DEGREES OF CUSTOMIZATION AND SALES SUPPORT SYSTEMS - ENABLERS TO SUSTAINIBILITY IN MASS CUSTOMIZATION

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Abstract

For more than 20 years, mass customization proofed as valuable business strategy to manufacture goods tailored to a customer's needs with nearly mass production efficiency. After pointing out key characteristics of the MC business model using the product-process change matrix we discuss modular product architectures and process stability with regard to sustainability. As tools for translating customer needs into technical specifications a classification of sales support systems is presented where catalogues, query forms, sales configurators and choice navigation systems are characterized. After this we define as different degrees of customization 'tuning', 'cosmetic', 'set-up', 'composition', 'aesthetic co-design' and 'function co-design' and compare them by their impact on the value chain. Depending on market needs and the over-all business strategy both issues can be addressed as enablers for sustainability in the mass customization business model.

Keywords: Business models and considerations, Complexity, Knowledge management, Sustainability, Mass Customization

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Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

1 INTRODUCTION

In order to compete in today's globalized and heterogeneous markets, manufacturers have to differentiate their offer to meet a wide variety of customer needs. Thereby, it is generally accepted that the customer's desired and perceived diversity as well as the desired individuality of products has to be dealt with a minimum of organizational efforts.

Managing complexity and product variety in the stage of order acquisition as well as in product development and manufacturing is critical to a company's success (Herlyn, 2012). From this perspective, mass customization as a business model gave proof of solving the original oxymoron of manufacturing products tailored to a customer's needs at nearly mass production efficiency.

Part of our research is on the one hand defining and characterizing enabling factors for mass customization and transformation models to shift other business models to mass customization. On the other hand we examine the effects that mass customization and its enablers have on other fields of research like organizational and engineering management. Since mass customization in the context of sustainability is still a relatively new discussion (Pourabdollahian et al., 2014), in this article we discuss the impact of sales support systems and the degree of customization on process stability as key enabling factor to sustainability.

1.1 Motivation

Process stability turned out as a key of success to the mass customization business model in order to reduce waste and errors in manufacturing. There, the impact of contemporary information and communication technologies is generally accepted. E.g., product configuration systems, either sales configurators or design tools in the meaning of knowledge-based-engineering systems, have gained importance. To use these capabilities, a company has at first to define the customization model for the offered products. It is not only depending on the different customer needs, it also has to meet the (manufacturing) possibilities of the company and its value chain. This portfolio of capabilities then has to be presented and communicated to the customer via suitable sales support systems.

1.2 Structure of this Paper

In the following section 2 a brief introduction of the mass customization model is presented, based upon Gilmour, Victor and Pine's Product-Process-Change-Matrix (1993). After the key characteristics are summed up, mass customization itself is depicted as enabler for sustainability. Since process stability is one of the main keys to success of this business model, in section 3 sales support systems are compared and introduced as valuable, effective and reliable translating systems for customer requirements into technical specifications. Afterwards different degrees of customization are set up and reviewed in order to anticipate these requirements resulting from different customer needs in section 4. Closing this paper section 5 contains a brief summary and points out future research questions.

2 MASS CUSTOMIZATION

The term mass customization (MC) was originally coined by Davis (1987) and then modified by Boynton, Victor and Pine (1993) as the ability of combining product variety with the production efficiency of mass production. Taking into account that only the customer himself is able to formulate his specific needs and requirements, Piller (2004) suggests that "MC refers to a customer co-design process of products and services, which meets the needs of each individual customer with regard to certain product features. All operations are performed within a fixed solution space, characterized by stable but still flexible and responsive processes".

2.1 Product-process change matrix

The product-process change matrix introduced by Boynton et al. (1993) has to be understood as framework or business typology (Figure 1). There, product change focuses on the demand for new products and services whilst process change involves all procedures and technologies to develop, market and manufacture them.

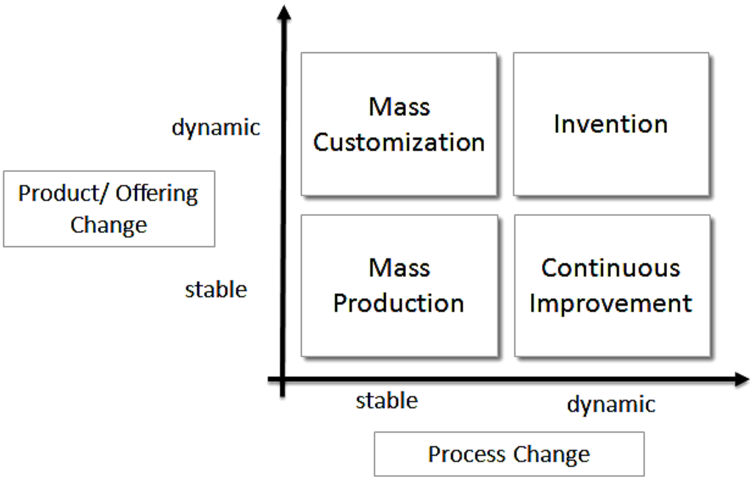

Figure 1. Product process change matrix (acc. to Boynton et al. 1993)

Both categories of change can either be stable or dynamic. The first is slow and foreseeable; the latter is fast, revolutionary and in general unpredictable. Within the fields of the matrix the four basic business models invention, mass production, continuous improvement and mass customisation are differentiated.

Invention refers to organic or job-shop design, where permanently new products and the according processes for development and production are invented which have to compete in market through differentiation. After the product developed to a certain degree of maturity and market transformed to mass market, **mass production** evolves. There, economies-of-scale are in focus so that the manufacturing process has to be kept stable. Boynton et al. point out, that there exists a critical synergy between invention and mass production since the mass production model is incapable of developing completely new products and the invention model has to deliver new products and processes to the mass producer.

The third business model is labelled **continuous improvement** and is based upon the improvement of processes and product quality while reducing costs. Known approaches are TQM and kaizen (Reichwald and Piller, 2009).

Mass Customization is the fourth business model where dynamic stability is focused which means that customer specific products can be tailor-made by the use of flexible but stable processes. In order to become a mass customizer, a company has to transform its business model along the so called *right path*. This means that all business models have to be traversed without skipping any; especially the transformation from mass production to MC cannot be done without continuous improvement since the mass production processes cannot stand the high change ratio and flexibility of mass customized goods.

2.2 Key Characteristics of a Mass Customizer

One of the major characteristics of the MC business model is its ongoing capacity "to produce product variety rapidly and inexpensively. In direct contradiction of the assumption that cost and variety are trade-offs, mass customizers organize for efficient dynamics" (Boynton et al., 1993). To do so, all material and information flows have to be organized in a network structure of generic, reusable, flexible and modular units. Pine (1993) points out that it is essential not to pre-engineer or pre-align those units to some single known end product but to reflect the realizable portfolio of capabilities. A detailed compilation of key characteristics is shown in Table 1.

Focussing on customers and customization, Piller (2004) as well as Böer et al. (2013) identify four very basic statements for a mass customizer. Since the **customer has to be integrated** into value creation, certain tools are needed to allow the formulation of requirements and configuration of the individual solution. At second **customization options** have to be identified to efficiently satisfy customer needs. Around these, a **stable solution space** has to be developed where the individual solution can be tailored from. The costs must be compatible with an **adequate price** the customer is willing to pay for it (although in comparison to standard products studies show, that consumers usually are honouring customization possibilities by paying premium prices).

Table 1. MC key characteristics (acc. to Boynton et al. 1993)

Change conditions	Constant and unforecastable changes in market demand, periodic and forecastable change in process technology
Strategy	Low-Cost process differentiation within new markets
Key organizational tool	Loosely coupled networks of modular, flexible processing units
Workflows	Customer / Product specific value chains
Employee roles	Network coordinators and on-demand processors
Control system	Hub and Web system; centralized network coordination, independent processing control
I/T alignment challenge	Integration of constantly changing network information processing/communication requirements; interoperability, data communication and co-processing critical to network efficiency
Critical synergy	Reliance on continuous improvement form for increasing process flexibility within processing units

2.3 Mass Customization as Enabler for Sustainability

To relate MC to sustainability a work definition for sustainability is presented. Compiled from a lot of definitions and sustainability models (refer e.g. to Henriques et al. 2004 and Bell et al., 2008) from our point of view *sustainability is the influence of a value chain on use and regeneration of resources, pollution and environmental degradation in general*.

As regards the influence of MC on sustainability, three basic assumptions can be made:

1. Waste can be reduced by exactly meeting customer needs
2. Reuse and recycling can be improved by use of modular product architectures
3. Waste and errors in manufacturing can be reduced with stable and agile production processes

Concerning the first, recent studies (as mentioned in Böer 2013) show that customers are willing to pay premium prizes for customized goods but on the other hand product life cycle is longer compared to an equivalent standard product. This might be due to the higher personal value but it also has to be taken into account that reselling customized goods is commonly more difficult since the possibility of meeting exactly the same requirements which lead to the distinct solution is not given in principle.
Another argumentation for higher sustainability due to meeting customer requirements is presented by Reichwald and Piller (2009) as Economies of Decoupling and Economies of Integration. Using the example of clothing industry they show explicitly the reduction of waste and the following cost reduction due to avoidance of discounts, inventory reduction and reduction of theft risk (since goods which only are manufactured on demand are not stored in an inventory or shop where they can be robbed from).

Relating to the second statement, the influence of product architectures on the ability of recycling products is generally accepted. In contrast to integral architectures modular ones allow a separate developing, manufacturing and testing of functional building blocks which then are aggregated to the desired end product (Renner 2007). Wohlgemuth-Schöller (1999) points out, that due to modularity both product life cycle and module life cycle are affected. Regarding the customized product, either damaged functions represented by modules easily can be replaced or obsolete modules can be upgraded. Also, products can easily be refurbished and dealt as second hand goods. Regarding modules, faultless ones can be resold or re-aggregated to new products. Last but not least, Pine (1993) also emphasises modularization as toolset for transformation from the continuous improvement business model to MC. Nonetheless, certain customization strategies do not explicitly require modular product architectures (refer e.g. to *tuning customization* or *cosmetic customisation* below).

On the subject of the third assumption, it is well understood that realizing economies-of-scale due to high lot sizes also has influence on reducing errors in manufacturing due to a high learning curve. Nevertheless, Pine (1993) also considers that changing a production in the mass production business model also might result in machinery getting obsolete. Since mass customizers usually rely on flexible and agile manufacturing systems this risk is reduced.

Since the effects of modular product structures are well understood, we will concentrate on the remaining two statements and examine possibilities of determining customer needs and realize them efficiently by use of different degrees of customization.

3 TRANSLATING CUSTOMER NEEDS INTO DESIGN: SALES SUPPORT SYSTEMS

The application of sales support systems is usually related to either helping sales staff in identifying customer requirements and so to define the product or they guide customers as stand-alone systems through the choice and configuration process within a more or less stable solution space. Key functions of sales support systems are product illustration and decision support (Haubl et al., 2000). For recent development and research on sales support systems e.g. refer to Blum et al. (2007) or Brown et al. (2013).

Note that in this section we do not consider techniques like quality function deployment (QFD) or product clinic since their focus is not on directly supporting customers themselves in formulating their needs and requirements but on support of customer-centric product development (refer to Wildemann, 1998 and Maierhofer, 2004).

Catalogues, either print, on digital media or online, are a very basic but old sales support system. The customer has to be very familiar with the content in order to find his product or he needs to know about the certain part number he is searching for. When some product out of the catalogue has to match to certain requirements, things are more difficult. Usually, there is "extensive information about how one can find the best product for her needs. (…) It usually takes a lot of time to read all the additional information and to decide for a certain product" (Vollrath et al. 1997). In other words expert knowledge is needed; the possibilities of sales support in classical catalogue systems are limited. Furthermore, the maintainability of catalogues is difficult since printed versions or distributed media have to be replaced regularly.

The request or query form assists in surveying of customer needs by using predefined checklists and questionnaires. Usually this form of sales support system is applied by and developed for sales agents in order to make their queries more precise and fitted to a company's offer. In principle, query forms can be used to describe a certain portfolio of capabilities but the formulated customer needs have to be translated into a design specification. It also has to be taken into account that the more complex the product the more difficult and exhausting is the determination process for the customer (Reichwald et al. 2009). The possibility of product visualisation in standard query forms is very limited.

This is different in sales configuration systems. Depending on the visualization technique the product can be shown either as 2D image or 3D model to the customer (Reichwald et al. 2009). Sabin (1998) states that "configuration is a special case of design activity with two key features: The artefact being configured is assembled from instances of a fixed set of well-defined component types and components interact with each other in predefined ways". Since configuration systems are more than just filters applied on the portfolio of capabilities, a knowledge base has to be implemented to define possible combinations of components or restrictions. Usual approaches are rule-based, resource-based or constraint-based paradigms, for a detailed review of configuration systems and different types of knowledge-based systems / expert systems refer to Hvam et al. (2008). As a sales support system the main tasks of configurators are providing a technically complete and correct product specification, commercial quotation costing, automatic generation of quote documents and visualization (Brinkop, 2011). Another capability of current sales configurators is data collection since the system is able to store all information according to the configuration process, i.e. the time for each configuration step, configuration history or abort of configurations. So, these systems can complement activities of marketing regarding trend scouting and preference analysis (Reichwald et. al, 2009). One of the most important characteristics is a sales configurator's ability to translate customer requirements into a valid product specification so that decision support is realized. Nevertheless, if the manifold of configuration items is too big the customer might not be able to choose the right components; Reichwald et al. express this as mass-confusion (2009).

From our point of view, choice navigation systems add a bidirectional communication component to an online sales process. In contrast to the sales configurator a choice navigator is able to guide a customer to a certain popular solution. On the basis of detailed customer information, a recommended default configuration is presented which then can be modified by the user. The idea behind is to use statistical data or data from social networks to forecast customer preferences or take influence on the customer in the sense that “other people who define themselves as stylish or sportive have chosen this or that product”. The inference engines of such systems rely on cased based reasoning so that the system is permanently learning (Sabin, 1998). First experiences with those systems are made in automotive or clothing industry nevertheless research in this context is still in the beginning.

	Catalogue	Request Form	Sales Configurator	Choice Navigator
Decision Support	-	(✓)	✓	✓
Customer Guidance	-	-	-	✓
No Necessity for Expert Knowledge	-	-	(✓)	✓
Direct Translation of Needs into Specs	(✓)	-	✓	✓
Maintainability	-	(✓)	✓	✓
Product Visualization	(✓)	-	✓	✓
Information Feedback	-	-	✓	✓

Figure 2. Characteristics of Sales Support Systems

As can be seen from Figure 2, only sales configuration systems and choice navigators ensure a proper formulation of customer needs and their translation into technical specifications in context of mass customization.

4 ANTICIPATING CUSTOMER NEEDS: DEGREES OF CUSTOMIZATION

In order to meet differing customer requirements the customer co-design process concretizes the product configuration out of the stable solution space. As Böer states, “the goal is to correctly identify the customization options and dimensions meant to satisfy the customer needs” (2013). There are different typologies of customization levels or degrees of customization. Da Silveira et al. (2001) identified eight different generic levels of MC according to different design and manufacturing activities. From our point of view, the degree of customization has to be differentiated by the influence the customer co-design process takes on the manufacturer’s value chain.

One of the most efficient possibilities of adapting products to customer needs is *set-up customization*. As Jørgensen (2011) states, most functional issues of mechatronic devices are provided via software. E.g. the acceleration curve of a combustion engine can be modified by editing the corresponding engine control unit. Another example is the iphone-itunes ecosystem by apple. So, the mechanical part is kept the same but its behaviour is controlled differently by the software component. The process of manufacturing is not influenced and so stable (Gräßler, 2013). Nevertheless this level has an impact to product data management and configuration management since the different versions of firmware and software have to be managed as well.

Regarding *cosmetic customization*, Gilmore and Pine (1997) define that a standard product is presented differently to different customers. In the original specification this addresses commonly the packaging of a product. Reichwald et al. (2009) argue that customer value is not raised noticeably in order to realize competitive advantages. From our point of view, cosmetic customization also allows to change the outer appearance of the product itself to a defined degree which usually can e.g. be realized through another paining. So, this degree of customization only takes little influence on the production process, machining keeps stable.

The standard way of customization which is realized by many companies is *composition customization*. This corresponds to the common assemble-to-order strategy where different sub-

assemblies (in general: buildings blocks) are assembled together to a product using standardized interfaces (Pahl et al., 2013). If the building blocks are set-up as modules their production process can be kept stable which meets the requirements of postponement.
As another degree of customization we define *aesthetic co-design*. Here a customer is not only permitted to select an outer appearance the supplier has defined, he defines it by himself. This is not only limited to modifications of colour and texture, also the shape of e.g. casings can be influenced according to the possible manufacturing processes. Nevertheless, all functional building blocks are kept stable and so their manufacturing processes.
The most far-reaching degree of customization from our point of view is *function co-design*. In opposite to the aesthetic co-design here also the functional building blocks are determined by the customer. This reflects the actual discussion on open innovation (Reichwald et al., 2009) and is still a big challenge to manufacturing companies.
Extending customization to a company's suppliers another degree of customization is possible which we name *tuning customization*. Here a standard product is refined by another supplier in the supply chain in order to adapt the standard product to either special applications or in general to markets with only few customers. One example is the automotive sector with companies like AMG or Quattro. In this model the customer integration can be very high since the standard product can possibly be adapted to all customer needs.

	Impact on in-house engineering	Impact on in-house data management	Impact on in-house manufacturing	Customer Integration Level
Tuning Customization	very low	very low	very low	middle
Cosmetic Customization	very low	low	very low	low
Set-Up Customization	low	middle	very low	very low
Composition Customization	middle	middle	low	middle
Aesthetic co-design	high	high	high	high
Function co-design	very high	very high	very high	very high

Figure 3. Degrees of Customization

Figure 3 summarizes our work on characterising the different degrees of customization and their influence on the value chain.

5 CONCLUSION

For more than 20 years, mass customization proofed as valuable business strategy to manufacture goods tailored to a customer's needs with nearly mass production efficiency. After pointing out key characteristics of the MC business model we discussed modular product architectures and process stability with regard to sustainability. As tools for translating customer needs into technical specifications different types of sales support systems were characterized and rated. After this we defined different degrees of customization and differentiated them by their impact on the value chain. Depending on market needs and the over-all business strategy both issues can be addressed as enablers for mass customization and sustainability.
Future considerations have to refine the impact of customization degrees to a company's processes in more detail. Actual examinations and a running case study are not finally completed yet. Also, other enablers have to be identified regarding the product development organization. Meeting our goal in defining enabling factors for mass customization and transformation models to shift other business models to mass customization, our aim is to provide a Zwicky-Box where manufacturers can identify a set of enablers with a certain characteristic in order to optimize their production and engineering

system. This has to be accompanied by a set of tools and methods like modularization or the use of knowledge-based-engineering systems. We assume that depending of the market situation and the general business strategy patterns can be found.

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