

Chapter 2

PRODUCT CUSTOMIZATION: THEORETICAL BASICS

Manufacturing companies are all different with respect to the way they meet the market demand. Some companies anticipate the customers' demand and deliver end products from their inventory (make-to-stock). Other companies do not keep finished goods' inventories and manufacture or assemble end products only after receiving a tangible customer order. However, producing finished goods to order does not necessarily mean that the manufactured item is tailored to a specific customer's requirements. For instance, a supplier can choose to produce to order when finished goods are connected with high inventory costs. Furthermore, product customization which involves the supplier's value chain, necessarily assumes the delay of some activities of the value chain until the customer puts in an order.

The trend towards product customization that can be observed nowadays is the result of many changes in the business environment. These have enforced many suppliers to revise their production strategies and management concepts. Many literature contributions emphasize that mass production, as a successful management paradigm, leads to success only under specific conditions. Otherwise, it fails.

Pine (1993, pp. 17) ascribes the extensive development of mass manufacturing in the United States in the early 19th century to the homogeneity of the American market. Furthermore, the individual income was equitable and customers had similar needs and requirements. Mass production provides a mass market with goods at a consistent quality and affordable prices. It builds upon main principals that include among others: economies of scale, product standardization, specialization, division of labor, hierarchical organization, and vertical integration. The main goal is to develop, manufacture, market and deliver goods and services at prices which

are low enough to where nearly everyone is able to afford them. Pine (1993, p. 25) speaks about a feedback loop that has characterized the interplay between customers and suppliers. This feedback loop has strengthened standardized products, mass production techniques and large, homogeneous markets. As a result, it was not necessary to offer several product options. For instance, Henry Ford promised his customers to receive any car color they would like to have, as long as it was black.

Mass production was accepted and successfully adopted by many manufacturing enterprises. It builds upon the precepts of the scientific management (Taylorism) and strongly focuses on operational efficiency and productivity. The main objective is to enable mass manufacturers to lower costs and to sell products at affordable prices. Mass production is also favored by a seller market, in which the customers' demand exceeds the offer. In such a market, suppliers are more powerful than customers because they basically instruct their customers what to buy. However, these market conditions have been enormously altered because of several changes that occurred in the economical environment such as input instabilities, changing demographics, changing needs and wants, saturated markets, demand uncertainties, innovations (Pine 1993, p. 32), etc. Thus, the main conditions that have ensured a successful mass production, namely stability and demand homogeneity are no longer available and do not coin the actual picture of the business environment. Nowadays, customers have more power and the suppliers' offer by far exceeds the demand. In contrast to the seller market, the involved market is called a buyer market, in which the mass production paradigm no longer represents a successful solution model. In many business fields, suppliers offer a wide range of choices in order to increase the likelihood that customers find the suitable product. However, the tendency observed is that large variety is not enough because customers want customized products that optimally fulfill their requirements.

1. PRODUCT CUSTOMIZATION: DEFINITION

Pine/Gilmore (1999, p. 76) define customization as "...producing in response to a particular customer's desires." The authors point out that it is relevant to make the distinction between variety and customization. Whereas customization strives for fulfilling individual customer's needs, variety simply involves more choice from which the customer is able to choose. "Fundamentally, customers do not want choice; they just want exactly what they want" (Pine/Gilmore 1999, p. 76). Customization is intended to add increased customer perceived value to a product, since a customized product

– compared to a mass produced product – increasingly fulfills the need of the customer (Svensson/Jensen 2001, p. 1).

When defining the term product customization, it is relevant to include the product perspective which can be a physical good or a service. Thus, product customization can be defined as producing a physical good or a service that is tailored to a particular customer's requirements. In this context, customer involvement is an important issue, because customers dictate what the enterprise has to produce. In the case of physical goods, product customization can occur ex post after manufacturing by the retailer or the customers themselves. In this book only physical goods' customization is considered because the main focus will be placed on manufacturing enterprises. However, value adding services around physical products are considered as additional criteria for differentiating goods and thus for customization.

2. PRODUCT CUSTOMIZATION AND COMPETITIVE ADVANTAGE

“Competitive advantage fundamentally grows out of the value a firm is able to create for its buyers that exceeds the firm's cost of creating it. Value is what buyers are willing to pay, and superior value stems from offering lower prices than competitors for equivalent benefits or providing unique benefits that more than offset a higher price” (Porter 1998, p. 3). It is obvious that Porter emphasizes the value offered to the customer as the most important factor which determines the extent of competitive advantage. In this context, offering customized products seems to be a source of competitive advantage because the ability to develop customer-tailored products can be marketed as a differentiating and distinctive capability that provides customers with superior value. Therefore, product customization can be considered as a feature to differentiate goods from those of competitors.

In contrast to mass produced goods that are designed for an average customer, customized products respond to particular requirements. A mass manufactured product may consist of product options or features that customers do not need. Thus, customers have to pay for components which are undesired and do not provide an additional value for them. But when the product is customized, the undesired features as in the case of mass production are not available and customers just pay for the product with the configuration that satisfies their requirements (Pine/Gilmore 1999, p. 79). For example, suppose that all variants of a car model of an automobile manufacturer are equipped with a navigation system in which the customers

appreciate the value of this device differently. Even when customers do not need this system they have to pay for it. Some customers may value the price of the car to be high and look for competitors' offers, although costs and price would be relatively lowered without such a system. This represents a waste that increases costs from a supplier's perspective. It would be cleverer to offer the navigation system as an option that can be freely selected by customers. Therefore, product customization appears as a way to considerably reduce costs as well as price.

Recapitulating, product customization enables suppliers to consider both basic types of competitive advantage that are identified by Porter (1998), namely the cost and differentiation perspectives. Although when identifying the generic competitive strategies, Porter mentions that firms have to choose either cost leadership or differentiation and all suppliers who are in between are "stuck in the middle", product customization appears as a hybrid competitive strategy that is able to combine both advantages together.

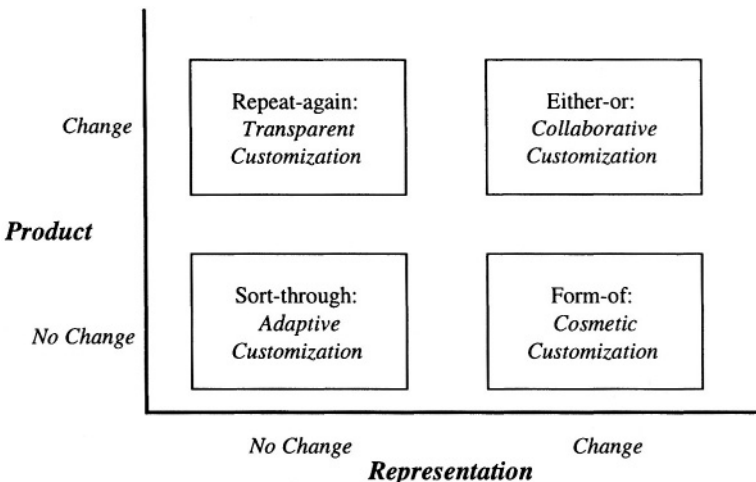
3. PRODUCT CUSTOMIZATION STRATEGIES

In order to customize products there are two main approaches. The first is to specifically design and manufacture products for a particular customer's requirements by using a job shop manufacturing system. These products are designed and produced from scratch for each individual customer, in other words, the needed resources are used differently to a great extent for each specific product. For instance, building an airport having particular characteristics is a specific project that is constructed once for one customer. However, the second approach is to implement a mass customization (Davis 1987; Pine 1993) system that aims at linking both advantages of mass production and customization. The main objective of mass customization is to produce individualized goods with near mass production efficiency (Pine 1993). The first approach is considered to be a project management problem and will not be dealt with in this book, the second approach of mass customization is very challenging. Thereby, not only the product individualization perspective plays a relevant role, but also the costs' perspective. For example, Rautenstrauch et al. (2002, p. 104) speak about mass customization when the product price does not exceed approximately 10-15 percent of a standard product. From a strategic point of view, the goal of mass customization is to differentiate products through customization and to also take advantage of the economies of scale. Piller (2000, p. 196) mentions that the mass customizer has to provide customers with an achievement potential by developing a wide product solution space from which customers can select or self-configure the product variant that meets

individual requirements. The rest of this book will basically concentrate on the mass customization paradigm. To implement mass customization, there are many different strategies which have been already discussed in the technical literature. In the following, the main identified mass customization configurations are presented.

3.1 Mass Customization Strategies by Pine/Gilmore (1999)

Pine/Gilmore (1999, pp. 86) introduced a taxonomy to classify suppliers who pursue mass customization. In their classification, two main dimensions are taken into account, namely the product and its representation. To elaborate the model represented by figure 2-1, the authors introduce the notion of customer sacrifice which is defined as “the difference between what a customer accepts and what he really needs, even if the customer doesn’t know what that is or can’t articulate it” (Pine/Gilmore 1999, p. 78). In order to respond to the customer sacrifice, the mass customizer can make decisions as to whether to change the product functionalities or not. Moreover, companies have the possibility to change the representation of the product or not, which relates to anything else outside the product itself such as the product description, packaging, name, etc.



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Figure 2-1. The four approaches to mass customization as a response to the customers' sacrifice by Pine/Gilmore (1999, p. 87)

When the product and its representation are changed, it is referred to the corresponding customization strategy as collaborative customization. The main objective is that customers no longer have to make either-or sacrifices. For example, when buying a standard pair of shoes one customer may wish for a certain model but the shoes' size may not fit his or her feet well. However, another pair of shoes may exist in the assortment that exactly fits customer's feet, but the shoes' model design may be undesired by the customer. In this case, the customer has to make an either-or sacrifice. In order to avoid that, a customer renounces one product dimension (either the shoes' model or size), collaborative customizers interact directly with their customers to determine what they want in order to manufacture the product that best fits their requirements.

However, when several alternative customers' requirements can be embedded into one single product, adaptive customization becomes an interesting approach. Thereby, the product as well as its representation remain unchanged. Adaptive customization is considered as a response to a cumbersome sort-through process that customers engage in when presented with too many finished goods. The outcome of this type of customization is adaptive products which are, according to Pine (1993, p. 14), standard products that can be adapted for or by customers themselves. These products can be either customizable or customizing. Whereas customizable products provide customers with the possibility to choose from many options, the one that most suits their specific requirements (e.g. graphic equalizer of a hi-fi system), customizing products adapt themselves to the user (e.g. Gillette Sensor).

In the case when it is only the product representation that has changed, Pine/Gilmore calls the corresponding mode cosmetic customization. The main goal is to avoid form-of sacrifices by differently presenting a standard product to a multitude of customers. For example, a standard product can be specially packaged for a particular customer's requirements.

In contrast to cosmetic customization, transparent customization assumes that the representation of the product does not change, whereas the product functionalities are adapted to particular requirements. This type of customization aims at eliminating repeat-again sacrifices that customers have to encounter each time they have to perform the same task of specifying their requirements again and in turn providing them to the supplier. Thus, transparent customization is suitable when customers do not want to be bothered with direct collaboration. Pine/Gilmore (1999, pp. 92-93) give the example of Chemstation, an industrial cleaning goods' manufacturer and distributor that provides its customers with individualized goods that suit their particular facilities without explicitly letting them know that the product is customized. In this case, transparent customization is an

advantageous approach because customers rather focus on the cleanness of their facilities than on the attributes or the chemical composition of the cleaning product.

3.2 Mass Customization Strategies by Duray et al. (2000)

The model of Pine/Gilmore is customer oriented and basically classifies mass customization according to its capability of avoiding a specific sacrifice that the customers have to make each time they settle for products that do not exactly correspond to their needs. However, the classification described by Duray et al. (2000, pp. 612) rather focuses on an operations perspective. In their model (Figure 2-2), Duray et al. present a taxonomy of mass customization with respect to two dimensions, namely the point of customer involvement and the type of modularity. These dimensions are analyzed in relation to the production cycle consisting of the design, fabrication, assembly and use phases.

Point of Customer Involvement	Type of Modularity			
	Design	Fabrication	Assembly	Use
Design	1 Fabricators		2 Involvers	
Fabrication				
Assembly	3 Modularizers		4 Assemblers	
Use				

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Figure 2-2. Matrix grouping of mass customization configurations by Duray et al. (2000, p. 612)

The customer involvement dimension is considered to be an indicator of the product customization level. If customers are involved in the design and fabrication stages, then the degree of customization is high. However, when customers are involved in the assembly or use phases customer involvement is considered to be lower. The second dimension which refers to the type of modularity is essential because it enables companies to put the “mass” in

mass customization and to reach lower costs when manufacturing customized products. Duray et al. make the distinction between modularity allowing the modification of modules and components during design or fabrication and modularity that only involves unchangeable standard modules in the assembly and use stages.

By juxtaposing both dimensions, Duray et al. create four types of mass customizers which are fabricators, involvers, modularizers and assemblers. Fabricators involve customers early on in the production cycle and use modularity to increase commonality of components. New modules can be developed or already existing ones can be modified. In opposition to fabricators, involvers use modularity in the late stages of the production cycle. Due to early customer involvement, involvers give the impression to customers that the product is specifically designed for them. However, customer requirements are met by assembling or using standard modules and components.

Modularizers are manufacturers that use modularization at the first stages of the production cycle but involve customers during assembly and use. At a first glance, this approach may appear inconsistent, especially for those who have a picture in mind that the single goal of module combinations is to suit a specific customer configuration. However, modularizers are companies who use modularity in the first stages in order to increase internal commonality between products. “*Modularizers* incorporate both customizable modularity in the later stages of the production cycle and non-customizable modularity in the design and fabrication stages of the production cycle” (Duray et al. 1999, p. 613).

Finally, assemblers are mass customizers that pursue an assemble-to-order strategy. They involve customers in the late stages of the production cycle and manufacture customized products on the basis of standard modules.

3.3 Mass Customization Strategies by Piller (2000)

In order to classify mass customization, Piller (2000, pp. 250) makes the distinction between soft and hard customization (Figure 2-3). Soft customization is solely based on activities of research and development, design engineering or sales. It involves only a few product variants that are manufactured in large batches. The soft customized products can either be individualized by the customers themselves (self customization) or by retailers (point-of-delivery customization). Soft customization can also result from secondary services around a standard product (service customization) in order to provide the impression that the product is tailored to individual customers' requirements. Thus, soft customization basically builds upon a

mass product with standardized manufacturing processes. In other words, customers have no direct influence on the production process.

<i>Soft Customization:</i> Customization based on fully standardized manufacturing processes	<i>Hard Customization:</i> Customization starts within the manufacturing processes
Self customization Create customizable products and services	Customization-Standardization-mix Either the first or the last activities of the value chain are customized within the factory, while keeping the others standardized
Point-of-delivery customization Customization of a standardized product at the point-of-delivery	Modular product architectures Modularize components and combine them to customized products
Service customization Customize services around standardized products and services	Flexible customization Using flexible manufacturing systems for production of fully customized products without higher costs

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Figure 2-3. Mass customization strategies by Piller (2000, p. 251)

In opposition, hard customization starts within the manufacturing processes because some production activities will not be achieved until customers specify their requirements. Each manufactured product can be unambiguously attributed to one single customer order. Three main modes can be discerned which are: customization-standardization mix, modular product architectures and flexible customization. With the customization-standardization mix, Piller (2000, pp. 256) considers product individualization where customers are integrated either at the first or last stages of the value chain. This mode of customization can be based on modularity whereby a set of standard parts are combined with a single individualized component, which can occur at the beginning or at the end of the manufacturing process. The customization mode that is referred to as modular product architectures involves a more advanced modularity where product variants can be configured on the basis of modular building blocks according to individual requirements. Whereas modular architectures considerably restrain the number of choices that are available to customers, flexible customization essentially is based on flexible manufacturing systems in order to produce a batch size of one by keeping costs as low as possible. Thereby, the individualized components represent the main elements of the product. This mode of mass customization has to be distinguished from job-

shop manufacturing where costs are very high and not comparable to those of corresponding standard products. Furthermore, manufacturing processes should be stable and mechanisms have to be established in order to ensure an efficient management of customer-oriented designs.

3.4 Mass Customization Strategies by Da Silveira et al. (2001)

On the basis of a literature analysis, Da Silveira et al. (2001, pp. 3-4) introduce a classification framework for mass customization levels. The established framework consists of eight generic levels and ranges from pure standardization to pure customization (Figure 2-4).

MC generic Levels
1. Design
2. Fabrication
3. Assembly
4. Additional custom work
5. Additional services
6. Package and distribution
7. Usage
8. Standardization

Figure 2-4. Generic levels of mass customization

(Adapted from: Da Silveira et al. 2000, p. 3)

Design refers to a collaborative project in the sense of Pine/Gilmore (1999) where customers interact with suppliers with the objective to design a product that fulfills particular requirements. However, *fabrication* is targeted on the manufacture of customized products by following basic predefined designs. Whereas fabrication allows the introduction of some modifications into the product building blocks, *assembly* is based on standard modules that can be combined into different product variants in order to meet particular customer requirements. In opposition to the first three levels: design, fabrication and assembly where the customer actively intervenes in the manufacturing process, in the five other levels customers have no influence on production. In levels 4 and 5, mass customization is achieved by

providing *additional custom work* at the point of delivery or secondary *additional services* around standard products. The *package and distribution* level involves a cosmetic customization. Finally, *usage* refers to customizable products, whereas *standardization* relates to customizing products which self adapts to specific customer needs (Da Silveira et al. 2001, pp. 3-4).

3.5 Mass Customization Strategies by MacCarthy et al. (2003)

Based on a literature analysis and a case studies' approach, MacCarthy et al. (2003, pp. 290) determine three dimensions according to which they define five modes for mass customization.

The first dimension refers to product design and product validation that can be achieved per product family, per product or per order. In the case of a product family, design and validation processes are completely achieved before any customer places an order. However, in the per product situation the supplier involves a particular customer in the design and validation processes before order placement. Then, the customized product can be ordered on a repeat basis without customer involvement. In contrast, the per order case assumes that the customer is involved at any time he or she places an order.

The second dimension relates to the resources utilized for order fulfillment. These resources can be either fixed or modifiable. Mass customizers with fixed resources predefine their customization capabilities, so that customers' orders are fulfilled on the basis of e.g. processing or delivery resources that are predetermined in advance. However, modifiable resources offer a larger degree of flexibility because mass customizers can engage suppliers with specific capabilities in order to suit particular customers' requirements.

The third dimension detects whether the product is based on a once-only or call-off approach. Whereas once-only means that the product is manufactured only once for one customer and that the probability of receiving identical orders is very low, the call-off approach is used in the business-to-business field when customers are mass merchants who can request customized orders in large batch sizes.

Although the juxtaposition of all three dimensions would theoretically lead to $3 \times 2 \times 2 = 12$ modes of mass customization, MacCarthy et al. (2003, p. 297) argue that some configurations are infeasible. They retain only five fundamental modes which are catalog mass customization (mode A), fixed resource design-per-order mass customization (mode B), flexible resource design-per-order mass customization (mode C), fixed resource call-off mass

customization (mode D), and flexible resource call-off mass customization (mode E). The following figure 2-5 indicates for each fundamental mode of mass customization the corresponding combination of the dimension values.

	A	B	C	D	E
	Catalogue	Fixed resource design-per-order MC	Flexible resource design-per-order MC	Fixed resource call-off MC	Flexible resource call-off MC
Product design	Per family	Per order	Per order	Per product	Per product
Product validation	Per family	Per order	Per order	Per product	Per product
Once-only/call-off	--	Once-only	Once-only	Call-off	Call-off
Fixed/modifiable resources	Fixed	Fixed	Modifiable	Fixed	Modifiable

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Figure 2-5. Mass customization modes by MacCarthy et al. (2003, p. 299)

3.6 Critical Comparison Between the Classification Models for Mass Customization

In order to evaluate the classification models for mass customization, a comparison based on relevant criteria has to be carried out. We identify five basic dimensions according to which we compare the different models, namely: research type, exclusiveness between strategies, main classification perspective, easiness of attribution and specification of application suitability. *Research type* indicates the research method on which the basis of the model is established. The dimension: *exclusiveness between strategies* captures whether the strategies in one model are mutually exclusive, in other words, if there is some overlapping in the classification. The *main classification perspective* refers to the basic criterion that is used in order to achieve the typology (e.g. the classification perspective according to Pine/Gilmore (1999) is: product/representation). The *easiness of attribution* relates to the fact of whether difficulties arise when trying to assign a particular mass customizer to one category according to the model. The *specification of application suitability* means whether the researchers have specified in their original contributions the context, in which their classification makes sense. For example, when considering an operations-oriented problem a particular classification model may be more suitable than another model that can be for instance more applicable when dealing with a

marketing-oriented problem. Figure 2-6 summarizes the evaluation of the classification models with respect to the identified dimensions.

	Pine/Gilmore (1999)	Duray et al. (2000)	Piller (2000)	Da Silveira et al. (2001)	MacCarthy et al. (2003)
Research type	Empirical investigation	Empirical research and validation	Literature research and 101 case studies	Literature research	Literature research and 5 case studies
Exclusiveness between strategies	Available	Available	Not available	Available	Available
Main classification perspective	Product/representation	Point of Customer involvement/modularity	Customer involvement in value chain	Customer involvement in value chain	Product design/repetition of orders/resources
Easiness of attribution	Easy	Not easy	Not easy	Not easy	Easy
Specification of application suitability	None	None	None	None	None

Figure 2-6. Comparison between the classification models for mass customization

The models by Pine/Gilmore (1999) and Duray et al. (2000) are based on empirical researches. Pine/Gilmore (1999) introduce the notion of customer sacrifice and derive their model that classifies mass customization into four main strategies. For each strategy, the authors provide a list of suitable illustrating examples from the practice. But an empirical validation of the model is not available. However, Duray et al. (2000) first theoretically conceive their typology and then validate it empirically on the basis of a survey involving the participation of 126 mass customizers.

In order to conceptualize their models, Piller (2000) and MacCarthy et al. (2003) carry out a literature research as well as a case studies analysis. It is relevant to mention that the case studies analysis achieved by Piller is by far more comprehensive than the analysis made by MacCarthy et al. In contrast, Da Silveira et al. (2001) base their model uniquely on a literature research.

The analysis of the different models with respect to the exclusiveness between strategies reveals that the strategies identified by Piller (2000) are not mutually exclusive. This basically concerns the point-of-delivery customization strategy which appears as a particular case of the customization-standardization mix because point-of-delivery customization can be seen as a form of customization that occurs at the last stage of the value chain. In addition, the customization-standardization mix can be seen as a particular case of modular product architectures.

With respect to the main classification perspective, Duray et al. (2000), Piller (2000) and Da Silveira et al. (2001) choose a value chain perspective,

whereas Pine/Gilmore (1999) and MacCarthy et al. (2003) base their models on other dimensions. It is noteworthy that it may not be straightforward to assign mass customizers to a suitable category when applying the approaches built upon a value chain perspective since these approaches are based on an implicit premise assuming a single point of customization (MacCarthy et al. 2003, p. 295). In many practical cases, it can be observed that there are many points of customization across the value chain. Therefore, the models by Pine/Gilmore (1999) and MacCarthy et al. (2003) are the most straightforward to be applied for the assignment of a mass customizer to a particular category.

An important issue that remains generally unaddressed by each described research relates to the application limits of each model. For example, the model by Duray et al. (2000) ignores mass customizers who offer standard products that are customizable by retail or by the customers themselves. The identified configurations: fabricators, involvers, modularizers and assemblers can be assigned to collaborative customization in the sense of Gilmore/Pine (1999) because suppliers usually involve their customers and directly interact with them. Thus, the model by Duray et al. (2000) can be considered as a further classification of collaborative customizers with the main focus on a manufacturing perspective. This model is rather relevant when addressing research issues in operations management for mass customization such as complexity in manufacturing. However, the model of Pine/Gilmore (1999) seems to be more suitable when addressing a customer's perspective.

Although in all cases the application limits of each model are not explicitly mentioned, these can be derived from the different definitions for mass customization adopted in each research. For example, Duray et al. (2000) speak about mass customization only when customers are directly involved in the value chain, either in the early or late stages and when products are modularized. In addition to modularization and customer involvement, Pine/Gilmore (1999) consider customizable products or standard products with tailored services as a form of mass customization. MacCarthy et al. (2003) include suppliers in their classification that manufacture customized products in large batches for mass merchants. Piller (2000) and Da Silveira et al. (2001) base their analysis on a similar definition as Pine/Gilmore (1999) and also consider adaptable products as well as customization through services as a form of customization. However, in contrast to Da Silveira et al. (2001), Piller (2000) explicitly distinguishes between mass customization configurations where customers have a direct influence on the manufacturing process and those configurations where customers are not directly involved in production. A main challenge to be addressed in this work is to provide a definition for mass customization, on

which basis we can determine what problems managers encounter during implementation. But before dealing with a definition of this new business paradigm, we will analyze the necessary conditions that must be available in order to shift to and pursue mass customization.

4. NECESSARY CONDITIONS WHEN ACHIEVING PRODUCT CUSTOMIZATION

This section deals with the necessary conditions that must be available when achieving product customization in the case of the mass customization paradigm. The main concern is to determine the specific organizational requirements and favorable market factors that will contribute to an increase in the probability of the success implementation of mass customization. For instance, according to Broekhuizen/Alsem (2002, p. 313) success in mass customization is attained when the supplier provides customers with “...*superior customer value* – in contrast to mass manufacturers’ offerings – through customization on a mass scale”.

As we will see in the literature review, the terms used by the authors to refer to what we call necessary conditions are quite different. This term is intentionally chosen in order to avoid the use of e.g. the term success factor which is unfortunately, arbitrarily utilized in the technical literature. We argue that the term success factors has to be exclusively used when addressing strategic management issues. That is why, we opt for the definition stated by Kaluza (1989, p. 28) who identifies six strategic success factors, namely: costs, quality, time, flexibility, service, and product variety. However, necessary conditions can relate to success factors, competences or capabilities that the supplier has to examine and to develop further before and during the pursuit of mass customization.

4.1 Literature Review

Pine (1993, pp. 54) develops a market-turbulence map that aims at supporting managers in an evaluation if their organizations need to move into mass customization. “The greater the market turbulence, the more likely that the industry is moving toward mass customization, and that the firm *has* to move in order to remain competitive” (Pine 1993, pp. 54-55). The elaborated market-turbulence map includes 17 factors and is structured in two main categories which are “demand” and “structural” factors (Figure 2-7). Demand factors such as stability of demand levels, uncertain customer needs or heterogeneity of demand basically relate to the customer. They can

be manipulated by the firm itself which can stabilize demand by e.g. retreating from the more turbulent segments. However, structural factors such as vulnerability to substitute products, product life cycle length or the rate of product technology change relate to the basic nature of an industry. Therefore, the manipulation of these factors by firms themselves is more difficult. However, the market turbulence introduced by Pine only covers the dimension of market conditions and does not deal with the organizational requirements that are necessary for the implementation of mass customization.

Demand factors
<ul style="list-style-type: none"> • Stability and predictability of demand levels • Basic necessities versus complete luxuries • Easily defined versus uncertain customer needs/wants • Homogeneous versus heterogeneous demand • Rate of change in customer needs/wants • Price consciousness • Quality consciousness • Fashion/style consciousness • Level of pre- and postsale service
Structural factors
<ul style="list-style-type: none"> • Buyer power • Degree of influence of economic cycles • Competitive intensity • Price competition versus product differentiation • Level of market saturation • Vulnerability to substitute products • Product life cycle length and predictability • Rate of product technology change

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Figure 2-7. Market-turbulence factors by Pine

(Adapted from: Pine 1993, pp. 56)

Pine (1993) considers the shift to mass customization as an inevitable reaction when firms want to be successful in turbulent market environments. He postulates that a competitive advantage can be attained if firms completely replace “mass production” with “mass customization”. In contrast, Kotha (1995, pp. 25) demonstrates through a case study of the National Industrial Bicycle Company of Japan (NIBC) the compatibility of both strategies. He argues that competitive success in changing environments can be achieved, if firms have the necessary capabilities to create knowledge by interacting mass customization with mass production. Kotha (1996, pp. 447) addresses the basic conditions which are necessary for a successful implementation of mass customization. He makes the distinction between external (industry-level) and internal (firm-level) conditions. Figure 2-8 presents the necessary conditions for a successful pursuit of mass customization as discussed by Kotha (1996, p. 449).

<i>External Conditions</i>
Success is more likely if
<ul style="list-style-type: none">• there is no well entrenched competitor already pursuing mass customization• the firm has access to a supplier network in close proximity• the industry is characterized by increased product proliferation and new product introductions• the firm develops an inter-connected information network with a selected group of trained retailers
<i>Internal Conditions</i>
Success is more likely when a firm
<ul style="list-style-type: none">• has made long-term investment in advanced manufacturing technologies and information technologies and human resource development• has access to substantial in-house engineering expertise and manufacturing capabilities• focuses its manufacturing tasks and competitive priorities at each plant to its product/market environment• institutes organizational mechanisms that foster interactions among focused plants• creates a culture that emphasizes knowledge creation and the development of manufacturing capabilities• has a savvy marketing group that can excite customers about individualized product offerings

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Figure 2-8. External and internal conditions necessary for success by Kotha (1996, p. 449)

A careful examination of the external and internal conditions for success suggests that Kotha has orientated his analysis too much on the case study of the NIBC. He assumes that both mass production and mass customization are pursued in two different focused plants by the firm. The analysis merely concentrates on mass producers who want to additionally pursue mass customization by offering individualized products to a specific customer segment. But the conditions discussed by Kotha will not be helpful for a startup firm that wants to offer mass customized goods. The model also does not consider the specific case when the company pursues a craft production and wants to move into mass customization.

According to Hart (1995, pp. 39), when companies intend to move into mass customization, four key decisive factors have to be examined in order to attain successful implementation: (a) customer customization sensitivity, (b) process amenability, (c) competitive environment, and (d) organizational readiness. Customer customization sensitivity is based on two main factors, which are: the uniqueness of customers' needs and customer sacrifice. The uniqueness of customers' needs basically depends on the nature of the product. For example, whereas customers would not really benefit from customized table salt, with respect to investment counseling, each customers' needs are absolutely unique. Customer sacrifice is defined in accordance with Pine/Gilmore (1999, p. 78) as the gap between what a customer wants exactly and what he or she settles for. The higher the level of the needs' uniqueness and customer sacrifice, the higher the customization sensitivity level.

The second key factor: process amenability encompasses the enablers which fall into two categories: technology based and organizational, as well as the following functions: marketing, design, production, and distribution. The main concern should be attributed to the assessment whether the necessary competencies are available for a shift to mass customization. The third factor: competitive environment has to be examined with respect to the existence or absence of competitive forces that would enhance or detract from the advantage gained when implementing mass customization. The fourth factor: organizational readiness aims at discovering the degree of suitability between the business opportunity inherent in mass customization and the organization's ability to efficiently pursue mass customization.

In their literature review on mass customization, Da Silveira et al. (2001, p. 4) discuss six factors in order to successfully achieve mass customization, which are: (a) customer demand for variety and customization, (b) appropriateness of market conditions, (c) readiness of the value chain, (d) availability of technology, (e) customizability of products and (f) knowledge sharing.

The first two factors (a) and (b) are market-related, whereas the other factors are rather organization-based. *Customer demand for variety and customization* is the main impulse that drives suppliers to develop processes and capabilities for product customization. If customers choose to not pay premium prices or to wait for longer delivery times, then mass customization is superfluous and success is improbable. Furthermore, success may depend on the point in time at which the company starts to offer individualized products. Being the first supplier over competitors that pursues mass customization can represent a significant advantage and substantially improves the supplier's image. This is referred to as the *appropriateness of market conditions*.

The achievement of mass customization is a complex task that assumes an optimal coordination and harmonization between all members of the value chain including suppliers, distributors and retailers. The achievement of this goal supposes the *readiness of the value chain* as well as the *availability of technology* such as modern information systems. Modern technology on the shop floor offering a high manufacturing flexibility (Kaluza 1995, p. 15) is also required in order to customize products. Flexibility in manufacturing has to be supported by a modular product design which in turn determines the *customizability of products*. In addition, the design of customized goods supposes a near interaction between suppliers and customers, which requires a comprehensive *knowledge sharing* across the whole value chain.

In the same context, Zipkin (2001, p. 82) defines three key capabilities of mass customization systems, which are: "*elicitation* (a mechanism for interacting with the customer and obtaining specific information); *process flexibility* (production technology that fabricates the product according to the information); and *logistics* (subsequent processing stages and distribution that are able to maintain the identity of each item and to deliver the right one to the right customer)."

Berman (2002, p. 59) develops a checklist for mass customization readiness on the basis of the key capabilities identified by Zipkin (2001). He mentions that suppliers have to compute the financial benefits associated with mass customization. They have to evaluate the extent of sacrifice when customers settle for standard solutions as well as the segment size of customers who would be interested in individualized products. A supplier has to ensure that technical and personal skills for customer needs' elicitation already exist or can be easily developed. Manufacturing capabilities should be assessed with respect to product modularity, postponement of orders and flexible production systems including computer-aided design and computer-aided manufacturing. An efficient achievement of mass customization also depends on efficient communication across the

supply chain with suppliers and customers. Furthermore, the use of just-in-time techniques, bar coding and scanning as well as the ability to run mass production at the same time as mass customization must be analyzed before moving into mass customization.

Broekhuizen/Alsem (2002, p. 313) criticize the fact that in the technical literature, there is no coherent and detailed framework according to which success factors for mass customization are classified. That is why, on the basis of a literature analysis, they develop a conceptual model that is structured according to five dimensions which are the customer, product, market, industry and organization. Figure 2-9 summarizes the hypotheses made by the authors with respect to the probability of success in mass customization.

Mchunu et al. (2003, pp. 6) do not speak about success factors or capabilities, but rather about competencies. They point out that there are five competencies with specific relevance for mass customization, which are:

- *Design* that has to be oriented on customers' interests
- Strategic and operational *flexibility*
- *Supply chain agility* with the main focus on market responsiveness
- *Distribution of inventory* with respect to the amount and position of material throughout the company's facilities
- *Logistics and information management*

Building upon these five key competencies, Mchunu et al. (2003, p. 10) propose a framework on which basis they claim capable of predicting the success or failure of suppliers who want to move into mass customization. They apply their predictive framework for two practical cases in order to assess whether the suppliers are fit for adopting a mass customization strategy or not.

<i>Customer factors</i>
H1a: Consumer heterogeneity positively affects the probability of success
H1b: Consumer involvement positively affects the probability of success
H1c: Consumer willingness to pay a price premium positively affects the probability of success
H1d: Consumer privacy concerns negatively affect the probability of success
<i>Product factors</i>
H2a: Purchasing frequency positively affects the probability of success
H2b: Product luxury level positively affects the probability of success
H2c: Product visibility positively affects the probability of success
H2d: Product adaptability positively affects the probability of success
<i>Market factors</i>
H3a: Market variety positively affects the probability of success
H3b: Retailer willingness and ability positively affect the probability of success
<i>Industry factors</i>
H4a: Information communication technology growth positively affects the probability of success
H4b: E-commerce growth positively affects the probability of success
H4c: Flexible production technology growth positively affects the probability of success
<i>Organizational factors</i>
H5a: The company's level of production technology and flexibility positively affects the probability of success
H5b: The company's level of logistics and distribution system flexibility positively affects the probability of success
H5c: The company's level of customer information dissemination positively affects the probability of success
H5d: First-mover advantage positively affects the probability of success
H5e: The available resources and company's readiness positively affect the probability of success

Figure 2-9. Success factors for achieving mass customization by Broekhuizen/Alsem
(Broekhuizen/Alsem 2002, pp. 319)

4.2 A Comprehensive Framework Encompassing the Main Conditions for Achieving Mass Customization

The presented literature review reveals that the authors do not fully agree with the scope and extent of the needed skills and conditions that must be available in order to successfully achieve mass customization. Although all authors deal with the same issue, the terms used are quite different. Da Silveira et al. (2001) and Broekhuizen/Alsem (2002) speak about “success factors”, whereas Zipkin (2001) and Berman (2002) about “key capabilities”. However, Mchunu et al. (2003) use the term “key competencies” for achieving mass customization. Kotha (1996) and Pine (1993) respectively use the terms “necessary conditions for success” and “demand and structural factors”, whereas Hart (1995) prefers the term “key decision factors”.

The contributions reviewed emphasize the basic conditions justifying the shift to mass customization. They generally assume that a supplier with an established production system wants to move onward to mass customization. This is in accordance with the work of Reiss/Beck (1994, pp. 28) who examine the different roads leading to mass customization. The authors argue that there are two principal alternatives. Either the mass manufacturer can shift to mass customization by attempting to preserve cost efficiency or the craft customizer can implement the strategy by maintaining the differentiation advantages. However, the framework to be elaborated should not only emphasize the conditions to be satisfied when moving into mass customization, but also those that are required for its pursuit. In so doing, we guarantee that the framework is more comprehensive and more helpful for managers because it explicitly distinguishes between both cases, namely before and after moving into mass customization.

For the elaboration of the framework, we primarily focus on *what* conditions are necessary for the implementation and pursuit of mass customization. We do not concentrate on *how* these conditions can be fulfilled or influenced. For instance, we argue that technology is just a means that supports manufacturing flexibility or optimal customers’ needs elicitation. Technology pertains to the category of enablers which can be defined as “... the means by which change occurs” (Hart 1995, p. 41). That is why, factors that relate to technology are not included in the framework. The framework summarizing the main conditions that we believe to be decisive for the achievement of mass customization is represented by figure 2-10. It distinguishes between market conditions and customizing ability as main dimensions before shifting to mass customization. After implementation, several internal abilities of the mass customizing system have to be maintained and further developed.

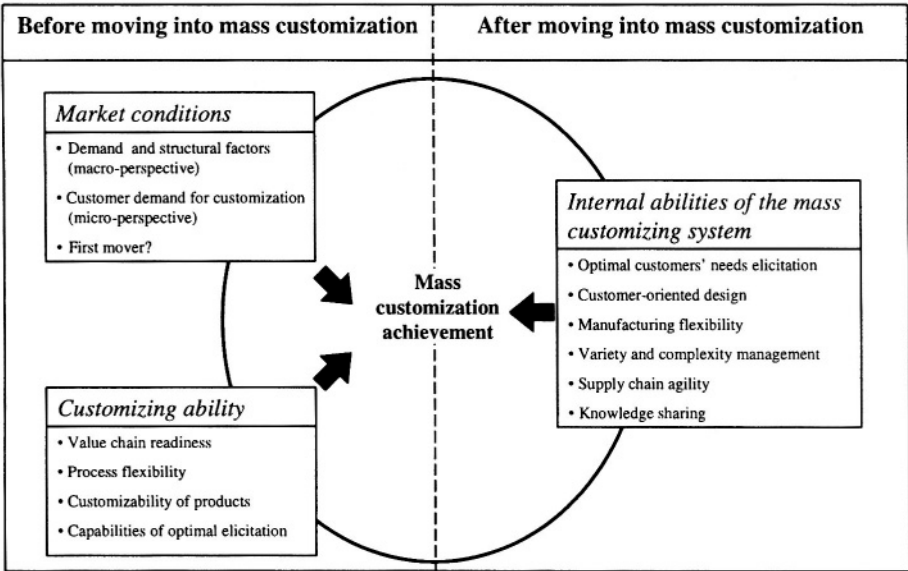


Figure 2-10. Necessary conditions for achieving mass customization

4.2.1 Market Conditions

Before shifting to mass customization, the supplier has to carefully examine whether the market conditions are favorable with respect to (a) demand and structural factors, (b) customer demand for customization and (c) first-mover advantage.

Demand and structural factors

We argue that the market turbulence map of Pine (1993, pp. 66) that consists of the demand and structural factors is a suitable tool. Pine (1993, p. 73) proposes a market turbulence questionnaire to be distributed to key executives and/or knowledgeable managers and professionals across a broad section within the company. On the basis of their responses, the market turbulence map can be drawn up, from which the turbulence level of the company's market environment can be determined. However, the market turbulence map of Pine singly takes into account information that stems from company members and not from customers.

Although Pine (1993, p. 71) empirically validates his market turbulence model by examining the correlation between the market turbulence factors and measures of customization and variety, we think it is also important to evaluate whether the customers themselves are interested in customization.

Customer demand for customization

The success of mass customization should be primarily initiated by customers. Their willingness to have individualized products with eventual premium prices and longer delivery times is a decisive condition that has to be examined before moving into mass customization. It is obvious that if final customers do not have any interest in customization, pursuing mass customization strategies will be superfluous. Zipkin (2001, p. 86) points out that customization may truly add value to customers when they sharply differ in their preferences for certain product attributes. MacCarthy et al. (2002, pp. 76) define the concept of key value attributes for mass customization as the attributes with the greatest perceived value to the customer. The analysis of the key value attributes is a relevant issue in order to determine where the focus of product variety should be. It can be identified as to which product variety is important and value adding from the customers' perspective.

However, a large body of research examining when mass customization would represent a serious opportunity including both suppliers' and customers' perspectives does not exist. "To date, very little scientific work examines consumer behavior and attitudes toward customized products. [...] In particular, we need to know how much consumers care for customized offerings and which customized products or services would be more wanted by consumers" (Guilabert/Donthu 2003, p. 2). In order to contribute in the filling of this research gap, Guilabert/Donthu (2003, pp. 3) use the notion of *Customer Customization Sensitivity* (CCS) which was first introduced by Hart (1995, p. 40). The authors define CCS as the "*customer's susceptibility to preferring customized products/services*" (Guilabert/Donthu 2003, p. 3) and develop a scale consisting of six dimensions which help evaluate whether potential customers will accept customization or not. These dimensions are presented in figure 2-11.

Customer Customization Sensitivity (CCS) Scale	
1.	In general, customized products/services meet my needs better than standard ones
2.	I wish there were more products/services that could be easily customized to my taste
3.	I believe there is a need for more customized products/services
4.	If the price is similar for standard and customized products/services I would choose customized products/services
5.	If I have to wait the latest version of a "----" product service I'd go with the previous version instead
6.	If I have a choice, I prefer to have customized products/services

Figure 2-11. Dimensions of Customer Customization Sensitivity

(Source: Guilabert/Donthu 2003, p. 7)

First-mover advantage

The last factor pertaining to market conditions is the first mover advantage. Kotha (1996, p. 447) argues that being a first mover in implementing mass customization will be beneficial for the supplier's image. Even when competitors enter the mass custom segment afterwards, they will find it difficult to prevail, especially when customers consider the first mover as the leader and best supplier of individualized products.

4.2.2 Customizing ability

Customizing ability deals with the evaluation of the readiness of the whole organization before moving into mass customization. Customizing ability basically must be examined with respect to (a) the value chain readiness, (b) process flexibility, (c) customizability of products and (d) capabilities to optimally elicit customers' requirements.

Value chain readiness

The objective of evaluating the value chain readiness before shifting to mass customization is to examine the customizing potential of the entire network including the company, its suppliers, distributors and retailers. It is important to note that companies generally reduce the vertical range of manufacture and focus on core competencies (e.g. Wigand et al. 1997, pp. 190) which are decisive for success in competition. Consequently, a large number of parts required in the end product assembly might be outsourced. Thus, it is conceivable that other partners in the value chain take over the task of producing the customized elements or the customization of elements. For this reason, several partners in the value chain can play a substantial role in achieving good responsiveness to customers' preferences. The result of the evaluation of the value chain readiness is a specification of the activities of the individualization process to be carried out inside the company and those to be outsourced. If strategic suppliers, distributors or retailers do not have the necessary capabilities, a narrow cooperation with the objective to improve the customization capabilities of the entire value chain, is required before moving into mass customization.

For example, Schenk/Seelmann-Eggebert (2003, p. 7) introduce four different logistical approaches of how to realize mass customization strategies across the value chain. They discuss different scenarios where the customizing process can be carried out either by the producer, logistics provider, retailer or customer (Figure 2-12). The authors emphasize that all

partners have to be involved at an early stage before introducing any of the four mass customization approaches.

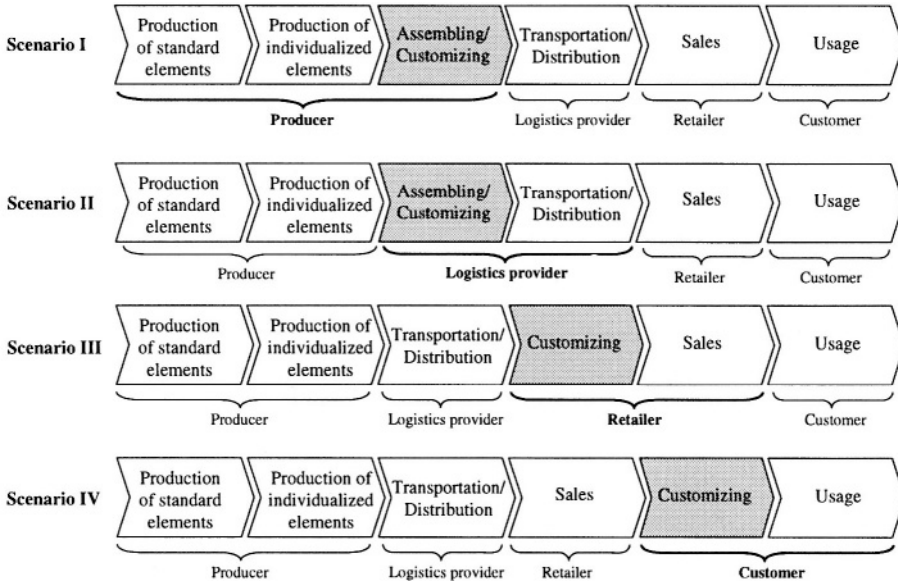


Figure 2-12. Customizing positions on the value chain

(Schenk/Seelmann-Eggebert 2003, pp. 3)

However, Hoogeweegen/Hagdorn-van der Meijden (2003, pp. 2) mention that pre-formed stable business networks of organizations are no longer available by introducing mass customization. Instead, dynamic business networks characterized by high instability emerge because an actual formulated customer order determines which organizations have to be involved in the fulfillment of this particular order. On the basis of the business networking game, a business network consisting of many companies is simulated. As the customers' demand shifts to more product customization, the different organizations (e.g. suppliers, service providers, logistics providers) involved in the network have to adjust their strategies by e.g. acquiring more competencies, specializing their offers or building new relationships with other organizations. The game shows that the organizations do not equally profit from the customization trend. Depending on the pursued strategy, some organizations improve their profit share, whereas others suffer a loss. These results have important managerial implications. They suggest that the shift of the entire value chain to mass

customization may be advantageous for some organizations and disadvantageous for others.

Process flexibility

In order to cope with a high diversity of customers' requirements in mass customization a large product variety is needed. This induces a variant-rich production where process flexibility plays a decisive role. Process flexibility can be improved by minimizing setup times. A setup can be defined as "...any changeover activity that is necessary in batch manufacturing to change parts, fixtures, tooling, equipment programming, or instructions from one product, or product variation, to another" (Anderson 1997, p. 46). Before moving into mass customization it is relevant to make sure that the current production system can be easily adapted to use flexible processes and to incorporate computer-aided manufacturing (Berman 2002, p. 59).

Customizability of products

In addition, to make processes flexible some changes on the product design level are necessary. In fact, "[t]he concept of modularity is a basic building block in the manufacturing situations traditionally considered to be flexible" (Duray et al. 2000, p. 610). Moreover, modularity is an approach that enables manufacturers to postpone customers' orders. Modules can be anonymously produced on a mass scale. When a customer order arrives, modules are then combined in a way that will satisfy the specific requirements of the customer. Thus, the product modularity level not only influences manufacturing flexibility but also the customizability of products.

Capabilities of optimal elicitation

Before moving onward to mass customization, the necessary capabilities for optimal customers' needs elicitation should be available. Kotha (1996, p. 447) emphasizes that mistakes and errors in processing customers' orders can be extremely costly in mass customization. Therefore, the company has to implement mechanisms that help customers find the products that fully correspond to their requirements. The information gained from customers is of high relevance since it represents the basis on which the individualized product is manufactured. If a mistake occurs at the elicitation stage, then the product will by no means correspond to customers' expectations.

In order to have access to customer information, it may be required to develop an inter-connected information network with a group of retailers who maintain direct contact with customers. Another alternative is to

directly communicate with customers by e.g. implementing a software tool over the World Wide Web which provides customers with the possibility to change and visualize product variations. The supplier should consider many alternatives and evaluate them with respect to the available capabilities and potential for the successful achievement of mass customization.

4.2.3 Internal Abilities of the Mass Customizing System

The internal abilities of the mass customizing system are the skills and capabilities that must be maintained and further developed when pursuing mass customization. These are: optimal customers' needs elicitation, customer-oriented design, manufacturing flexibility, variety and complexity management, supply chain agility and knowledge sharing. It is important to note that the mass customizing system includes not only the firm who is liable for the individualized product but also its partners in the value chain that actively participate in the customization process.

Optimal customers' needs elicitation

In order to be able to offer a superior value to customers, the mass customizer has to continuously develop its capabilities with regard to customers' needs elicitation. There are four kinds of elicited information in mass customization: identification, such as name and address; customers' selections from product alternatives; physical measurements; and reactions to prototypes (Zipkin 2001, p. 83).

The information related to identification and customers' selections can be easily gained by implementing software systems over the Internet. Nowadays, these software systems that are sometimes called configurators can be cheaply and quickly constructed. They guide customers through an array of choices with the objective to lead them to the suitable product variation. In order to improve learning about customers and optimize the elicitation process, the integration of configurators with Customer-Relationship Management (CRM) systems is very promising. CRM systems aggregate customer related data and derive useful information such as individual desires and behaviors. This information can be used to help customers find in a fast paced manner the product that fully meets their requirements (Blecker et al. 2004a, pp. 7).

In many cases, the customization process requires information about physical measurements. For instance, body measurements are necessary when the product is a custom-made pair of trousers. This information can be elicited either manually (manual measurement of waist and length by oneself

or at a retailer store) or automatically (automated body measurement through an optical body scanner).

However, the use of prototypes to elicit customer information is not yet a common method and requires complex software systems. Some application fields stem from the building industry where customers are invited to build their houses with a click of the mouse (Zipkin 2001, p. 83).

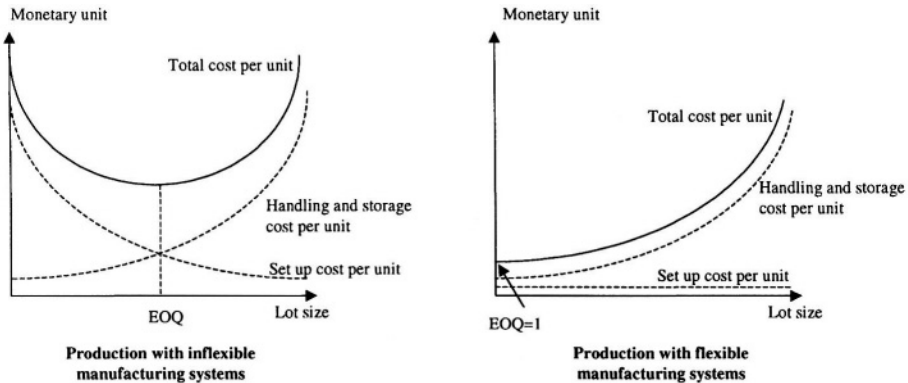
Customer-oriented design

A fundamental internal ability that has to be available when pursuing mass customization is an efficient customer-oriented design. Before starting to listen to the “voice of the customer”, one must determine which “voices” to listen to, which means to decide which market segments might be attractive for customization. Furthermore, “[i]n contrast to the development of a discrete product, developing products for Mass Customization focuses on product *families/platforms* or many product families and their *evolution over time*” (Anderson 1997, p. 202).

Thus, in mass customization, customer requirements have to be mapped to a family of products, instead of a single product such as in mass production environments. The mass customizer must determine the product attributes for which customer requirements are considerably different. Therefore, a product family generally consists of both standardized elements (product platform) and variable elements to ensure product variation. It is noteworthy that product design to a great extent determines the costs in manufacturing. Each product variation is associated with additional costs and therefore too much variance can weaken the entire product program.

Manufacturing flexibility

Slack (1983, pp. 4) argues that manufacturing flexibility has three main dimensions: (a) the range of possible configurations a manufacturing system can adopt, (b) the cost of migrating from one configuration to another, and (c) the time needed to make a transition. According to this definition, a mass customization manufacturing system should endue a wide range of possible configurations that makes the production of a large product variety possible. Moreover, both the costs and time necessary to change from one configuration to another (i.e. from one product variation to another) should be kept low, which means that the setup costs and times have to be minimized. In this context, Pine (1993, p. 50) graphically shows the importance of the reduction of set up costs in order to move the Economic Order Quantity (EOQ) towards a lot size of one, which allows the company to efficiently handle more product variety.



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Figure 2-13. The effect of reducing setup costs on economic order quantities

(Adapted from: Pine 1993, p. 51)

When producing with inflexible manufacturing systems, EOQ is the point at which the increasing handling and storage costs begin to outweigh the decreasing setup cost, which yields the lowest total cost per unit (left side of figure 2-13). For flexible manufacturing systems with low setup costs, the lowest total cost corresponds to a batch size of one (right side of figure 2-13). Nevertheless, the achievement of “a lot size of one” is very demanding and is by no means a simple task even if modern manufacturing technology is available. Therefore, during the pursuit of mass customization, manufacturing flexibility has to be continuously improved by minimizing both setup times and costs.

Variety and complexity management

This condition that is necessary for the achievement of mass customization is not mentioned in the literature reviewed in section 4.1. We demonstrate in the next chapter that variety and complexity management are indispensable pillars for the pursuit of mass customization. Variety management embraces methods that control product variety proliferation. The main concern is to cope with the complexity stemming from the product (e.g. number of parts, components, and variants) as well as the complexity acting on the product (e.g. market diversity, production flows) by means of suitable instruments. Complexity management not only deals with the proliferation of product variety, but also with the proliferation of processes and resources in companies. Through a conscious increasing or decreasing of complexity, the target is to cope with variety in all value adding chain activities, so that a maximal contribution to customer perceived value and a

high efficiency are simultaneously attained (Schuh/Schwenk 2001, pp. 34-35).

Supply chain agility

Fisher (1997, pp. 106) develops a taxonomy based on two main dimensions for matching supply chains with products. The first dimension distinguishes between functional and innovative products, whereas the second dimension makes the difference between efficient and responsive supply chains.

Functional products satisfy basic needs and do not change much over time. They have a stable, predictable demand and long life cycles. However, innovative products have short life cycles. Their very newness makes demand for them unpredictable. In addition, innovative products are characterized by a great variety which further increases unpredictability.

Efficient supply chains basically focus on the reduction of physical costs which include the costs of production, transportation, and inventory storage. In opposition, responsive supply chains concentrate on minimizing market mediation costs that arise when supply exceeds demand or when supply falls short of demand. The taxonomy presented by figure 2-14 suggests that a match between supply chains and products occurs when functional products are manufactured and delivered within the scope of efficient supply chains, whereas innovative products are made within a responsive supply chain. Otherwise, there is a mismatch.

	Functional products	Innovative products
Efficient supply chain	match	mismatch
Responsive supply chain	mismatch	match

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Figure 2-14. Matching supply chains with products

(Source: Fisher 1997, p. 109)

All properties that Fisher has used to define innovative products also hold for mass customized products. Therefore, good matching assumes that mass customized products are produced within responsive supply chains. In addition, Goldman et al. (1995, p. 330) define agility as the rapid system responsiveness to unforeseen customer requirements. From Fisher's taxonomy and the agility definition of Goldman et al., it can be deduced that mass customized products require supply chain agility. Furthermore, Naylor et al. (1999, p. 112) argue that supply chain agility gains importance in manufacturing environments characterized by a high demand for product variety and a high demand for variability in production.

To achieve supply chain agility, the mass customizer has to manage uncertainty that is triggered by unforeseen customer requirements. Three coordinated strategies can be employed, namely by (a) reducing uncertainty (e.g. finding sources of new data), (b) avoiding uncertainty (e.g. cutting lead times and increasing supply chain's flexibility), and (c) hedging against the remaining residual uncertainty (e.g. with excess capacity) (Fisher 1997, p. 14).

Knowledge sharing

Mass customization is a dynamic strategy that highly depends on the ability of translating new customer demands into new products (Da Silveira et al. 2001, p. 4). Knowledge about customers' preferences and desires that is obtained at retail stores or through a direct interaction with customers has to be rapidly and efficiently transferred across the value chain. Moreover, the achievement of mass customization considerably relies on the ability to create and harness a worker's knowledge at the point of production. Compared to mass products, the manufacturing of mass customized products requires higher skills and qualifications of employees (Kotha 1996, p. 448).

5. THE CHALLENGING APPROACH OF PRODUCT CUSTOMIZATION: MASS CUSTOMIZATION

In the technical literature, there is no consistent and uniform definition for mass customization. This may be due to the fact that mass customization is a paradigm which has quite recently gained more attention from academia and practitioners. Research on mass customization is not extensive and further work is needed to solve many research questions. The concept emerged in the late 1980s and the term "mass customization" was coined for the first time by Davis (1987) in his book "future perfect". The popularity of the concept has dramatically increased among managers and academics after

the publication of Pine's book "Mass Customization: The New Frontier in Business Competition" by 1993.

Another reason why mass customization lacks a generally valid definition is the multidisciplinary nature of the approach. The work on mass customization involves many researchers from different fields such as business administration, artificial intelligence, mechanical engineering, industrial engineering, and psychology, just to name a few. Thereby, each field has developed specific language in order to deal with research issues in mass customization.

In order to define mass customization, Pine (1993, p. 44) notes that "...practitioners of Mass Customization share the goal of developing, producing, marketing, and delivering affordable goods and services with enough variety and customization *that nearly everyone finds exactly what they want.*" Pine basically focuses on the value chain that should have the ability to provide customers with choice and individualization possibilities, so that nearly every customer finds the product corresponding to his or her needs.

Piller (2000, p. 206) defines mass customization as the production of goods and services for a relatively large market, in which the needs of each individual customer can be met at a cost level that is comparable to that of mass producers. The information that is gained from customers during the customization process serves as a means to build long-lasting relationships with each customer. The definition set forth by Piller consists of two main parts. Whereas the first part deals with the production of individualized goods and services with near mass production efficiency, the second part rather emphasizes on the learning relationship between customers and mass customizer. The involvement of customers is a necessary requirement for product customization and the information gathered can be used in order to more efficiently meet customer preferences and desires. For instance, Broekhuizen/Alsem (2002, p. 311) do not agree with Piller that learning relationships are important to efficiently pursue mass customization. They point out that when the time gap between repurchase is considerable, the information gained from customers may become irrelevant. However, we believe that the knowledge acquired from customers is always of great relevance. The main concern should be attributed to the implementation of mechanisms and procedures that enable the evaluation of this information. At a specific point in time, only useful and filtered information has to be exploited in order to better fulfill a customer's requirements, whereas obsolete information has to be discarded.

In opposition to Pine (1993) and Piller (2000) who each give a single definition for mass customization, Hart (1995, p. 36) argues that two distinct definitions would be necessary for mass customization. The first one is

called the visionary or Platonic definition of mass customization. It is “... the ability to provide your customers with anything they want profitably, any time they want it, anywhere they want it, any way they want it” (Hart 1995, p. 36). The second definition is the practical one. It is “the use of flexible processes and organizational structures to produce varied and often individually customized products and services at the low cost of a standardized, mass production system (Hart 1995, p. 36). Whereas the first definition rather represents a goal or an ideal that can be rarely achieved, the second one is pragmatic and can be understood as customization within a predetermined “envelope of variety” (Hart 1995, p. 37). The role of the visionary definition is to continuously incite suppliers to intensify and reinforce their customer orientation. We argue that Hart has defined mass customization in an intelligent way. On the one hand, he emphasizes the strong customer orientation that mass customization has to strive for. On the other hand, he does not neglect the efficiency constraint that also has to be satisfied when pursuing mass customization.

Thus, what is common among all of the definitions discussed above is that mass customization has to include two main perspectives, namely customer orientation and costs’ efficiency. This is also in accordance with the definition set forth by Duray et al. (2000) who argue that customer involvement in the production cycle as well as modularity to achieve efficiency are the most important dimensions to classify mass customizers. We also argue that mass customization has to be built upon these two fundamental pillars. For this reason, we totally reject the claim of Da Silveira et al. (2001, p. 4) who state that modularity is not the fundamental characteristic of mass customization and that true mass customized products are individually made.

We define mass customization as the process of the fulfillment of the needs of each individual customer pertaining to a relatively large part of a market the supplier focuses on, with prices that do not exceed 10-15% of the prices of comparable standard products.

Furthermore, mass customization has to provide each customer with the required means enabling him or her to easily and comfortably interact with the product assortment in order to find the product corresponding to his or her needs. The information that arises during the customization process serves on the one hand to build a long-lasting relationship with the customer and on the other hand to continuously optimize operations and manufacturing-related tasks in order to improve costs’ efficiency.

6. SUMMARY

In this chapter, we define product customization and we show its contribution to create a competitive edge over competitors in dynamic business environments. To customize products, two main alternatives are identified. The first alternative is to use craft customization, whereas the second one is to implement mass customization. Craft customization is achieved by methods and concepts from the project management field. It reposes on a job shop manufacturing system characterized by extremely high flexibility. However, mass customization is an emerging paradigm that is challenging for manufacturing enterprises. In comparison to craft customization, mass customization assumes a more restricted level of flexibility. It aims at individualizing and delivering products by means of processes that nearly have mass production efficiency. Whereas craft customization is a well-established concept that has been applied for many decades, mass customization is still a new paradigm that requires further research. Therefore, within the scope of this book, we argue to uniquely handle mass customization.

Mass customization can be considered to be a strategy in itself. However, the literature research has shown that there are many strategies or configurations for the pursuit of mass customization. In the contributions reviewed, the authors classify mass customization concepts differently. The main conclusion to be drawn is that mass customization configurations can be represented on a continuum with adaptable standard products at one extreme point and products incorporating a very high level of customization at the other extreme point. Different classification approaches as discussed in the literature are criticized according to specific criteria but we do not provide a categorization model. We are convinced that each model in the literature reflects a particular definition of mass customization and therefore a specific perspective when dealing with mass customization. For example, some researchers would consider the manufacturing of adaptable standard products as a form of mass customization, while other researchers would not do so. For the purpose of this book, the classification model of Duray et al. (2000) will be adopted for the classification of mass customization configurations.

The second literature review examines the necessary conditions for the achievement of mass customization. On the basis of the performed literature research, a framework has been established that distinguishes between the necessary conditions for shifting to mass customization and the necessary conditions to be maintained and further developed while pursuing mass customization.

Finally, we elaborate a working definition for mass customization on which we will base this book. We define mass customization as the process of fulfillment of the needs of each individual customer pertaining to a relatively large part of a market that the supplier focuses on, with prices that do not exceed 10-15% of the prices of comparable standard products. This definition basically concentrates on the customer's perspective. However, it does not neglect the efficiency perspective. In contrast to other definitions, it also explicitly mentions how much "mass" should be put into mass customization in order to be able to speak about mass customization. When the prices of customized products exceed 10-15% of the prices of comparable standard products, then it is no longer legitimate to speak about mass customization. Instead, it will be more suitable to use another term such as job shop production.

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