focused on the possibilities of implementation of some aspects of mass customization by furniture producers during the process of new product development. An approach to measure customer preferences within the context of mass customization is introduced, using the methodology for product family positioning and analysing the results. Developing product families has been recognized as a natural technique to facilitate increasing complexity and cost-effective product development [9]. In this regard, the manufacturing companies put their effort in organizing, developing, and planning product families to balance the tradeoffs between product diversity and engineering costs.
Mass customization aims at satisfying individual customer needs with the efficiency of mass production [Pine]. To optimize the product variety, a company must assess the level of variety at which customers will still find the company's offerings attractive and the level of complexity that will keep the costs low [11]. The problem of defining customer profile and the knowledge necessary for performing customizations is elaborated in [12]. The problem of identifying customer needs can be solved by applying market research which contains all of the offered product combination in a product family. Not all the existing market segments create the same opportunity for the companies in the same industry due to the discrepancy of their targets, strategies, technologies, cultures, etc. Therefore, it is most

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important for the manufacturing companies to make the decisions which market segment should be targeted and what products should be planned for the target market, namely, product family positioning.

IV. PROPOSED METHODOLOGY AND DISCUSSION

A. MEASURING CUSTOMER PREFERENCES

Measuring customer preferences means identifying a set of product attributes, $A=\{a_k \mid k=1,...,K\}$, which company can produce it. Each attribute has a few levels, $A_\kappa^*=\{a_{kl}^* \mid l=1,...,L_k\}$, the product family is a combination of these attribute levels, $Z=\{\bar{z}_j \mid j=1,...J\}$. Each product is defined as a vector of specific attribute levels, $\bar{z}_j=[a^*_{klj}]_K$, where any $a^*_{kl\,j} \neq \emptyset$ represents an element of the set of attribute levels that can be assumed by the product, $\{a^*_{klj}\}_K \in \{A_1^* X A_2^* X ... X A_K^*\}$ and any $a^*_{kl\,j}=\emptyset$, represents that the product does not contain some of the attributes [15].

The product family which is positioned, A, is a set of a few selected product profiles, $A=\{\bar{z}j \mid j=1,...J'\} \subseteq Z$. Every product is associated with certain engineering costs, denoted as $\{c_j\}_J$. The company has to make decisions about the price of its offered products, $\{pj\}_J$. The market today has multiple segments, $S=\{si \mid i=1,...,I\}$, each of them contains homogeneous customers. Product demands of the market, $\{Pi\,j\}ixj$, are described by the products which the customers choose, denoted as customer or segment-product pairs, $\{(si, \bar{z}j)\}_{i\,x\,j} \in S\,X\,Z$.

The modelling of the price is to treat price as a separate attribute that can be chosen from a limited number of values for each product [16]. Adding price as one more attribute, the attribute set becomes $A = \{a_k\}_{K+1}$, where a_{K+l} represents the price possessing a few levels, $A^*_{K+l}=\{a_{(K+l)l} \mid l= 1..., ,L_{K+1}\}$.

Measuring customer preferences helps companies to predict customer needs at different market segments. Next, is presented measuring customer preferences with example of a product family with its attributes and attribute levels.

B. DEFINITION OF THE CONFIGURABLE PRODUCT ATTRIBUTES

Considering that the company produces mainly sitting furniture, it is going to be the product family of the focus. At the beginning, it is necessary to define attributes and attribute levels, which are presented in Table 3 and include: material, mechanism, armrest, as well as price [11].

Table 3: List of product attributes and their levels

attribute (a_κ)	a_{kl}	code	attribute level
material	a_{11}	A1-1	skin
	a_{12}	A1-2	eco- skin
	a_{13}	A1-3	toile
	a_{14}	A1-4	combination skin-toile
	a_{15}	A1-5	combination eco skin-toile
mechanism	a_{21}	A2-1	sitting
	a_{22}	A2-2	sitting and sleeping
armrest	a_{31}	A3-1	whit armrest
	a_{32}	A3-2	without armrest
price	a_{41}	A4-1	30 000-50 000 mkd
	a_{42}	A4-2	50 000-70 000 mkd
	a_{43}	A4-3	70 000-90 000 mkd

The generic structure of the sitting furniture product family is presented in Figure 1. The first level represents the selected product family, the second level are the key attributes of the product that can be customized and the third level

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are the attribute levels, or the possible variants of the key attributes. In this way a configurator can be developed for the selected product family of this company. All the variants are offered to customers with proper visualization, which makes their communication with company more efficient. Graph theory can be used to support configurator development.

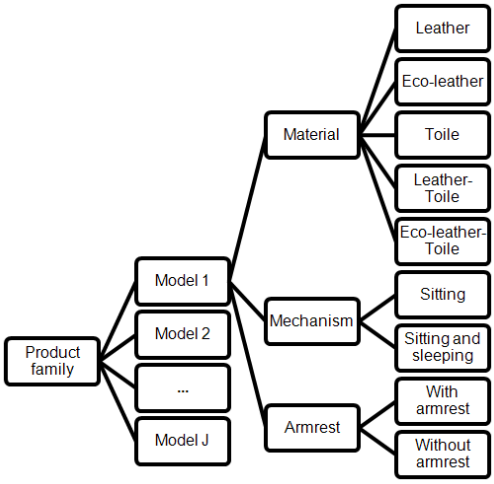

Figure 1: Generic structure for the selected product

C.MEASURING RESULTS

For exploring customer requirements, a survey was done with interviews of twenty customers in order to assess their requirement. Each of interviewed customers selected to act as the respondents is asked to evaluate all 20 profiles one by one with a requirement scale from 1 to 5 (1 means the least, 5 means the most).

Analysing these data, customer segments based on the similarity among customer preferences are found and two segments of customers are formed: s1, and s2. The first one (segment s1) represents home users (customers which buy furniture for their home) and the second segment (s2) represents business users (customers which buy furniture for their business needs). Product family positioning optimizes both a mix of products and the configurations of individual products in terms of specific attributes.

This research allows products to be configured directly from attribute levels and the analysis is used to quantify the customer preference. On the figure 2, there are represented the results for customer preferences to each of the 28 product profiles, as average for both segments of customers.

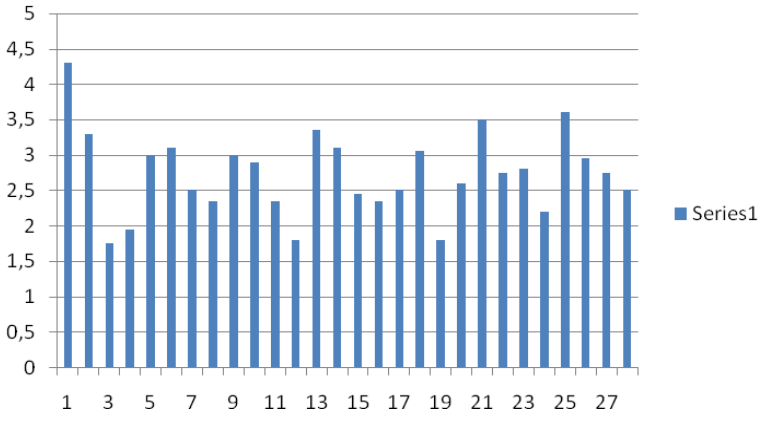

Figure 2: Customer preferences for each of the 28 product profiles

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On the figure 3, there are given the differences in products' assessing between two customer segments, home oriented s1, and business oriented s2. According to analyse done in this research and results from customer requirement assessment, it can be concluded which are the preferred products from market site and the company should oriented to produce in large volume. Defining customer requirements is the first step for implementing mass customization strategy in small and medium enterprises in order to include strategy that will introduce the competitive advantage and profit grooving.

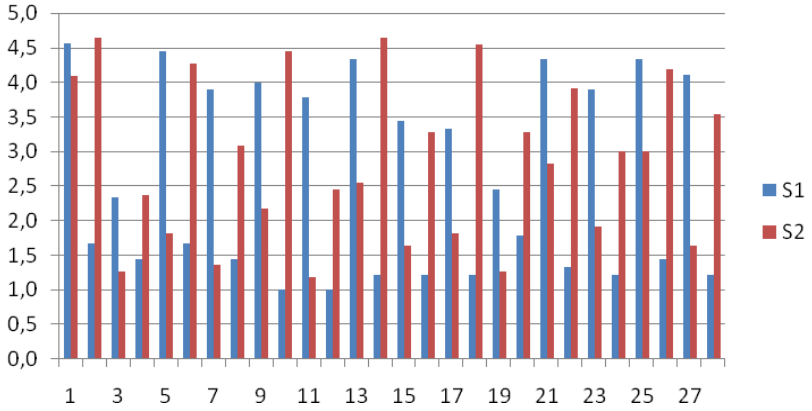

Figure 3: Differences between the customer preferences in both market segments s1 and s2

V. EXPERIMENTAL RESULTS

A.GRAPH THEORY IN PRODUCT CONFIGURATION

Graph theory is the study where mathematical structures are used to model relations between objects from a certain collection. Product configuration can be realized using the model based on graph theory. This model based on the graph theory is represented on the Figure 4, applied for making choice decisions for different product variants for furniture product analysed.

With the implementation of this model for product configuration, the simpler and more efficient communication with customers is enabled, that brings benefits to both sides, for customers and for company.

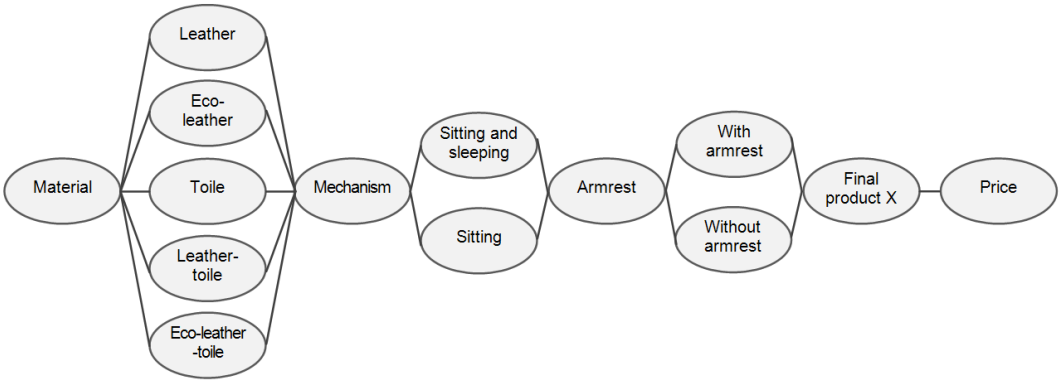

Figure 4: Configuration model for different product variants

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Considering that the configuration model for the product family is created, based on market research previously made, it is possible to represent examples of product variants that are chosen by the customers. The choice for the first product variant that is shown as the most preferred is given on the Figure 5.
This represents an oriented graph, which shows the path, or the customer's choice of the variants offered. The path on the graph shows the chosen product variant with previously represented attributes. Configured product is described with the following path: material (leather) – mechanism (sitting) – armrest (with armrest) – final product 1 –price.

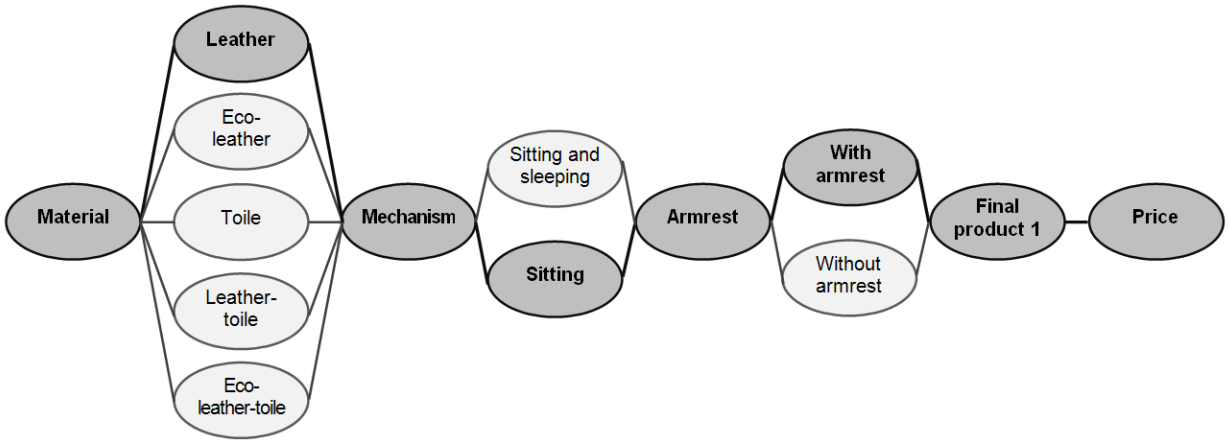

Figure 5: Configuration for the most preferred product (variant 1)

B.WEB-BASED CONFIGURATOR

Configurators are information systems that support the specification of product individuals and the creation and management of configuration knowledge, therefore being prime examples of information systems supporting mass customization. The configurators have been used in different companies to help the customers to create the product they need.
One example of furniture product web based configurator is given on the Figure 6. Customers can make changes to the standard product only where the production process allows it. These changes are the potential product combinations which the configurator offers to the customers. Development of web-based configurator enables manufacturers to gather various information about customers. It shows the company which are the main customer needs.

Figure 6: Choosing object and material

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VI. CONCLUSIONS

Mass customization as a future strategy is almost a feature that companies have to offer to keep their customers and coming back for more. Due to the highly competitive marketplace, small and medium enterprises may need to develop a concept such as mass customization, which may become even more important in small and medium enterprises than in larger ones. The main benefits of mass customization and the use of configurators are: higher profit, a rich source of new ideas, satisfied customers and growing product variety. Defining customer needs is essential for implementing mass customization strategy. To accomplish this, companies have to communicate with customers and make them their partners and co-designers of the final product solution. Considering that mass customization dramatically increases the number of product variants, companies have to establish a model to support product configuration.
Graph theory is represented in this paper as a basis of the model for configuring product variants in a product family. Furniture production is very convenient for implementation of mass customization concept, while there is a suitable production program that allows many combinations of product attributes on different levels. The policy makers responsible for SME development necessarily need a reliable mechanism for systematic follow up and assessment of the condition of the sector. The implementation of some aspects of mass customization and the expertise in this area help its SMEs to achieve adaptability to trends and change in demand, as well as close customer interaction, even though they are characterized with limited resources.

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