

# Mass Customization

## Part I: Definition, levels and success factors

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### *Abstract*

*Mass Customization relates to the ability to provide individually-designed products and services to every customer through high process flexibility and integration. Mass customization has been identified as a competitive advantage strategy by an increasing number of companies. This paper surveys the literature on mass customization. Differences between mass production and mass customization, and their impact on the development of production systems are discussed in length. Mass customization levels and success factors are compiled and classified.*

### *Keywords*

Mass customization, customer-driven manufacturing, user involvement, agile manufacturing.

## **1. Introduction**

Mass customization relates to the ability to provide customized products or services through flexible processes in high volumes and at reasonably low costs. The concept has emerged in the late 80's and may be viewed as a natural follow up to processes that have become increasingly flexible and optimized regarding quality and costs. Also, mass customization appears as an alternative to differentiate companies in a highly competitive and segmented market.

In this paper we present a literature review on mass customization (MC). Topics covered here include (i) the MC concept, (ii) a comparison between MC and mass production; (iii) a description of MC levels, and (iv) MC success factors. In Part II of this article, we conclude the literature review presenting enablers of MC implementation and directions for future research on the topic.

Our main objective is to provide a framework for understanding the several developments that emerged in the literature in the past ten years. There are at least two significant reasons for reviewing the MC literature: (i) industry is strongly bending towards MC; this new strategy takes full advantage of increasing agility and flexibility present in operations environments; and (ii) customers are looking for individualization and willing to pay a premium price to have it; therefore, MC should guide marketing efforts in companies willing to increase their market share.

We developed a framework for presenting this survey where MC is deployed from concept to practice. We start by conceptualizing MC. Our objective is to confront strictly theoretic concepts and its practice-oriented counterparts. We want to explore the extent at which theoretical MC concepts describe a production strategy that may be indeed pursued in practice. Next, we analyze the relationship between MC and mass production, their operational and strategic differences. Since many authors classify mass

production and MC as entities on a continuum, we explore the feasibility of implementing an MC strategy in a mass production environment. These issues are essentially conceptual.

We then look at the different levels at which MC may be implemented. In other words, we classify levels of individualization that may be provided to customers. The choice of appropriate MC level takes into consideration factors such as product/service specific properties, current operations, capabilities and point of delivery. This issue relates to the design of an MC product.

We finally move to more applied matters, listing a number of factors that, according to several authors, may lead to a successful implementation of an MC strategy. Success factors relate mostly to market and operations.

There is one main contribution here. This article presents a comprehensive guide that should help researchers to screen the vast MC literature in search of references on specific topics. Through a structured framework, seemingly unconnected aspects of MC are brought together and explored in enough detail to provide a useful introduction to the subject.

The remaining sections in this paper are organized to reflect the survey presentation scheme. The next section is devoted to the concept of MC. Section 3 presents a comparative of MC and mass production. In section 4, levels of MC are detailed. Section 5 explores success factors of mass customization systems. A conclusion closes the paper in section 6.

## **2. Mass customization concept**

Mass customization (MC) can be defined either very broadly or narrowly. The broad, visionary concept was first coined by DAVIS (1989) and promotes MC as the ability to provide individually-designed products and services to every customer through high process agility, flexibility and integration (PINE *et al.*, 1993; EASTWOOD, 1996). MC systems may thus reach customers as in the mass market economy but treat them individually as in the pre-industrial economies (DAVIS, 1989). MC systems are positioned below the main diagonal of HAYES and WHEELWRIGHT's (1979) product/process matrix, i.e. having medium to high-volume process types such as manufacturing cells or assembly lines that are able to deliver the high product varieties usually associated to functional or fixed-type operations.

Many authors propose similar but narrower, more practical concepts. They define MC as a system that uses information technology, flexible processes, and organizational structures to deliver a wide range of products and services that meet specific needs of individual customers (often defined by a series of options), at a cost near that of mass-produced items (HART, 1995; KAY, 1993; KOTHA, 1995; ROSS, 1996; JONEJA and LEE, 1998). In any case, MC is seen as a systemic idea involving all aspects of product sale, development, production, and delivery, full-circle from the customer option up to receiving the finished product (KAY, 1993; JIAO *et al.*, 1998).

The justification for the development of MC systems is based on three main ideas (HART, 1995; AHLSTROM and WESTBROOK, 1999; KOTHA, 1995; PINE, 1993). First, new flexible manufacturing and information technologies enable production systems to deliver higher variety at lower cost. Second, there is an increasing demand for product variety and customization [according to KOTLER (1989), even segmented markets are now too broad as they no longer permit developing niche strategies]. Finally, the shortening of product life cycles and expanding industrial competition has led to the breakdown of many mass industries, increasing the need for production strategies focused on individual customers.

The main objective of MC systems is to deliver products and services that best translate the actual choices of individual customers. This is one step ahead of conventional flexible systems where customer choices are anticipated by delivering wide varieties (AHLSTROM and WESTBROOK, 1999; WESTBROOK and WILLIAMSON, 1993). MC systems aim at turning market uncertainties into sources of competitive advantage (HART, 1995) by producing items that are meaningful to customers,

more valuable than competitors' offerings, and feasible to design, manufacture, distribute, and service (HART, 1996).

Successful MC systems may bring in major competitive strategy and performance enhancements such as: (i) inventories of finished products tend to disappear and the risk of product obsolescence is reduced (KOTHA, 1995; WESTBROOK and WILLIAMSON, 1993); (ii) need for forecasting and market research decreases as products are designed according to actual customer choices (KOTHA, 1995; WESTBROOK and WILLIAMSON, 1993); (iii) companies may be able to get revenues from customized products (PINE *et al.*, 1993); (iv) customer loyalty tends to increase and the value chain tends to become more integrated as links between manufacturers, suppliers, retailers, and customers improve (AHLSTROM and WESTBROOK, 1999; KOTHA, 1995; WESTBROOK and WILLIAMSON, 1993; KNOWLES, 1997).

The MC concept is in many ways a natural development of many ideas that have emerged in the past three decades. Just-in-time, Lean Production and Agile manufacturing, among others, belong within the MC concept. A thorough discussion on this issue is given in Part 2 of this article.

### **3. Mass customization versus mass production**

One of the main debates within the literature on MC regards the difference between MC and MP. This question branches into aspects such as whether MC and MP are both parts of a continuum, their operational and strategic differences, and the feasibility of pursuing both strategies within the same company.

PINE, VICTOR and BOYNTON (1993) suggest that MC and MP are essentially different and incompatible within the same organization. These differences concern fundamental aspects such as focus, goal, key features, and structure of each approach. TAYLOR and LYON (1995) stress the differences in the way products and processes are developed in the two approaches: in MP products are created first and then a coupled process is designed to produce them; in MC the process is created first and remains de-coupled from products.

However, some authors suggest that MC is not very different from MP. In LAU's (1995) view, successful MC strategies depend exclusively on application of MP techniques with smaller lot sizes. LAMPEL and MINTZBERG (1996) argue that customization and standardization are not alternative models of action but rather poles in a continuum of real world strategies (discussion on this issue is resumed below).

KOTHA (1996a) is likely to be the author most supportive of combining both strategies, if not within the same production system, at least within the same firm. In his view, a successful combination of MC and MP relies on appropriate factory focus, and in the ability to explore the interactions between the two focused factories. Based on the National Industry Bicycle Company case, KOTHA (1995; 1996a; 1996b) suggests exploring the interaction between MC and MP factories to foster organizational learning, improve the utilization of work skills, enhance strategic flexibility, refine engineering and manufacturing capabilities, and improve market responsiveness. That is possible in view of the unique opportunities offered by such integration such as sharing of design and process engineers and workers between the two factories, training of MC workers at the MP factory, and transferring of process knowledge and information on market trends from the MC to the MP plant.

The potential to pursue MC and MP strategies within the same industry, although in different market segments, may be the key to a successful MC implementation. Companies attempting at pursuing MC for the first time may find it risky to change their entire operation in this direction. In such cases, a better strategy may be first implementing a pilot MC system, and then exploring the interactions between MP and MC. In addition, as discussed next, MC is suitable for companies operating in specific market types and with specific configurations, while MP is still the best strategy in many markets. Hence pursuing both MC and MP by focused factories may be the best choice in many cases.

#### 4. Levels of mass customization

Determining the level of individualization characterizing truly mass customized products seems to be a major point of contention in the MC debate. Purists may attribute the MC concept only to products that contemplate all requirements made by individual customers. Pragmatists suggest MC to be simply about delivering products following customer options, independent of the number of options actually offered. According to HART (1995) the solution for this contention lies in careful determination of the range in which a product or service can be meaningfully customized, and how individuals make options upon this range. To WESTBROOK and WILLIAMSON (1993) successful MC systems should be able to mix true individualization with high part variety and standardized processes.

Several authors (DAVIS, 1989; LAMPEL and MINTZBERG, 1996; GILMORE and PINE, 1997) propose a continuous framework upon which MC may be developed; namely, MC can occur at various points along the value chain, ranging from the simple "adaptation" of delivered products by customers themselves, up to the total customization of product sale, design, fabrication, assembly, and delivery. GILMORE and PINE (1997) identify four customization levels based mostly on empirical observation: collaborative (designers dialogue with customers), adaptive (standard products can be altered by customers during use), cosmetic (standard products are packaged specially for each customer), and transparent (products are adapted to individual needs). LAMPEL and MINTZBERG (1996) define a continuum of five MC strategies (and therefore levels) involving different configurations of process (from standard to customized), product (from commodities to unique) and customer transaction (from generic to personalized). A recent study provided empirical evidence of these levels (AMARO *et al.*, 1999). PINE (1993) suggests five stages of modular production: customized services (standard products are tailored by people in marketing and delivery before they reach customers), embedded customization (standard products can be altered by customers during use), point-of-delivery customization (additional custom work can be done at the point of sale), providing quick response (short time delivery of products), and modular production (standard components can be configured in a wide variety of products and services). SPIRA (1996) develops a similar framework with four types of customization: customized packaging, customized services, additional custom work, and modular assembly. The combination of these frameworks leads to 8 generic levels of MC, ranging from pure customization (individually designed products) to pure standardization; these levels are presented in Tab. 1.

Design is the top level in Tab. 1 and refers to collaborative project, manufacturing and delivery of products according to individual customer preferences (e.g. residential architecture; LAMPEL and MINTZBERG, 1996). Level 7 (fabrication) refers to manufacturing of customer-tailored products following basic, pre-defined designs (e.g. Motorola's Bandit pager; EASTWOOD, 1996). Level 6 (assembly) deals with the arranging of modular components into different configurations according to customer orders (e.g. Hewlett-Packard products; FEITZINGER and LEE, 1997). In levels 5 and 4, MC is achieved by simply adding custom work (e.g. Ikea's furniture; DAVIS, 1989) or services (e.g. Burger King's hamburgers; DAVIS, 1989) to standard products, often at the point-of-delivery. In level 3, MC is provided by distributing or packaging similar products in different ways using, for example, different box sizes according to specific market segments (e.g. Wal-Mart's peanuts; GILMORE and PINE, 1997).

In level 2, MC occurs only after delivery, through products that can be adapted to different functions or situations (e.g. Lutron's lighting systems; GILMORE and PINE, 1997). Finally, level 1 refers to LAMPEL and MINTZBERG's (1996) pure standardization, a strategy that can still be useful in many industrial segments. As seen above, MC can be provided in different scopes and forms. One of the main challenges in developing MC systems deals with the determination of customization level and configuration. That will depend on the status of the success factors discussed in the previous section and on the competitive strategy defined. Providing a prescriptive model for determining the proper scope and configuration of an MC implementation is perhaps one of the main challenges in MC research and practice.

## 5. Success factors of mass customization systems

The success of MC systems depends on a series of external and internal factors. The existence of these factors justifies the use of MC as a competitive strategy and supports the development of MC systems. The six factors most commonly emphasized in the literature are presented next. Factors 1 to 2 are primarily market related factors. Factors 3 to 6 are primarily organization based factors.

1. Customer demand for variety and customization must exist. The need to deal with increasing customer demand for innovative and customized products is the fundamental justification for MC (PINE *et al.*, 1993; LAU, 1995; KOTHA, 1996b). The success of MC depends on the balance between, on one hand, the potential sacrifice that customers make for MC products (i.e. how much they will to pay and wait for the delivery of mass customized products; HART, 1996 and KOTHA, 1996b) and, on the other hand, the company's ability to produce and deliver individualized products within an acceptable time and cost frame.

MC Generic Levels	MC Approaches (GILMORE and PINE, 1997)	MC Strategies (LAMPEL and MINTZBERG, 1996)	Stages of MC (PINE, 1993)	Types of Customization (SPIRA, 1996)
8. Design	Collaborative; Transparent	Pure Customization		
7. Fabrication		Tailored Customization		
6. Assembly		Customized Standardization	Modular Production	Assembling Standard Components into Unique Configurations
5. Additional Custom Work			Point Of Delivery Customization	Performing Additional Custom Work
4. Additional Services			Customized Services; Providing Quick Response	Providing Additional Services
3. Package and Distribution	Cosmetic	Segmented Standardization		Customizing Packaging
2. Usage	Adaptive		Embedded Customization	
1. Standardization		Pure Standardization		

Table 1. Generic levels of Mass Customization.

2. Market conditions must be appropriate. According to KOTHA (1995), a company's ability to transform MC potential into actual competitive advantage greatly depends on the timing of this development. In other words, being the first to develop an MC system can provide substantial advantage over competitors, since the company may get well entrenched in this position, and start being seen by people as innovative and customer-driven.

3. Value chain should be ready. MC is a value chain-based concept. Its success depends on the willingness and readiness of suppliers, distributors, and retailers to attend to the system's demands. The supply network must be at close proximity to the company to deliver raw materials efficiently (KOTHA, 1996b; FEITZINGER and LEE, 1997). Most important, manufacturers, retailers, and other

value chain entities must be part of an efficiently linked information network (KOTHA, 1996b; HAGLIND and HELANDER, 1999; KIM, 1998; MAGRETTA, 1998).

4. Technology must be available. The implementation of Advanced Manufacturing Technologies (AMTs) is fundamental to enable the development of MC systems (PINE *et al.*, 1993; LAU, 1995; KOTHA, 1996b; HIRSCH *et al.*, 1998; ADAMIDES, 1996). One could argue that the very concept of MC appeared only after some companies were able to successfully integrate a series of information and process flexibility technologies. MC is one of the best opportunities offered by coordinated implementation of AMTs and information technology (IT) across the value chain.

5. Products should be customizable. Independent units that can be assembled into different forms compose a modular product (FEITZINGER and LEE, 1997). Successful MC products must be modularized, versatile, and constantly renewed. Even though modularity is not the fundamental characteristic of MC (true MC products are individually made), it enables simpler and lower-cost manufacturing of products with similar effectiveness if compared to true customization. Also, MC processes need rapid product development and innovation capabilities due to typical short life cycles presented by MC products (PINE *et al.*, 1993; LAU, 1995).

6. Knowledge must be shared. MC is a dynamic strategy and depends on the ability to translate new customer demands into new products and services. To achieve that, a culture that emphasizes knowledge creation and distribution across the value chain must be pursued by companies. That requires the development of dynamic networks (PINE *et al.*, 1993) along with manufacturing and engineering expertise (KOTHA, 1996a), and in-house development of new product and process technologies (KOTHA, 1995).

These factors have direct practical implications. First, they corroborate the idea that MC is not every company's best strategy, for it must conform to specific market and customer types. Second, they assert the complexity involved in MC implementation. In other words, MC implementation involves major aspects of operations including product configuration, value chain network, process and information technology, and the development of a knowledge-based organizational structure.

## 6. Conclusions

MC has become an important choice of manufacturing strategy. Agility and quick responsiveness to changes have become mandatory to most companies in view of current levels of market globalization, rapid technological innovations, and intense competition. MC broadly encompasses the ability to provide individually-designed products and services to customers in the mass market economy.

However, MC should not be viewed as a monolithic solution. Manufacturing processes are too complex and context sensitive for a single black-box idea to generate flexible, agile and focused systems. To implement MC it is necessary to integrate different manufacturing technologies into a structured framework capable of combining human and technological factors.

This paper presents a literature review on MC. The objective is to identify required conditions and situations where MC implementation is suitable. In addition, fundamental principles and concepts in MC theory are thoroughly discussed.

The study reveals that, while there is little contention on theoretical aspects concerning MC concepts and objectives, there are several pending issues regarding its practical implementation. Literature on MC implementation is still incipient. Most claims are drawn from limited case examples or based on educated guesses from authors rather than from hard facts obtained through exhaustive research.

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