

A Survey of Mass Customization in Practice

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Abstract- This paper is a literature review of the application of mass customization (MC) in businesses. We identified business processes that have applied the MC concept to create and deliver both tangible goods and intangible services. With an explanation of the key MC concepts, the research describes the key elements of MC, such as elicitation, process flexibility, and logistics. We also include a description of the four specific MC approaches: collaborative, adaptive, cosmetic, and transparent. Finally, we conclude that there exist many possible applications of MC that are yet to be explored.

Keywords - mass customization, mass production, customized products, customized services, operational efficiency, logistics,

1. Mass Customization

Mass Customization (MC), within the marketing, manufacturing, and management contexts of an organization, is the use of flexible, computer-aided manufacturing systems to produce custom outputs in a mass production environment. The main purpose of such a strategy is to combine the low unit costs of mass production process with the flexibility of individual customization. It allows the customers to interact directly with the producer during the time the product is produced or designed, which allows the manufacturer to satisfy the customer's specific needs that may not be possible with a standard product.

The term MC may seem contradictory because it includes two opposing concepts: mass production and customization. While mass production implies uniform products, customization means custom outputs to satisfy individual needs [34]. In order to better understand the concept, it is important to consider the definition of each of the two terms.

Mass production is a business strategy that focuses on taking advantage of the economies of scale by offering standardized goods and services. Mass producers can offer low prices because production costs can be lowered by producing homogeneous goods in a large scale. It is considered to be a capital intensive business strategy because it necessitates expensive machinery and therefore high fixed and low variable costs. On the other hand, customization is derived from the idea of trying to best

satisfy customers' needs, without a deliberate emphasis on low prices. Therefore, the term 'mass' implies a relatively high volume of products produced for a mass market while the word 'customization' means that products are designed to fit specific customers' needs [19]. Instead of producing one standard product for some imaginary average customers, mass customization aims to satisfy each customer's unique requirements. Such a strategy is then "a synthesis of two long competing systems of management: the mass production of individually customized goods and services" [2].

MC is the result of some fundamental changes that occurred during the last decades in the business environment and in the development of new manufacturing technologies and strategies. According to [19], some of the motives that drove companies to develop this new business strategy include:

- The change in customer expectations from relatively homogeneous to very heterogeneous market requirements.
- The increasing speed at which customer needs change and the consequent shortening of product lifecycles.
- The development of new manufacturing strategies like assemble to order and the creation of product families, which allow offering customers a greater variety while maintaining low costs and high quality.
- The understanding of specific customer needs and the subsequent development of products that meet these needs leads companies to align their strategies to satisfy customer wants in the long run.
- The increasing number of channels to communicate with customers has improved manufacturers ability to determine customer needs, and also understand market opportunities and forecast market trends more accurately.

Based on all these fundamental factors concerning the need for mass customization, McCarthy (2004) defines the term as "the capability to manufacture a relatively high volume of product options for a relatively large market (or collection of niche markets) that demands customization, without tradeoffs in cost, delivery and quality".

However, there are many different kinds of companies and not all of them are going through the same changes at the same rate; which implies that not all of them need to lower costs and increase variety in the same way. Therefore, "even though the essence of mass customization is relatively fixed, at an operational level it

will often mean different things to different groups of firms” [19]. As a result, a variety of approaches to mass customization has been developed over time by different companies in order to fulfill their specific needs.

On the other hand, no matter the kind of company, mass customization is a strategy that cannot be successfully implemented in isolation. In order to achieve customization, along with low costs, high quality and high customer satisfaction, mass customization has to be applied in combination with some relatively new manufacturing concepts, such as Just-In-Time, lean manufacturing, time-based competition, etc.. As stated in [24], Just-In-Time reduces inventory; lean manufacturing eliminates waste, increases process flexibility and responsiveness while also lowering expenses; and made-to-order provides valuable information for customization and also lowers holding costs. These techniques have “increased flexibility and responsiveness and therefore the ability to increase variety and customization without parallel increases in cost” [25]. All the benefits derived from the appropriate implementation of these strategies are essential in achieving low production costs while customizing the product or service at the same time.

MC, applied in collaboration with all these management techniques, is then a business strategy that “bids return to an axiom frequently ignored in the homogenized world of Mass Production: *Each customer is unique*, and all deserve to have exactly what they want at a price they are willing to pay” [26].

2. Mass Production Systems

This mass production system, a direct extension to the factory system of manufacturing, is mostly based on the following four principles: interchangeable parts, specialized machines, process efficiency, and the division of labor. In addition, the following principles could be attributed to mass production systems [24]:

- Continuous flow of work
- Focus on low costs and low prices
- Economies of scale
- Product standardization
- Degree of specialization
- Focus on operational efficiency
- Hierarchical organization with professional managers
- Vertical integration

The manufacturing system developed from the application of the above eight principles was also called *Fordism*, after the production system implemented by Henry Ford to manufacture automobiles. The production of the first Ford’s Model T in 1913 represented “the culmination of a century’s experience with mass production” [28].

Ford was the first to use a continuous assembly line, a continuous *flow* of work from one worker to the next. The assembly line was necessary to increase worker and machine productivity, which helped achieve the main objective of *Fordism*: to focus on low costs and low prices. Low costs and the invention of the assembly line led to the use of *economies of scale*. With lower prices, products experienced a higher demand, which led to a

cycle of even lower prices. In order to continue with this cycle, *standardized products* were required “because any complexities or custom work would upset the production process and result in much higher costs” [25]. Also, in order to take advantage of the economies of scale an even higher level of *degree of specialization* was necessary to sustain an increasing rate of worker and machine productivity.

This constant focus on increasing productivity led to the next principle of mass production, the *focus on operational efficiency*, which was achieved by constantly increasing the throughput rate of workers, machines and the factory in general. The continuous control and measurement resulted in the need of a *hierarchical organization* with *professional managers* whose responsibility was to accurately measure productivity and efficiency, and set policies to help increase them both. The last principle, *vertical integration*, was necessary to ensure that the production line had the required supplies to remain busy during most of the production time.

3. Key Elements

For a successful implementation, MC must include three key elements: elicitation, process flexibility and logistics [34].

a. Elicitation

One of the biggest challenges manufacturers face when implementing a mass customization strategy is the process of determining out what their customers want or need. This task is usually very difficult because, in many cases, customers are uncertain about their own needs. The elicitation process, defined as “a mechanism for interacting with the customer and obtaining specific information” [34], is aimed to determine specific customer needs for a particular product or service. It plays a major role in mass customization because it enables manufacturers to correctly determine what their needs are. As stated in [34], “... any elicitation process is an artful means of leading customers through the process of identifying exactly what they want”.

However, in the development of every product or service the elicitation process does not take the same amount of time. Depending on the type of customization and the specific product or service, the process of obtaining the required information to customize it takes varying degrees of time and effort. For example, the process of customizing an iPod by engraving a personal message or a name takes only one question; while the whole mechanism necessary to create a special industrial soap for a specific factory takes a lot of different studies, analyses and trials.

b. Process Flexibility

In order to better fulfill specific customer needs, the manufacturing process needs to be flexible. Otherwise, the final product will be uniform (standard), with little scope for customization. This basic characteristic of MC is derived from the craft production system which is all but

ignored by the mass production system. In fact, the best example is the famous phrase coined by Henry Ford: "Any customer can have a car painted any color he wants so long as it is black". Mass Customization calls for an opposite view, which is based on a persistent search for better ways to meet customers' needs while keeping costs low. Flexibility is a key requirement for such a process.

Some of the most common strategies used to increase flexibility are modular design, lean manufacturing and CAD/CAM systems. One common way of determining the flexibility of a process is to "determine how many spatial dimensions are involved in each step" [34]. The fewer the number of dimensions involved in a process, the higher the potential for mass customization.

c. Logistics

Managing all the resources in an efficient way is very important when applying a mass customization strategy. *Logistics* involves all the processes required to ensure the adequate supply of raw materials and their storage needs; the flow of information through the whole production process; and packaging, storage and delivery of manufactured products.

Mass customization requires efficient logistics in order to maintain the availability of necessary raw materials to manufacture the product and to deliver the right product at the right time to the right customer. It is also responsible for lowering inventory, warehousing and transportation costs in order to keep prices low. As stated in [29],

"Logistics systems have to be redesigned in order to face the new challenges. Long transport times have to be reduced within and between production lines. Lot size 1 in the machine does not imply lot size 1 in transport. Both information and goods have to be controlled and steered in order to be at the right place at the right time. Logistics therefore plays an essential role in mass customization".

Obviously, logistics plays a major role in and is a key determinant of the successful implementation of the mass customization strategy.

4. Four Approaches

Mass customization can be applied at the design, production, or the delivery stage of any product or service. However, it is the management's responsibility to determine the stage at which it could be most effectively applied in order to better satisfy customer needs while keeping costs at a competitive level. According to [8], there are four main approaches to mass customization: collaborative, adaptive, transparent and cosmetic. They can be applied individually or in any combination of some or all, depending on the production and market requirements.

4.1 Collaborative Approach

When dealing with MC, customers could feel overwhelmed by the sheer number of options available for a specific product or service. The collaborative approach deals with this issue by helping the customers decide on what they need [26].

The main objective of the collaborative approach is to communicate with the customers to determine what their true needs are and to identify the specific product or service characteristics needed to fulfill those needs [8]. Furthermore, for such an approach, the customer may take part in the design process, but manufacturing and assembly processes may be standard while distribution could be customized [29].

One well known application is Dell's approach to configure personal computers, where "customers work with Dell to identify what components they want configured into their personal computer, which the company then develops exclusively for them" [6]. With the widespread use of the Internet as a direct distribution channel, this approach has been adopted and implemented effectively by other computer manufacturers, such as Sony, Toshiba and Hewlett-Packard. Another example of collaborative mass customization is Paris Miki, the largest Japanese eyewear retailer that allows customers to design their frames and lenses [8]. Specifically, the system takes a digital picture of the customer, along with his or her preferences, and recommends lenses, frames, nose bridges, arms, and hinges. The customer continues to work with the system until a satisfactory choice is obtained. The approach is also used by Andersen Windows, a window and door manufacturer, that lets its customers design windows that fit their homes and needs by trying out different styles, shapes, sizes, and colors.

4.2 Adaptive Approach

Sometimes there exist a great variety of final products for customers to fulfill their needs. In such cases, it could become difficult for customers to identify the ideal or the best product because it may not include all of the desired features. Consequently they could end up choosing a product that may not meet their actual needs.

The adaptive approach offers customers a product that they can customize depending on how they want it to perform under a specific situation. In this approach all processes are typically standard [29], but the customer can modify the final product according to their needs; "neither the product itself nor the representation of the product is changed for the individual customer; rather the customer customizes the good or service as desired using customizable functionality embedded into the offering" [26].

One example of adaptive customization is the 'sleep number bed' in that each customer buys the same bed but could adjust the firmness of the mattress to meet his or her preference. Also, online learning programs are "... good examples of adaptive customization because they are designed to adjust according to the alternative paths the individual learners take and the varying progress they make, without changing the programs' infrastructure or platform" [6]. Another example of this approach is the lighting systems manufactured by Lutron Electronics

Company [8]. The system allows the customer to program the lighting system for different effects without having to experiment with different lights and separate switches to create those effects. Software configuration is also an excellent example of this approach because individual users may choose to use the features they need and disregard those they don't [29]. Manufacturers of tangible products could use a collaborative approach to offer products with different options and features so a customer can choose the one with desired functionality or fits individual preferences [8]. Especially, with the advances in technology, it could be technologically feasible, and yet cost efficient, to include a set of desired features in any one product consistent with the adaptive customization approach.

4.3 Cosmetic Approach

As the name implies, in a cosmetic customization approach "customers use the product in same way but they want it to be presented in a different way" [29]. In other words, a standard product is offered in different ways to different customers using special packaging, marketing or advertising. Instead of changing the product or service to meet the needs and desire of different customers, it is stated in [8] that "the standard product is packed specially for each customer."

The way Hertz treats its golden customers is an application of this kind of customization. Hertz Gold members bypass the check-in counter and go directly to the bus instead. The bus driver informs that the customer is on his way and when he gets to the parking lot an electronic billboard directs him to the car. "It's the same car everyone else in your product class gets, but the delivery of the car is customized" [6]. The way most soft drink manufacturers market their products exemplifies this approach also. The same product is sold in different containers - aluminum can, plastic or glass bottles, and in different sizes: 12-ounce cans, 20-ounce bottles, 2-liter bottles, etc.

Oftentimes manufacturers "... postpone many activities in order to perform them before the observant eye of the customer, who feels that the performance is being staged just for him" [8]. As an example, there are many manufacturers who customize their products by placing the customer's name, company's name or logo, or a personal message on each item of a standard product.

4.4 Transparent Approach

The final type is called transparent customization. It occurs when the manufacturers or service providers observe the customers' needs without having a direct communication with them but provide the customers the products or services with the specific features they want or need. The customer does not necessarily know that the product or service has been specifically designed for him or her. In effect, "... transparent customization is the exact opposite of cosmetic customization, which has standard content but a customized package" [26]. The transparent approach works best when individual preferences are easily understood and predicted.

As an example of this approach is the case of ChemStation, a soap manufacturer that develops the right

mixture of soap for each specific customer after carefully analyzing their requirements. They go through a very long analysis process in order to determine what soap composition works best for a customer and in what quantity the customer needs it. The customers don't know the type of soap they are using or how much is left of it, they only care about the fact that it works and that it is available when needed [8]. The Ritz-Carlton hotels also apply the principles of transparent customization by keeping a record of their customers' personal preferences so they can customize their needs during their future trips. For example, "... if a guest requests extra pillows, then extra pillows will be provided at every Ritz Carlton hotel the guest visits" [11]. This approach results in an ever more comfortable experience for the customer because "the more frequently someone stays in Ritz-Carlton hotels, the more the company learns, and the more customized goods and services it fits into the standard Ritz-Carlton room, thereby increasing the guest's preference for that hotel over others" [26].

Keeping records and analyzing customer preferences obviate customizers to ask repeated questions, which could annoy customers and adversely affect their overall experience. Therefore, this kind of approach is really useful in situations where customers don't want to state their needs repeatedly. However, it is important to note that transparent customization can be applied only when customer needs can be accurately predicted.

5. Applications of mass customization

Since its introduction, MC has been applied in various industries and sectors. It has been used as a strategy to tailor products, like clothing and automobiles, and services, like restaurants and hotels, to satisfy customer desires and preferences.

5.1 Manufacturing Operations

Ref. [13] studied the application of mass customization in one of Japan's largest bicycle manufacturing facilities, the National Bicycle Industrial Company (NBIC). The author suggests that mass production and mass customization can be applied in conjunction and that it doesn't have to be one or the other. NBIC has two factories: one for mass production and a smaller one for the fabrication of mass customized products. Company workers rotate from one to the other, leading to the development of a "knowledge-creating system." The main conclusion of the study is that "the interaction between mass-production and mass-customization leads to knowledge creation and organizational learning." The application of mass production and mass customization in NBIC has led to the creation of useful knowledge because highly skilled workers are continuously trained in two different environments, contributing to the development of a very flexible and responsive manufacturing system.

Mass customization applications are also evident in the apparel industry. Ref. [15] explored the new technologies and strategies that have been applied in the apparel industry. Specifically, they explain "how apparel industries practice mass customization and what dynamics of the industry are changed by the impact of mass customization." They cite three different manufacturers:

Custom Foot Inc., Levi Strauss and Second Skin Swimwear, as examples of firms that have applied this approach.

Custom Foot Inc., located in Florence, Italy, manufactures customized shoes for their customers. They use a computer scanner that registers information about the customer's feet, and then the customer selects the specific style, material and color from 160 different models. The shoes are manufactured in seven different factories with an estimated delivery time of three to four weeks from the time an order is placed.

Levi Strauss developed a program called "Personal Pair" and its main objective is to manufacture custom-fitted jeans for women. In the store a sales person would take four initial measures and enter them into a computer system. The system would suggest some initial "prototype test garment" that the customer would try on and based on the fit the customer would decide on the needed adjustments, such as shorter, longer, tighter or looser, for example.

Second Skin Swimwear developed a mass customization strategy where customers had to first try on some sample suits and choose the one that he or she likes best. A digital camera would then scan the customer's body, and the customer would select the fabric from a broad range of options. All the information would then be entered into a computer and sent to the manufacturing facility. The time to manufacture and deliver the suit is less than two weeks.

All three examples show how some apparel manufacturers have used new technology in developing new tools to customize clothing. These companies have used scanners, digital images and the internet, among many others, in order to get more accurate information about their customers. And then, based on that information, the final product is designed, manufactured and delivered, consistent with the MC principles.

Another application of mass customization was studied by [4], which emphasized that nowadays a lack of information regarding how to apply mass customization exists. They studied the case of a Chinese restaurant chain with three outlets and 300 different items on their menu. The high variety of products, along with the main objective of meeting customers' needs best, plus the application of a traditional production system where everything needs to be processed from the very beginning, made the business operations quite complex. Since its offerings include a high variety of items, the company decided to make some strategic and operational changes. First, it chose to outsource most of the primary handling and some of semi-processing activities which had been previously conducted inside the kitchen. Second, it decided to outsource the seafood inventory in order to improve efficiency and reduce inventory risk. The outsourcing of non-core processes "simplified the operational complexity caused by mass customization and helped the company focus on the core competence: innovation in final cooking and better dining services" [4].

5.2 Service Operations

Netflix is a good example of the MC application in service organizations. The company developed a business model that revolutionized the traditional way of movie renting business. Using the Internet, Netflix lets their customers browse a huge selection of movies and other DVDs that wouldn't be available at a regular rental store. As a result, customers get the title they want and, at the same time, Netflix manages to keep the cost low by targeting a mass market. The success of Netflix stems from the advances in technology and the wide access that customers have to the Internet and computers, which especially has increased very rapidly in recent years. This wouldn't have been possible twenty years ago and therefore serves to illustrate that technology is a very useful tool for the application of mass customization.

Another application of MC can be found in the cell phone industry [30]. A number of approaches exist from the customer's viewpoint. For example, in addition to the basic services every customer needs, services such as diverse ringtones, voicemail services, text messaging, access to the Internet each give customers to customize their cell phone services. Consequently, mobile phone services that can develop MC strategies from a customer-centric approach, that enhances both the extrinsic and intrinsic values, have customers that both "give" and "get" customer value dimensions. Ref. [21] explains how MC can be effectively applied in the hospitality industry, which caters to a wide range of customers with varying needs. The customers include those on business trips, pleasure travelers, honeymooners, vacationing couples and families, all with unique needs and desires. The services can be customized to satisfy their needs with options such as wake-up calls, flexible check-in, various in-room entertainments via the television or video games, Internet connections, in-room mini-bar, etc. New features include ergonomically-designed furniture, blankets with space shuttle heat shield technology, and visual alarm clocks that wake guests with increasing levels of light. Each new feature enables the hotel to cater to each individual customer while serving the masses. Also, how MC can support the China Railway Freight Transportation System Service through product design innovation and service process diversification is presented in [9]. The most critical issues to success are: customization ability of production system, rapid delivery system in between production systems and external organizations, and information support systems.

The application of the MC concepts in wireless communications and services is also described in [3]. It advocates for a user-centric view of wireless service configuration and pricing as opposed to present-day service catalog options. Furthermore, the implementation of personalized service bundles and tariffs can be valuable to suppliers and users. In fact, a critical mass of the population, according to research, is willing to adopt mass customized services and tariffs. Furthermore, how MC can be applied in the training industry through four types of customization described earlier is proposed in [5]. Ref. [23] provides a number of case examples from automotive, sports equipment, and credit cards to explain how MC supports and enhances operational and market effectiveness. It is explained in [32] how the Dutch

secondary schools system, which faced diversity-efficiency dilemma, successfully applied the principles of MC to add diversity without adding costs. As schools are encouraged to become increasingly focused on putting individual students at the center, the diversity-efficiency dilemma may cause schools to implement policies students never asked for. Ref. [6] argues that globalization is causing a need for companies to be agile and quick to respond to challenges and changing markets. However, it also contends that companies should not become monolithic and integrate different manufacturing techniques into a framework of both human and technological aspects.

Numerous conceptual ideas regarding the application of MC in service operations exist. A framework for analyzing service offerings, production and networks in terms of modularity and customization is presented in [1]. It provides a basis for analyzing different combinations of these two aspects from the three perspectives: the service offerings, the service production process, and the service production process. The degree of customization used is the penetration of customer involvement in the production process or, from the service offerings perspective, the profundity of the customization experience for the customer. The degree of modularity is the use of modularity principles in production, or, from the customer perspective, the product variants offered with different modules and service levels that can be mixed or matched. Ref. [19] made an attempt to bridge the gap in MC applications in the services industry based on extensive MC research in manufacturing. It suggests that the modularization, delay strategy, and e-commerce platform are the basis for the realization of MC in non-physical product service industries. Challenges to the service industry include a non-physical and indivisible factor, quality differences and the fact that services cannot be stored. Each challenge further delineates the difference between MC in manufacturing and MC in services. A MC based service product innovation (MCSPI), which integrates the personalized service feature for the service industry and the efficiency of mass production in the manufacturing industry, is proposed in [16]. It includes four features: marketing, organization, engineering and design, and operations management. Ref. [33] presented a concept called customerization, a buyer-centric company strategy that combines MC with customized marketing. In addition to its potential benefits and possible challenges, the authors described how such a strategy differs from MC, personalization, and one-to-one marketing. The antecedents of consumer intentions to use MC on the Internet is investigated in [6]. It found that by increasing both the range of MC options and providing complementary online services enhance the perceptions of product outcome, control and enjoyment in using an online MC process. Online retailers can overcome complexity in MC by offering attractive complementary online services that increase buyers' enjoyment and control. Of the three complementary services offered, visualization was the most important. Following visualization were salesperson interaction and free product adaptations. Ref. [20] proposed an idea based on the principles of MC to create brochures for the tourism

industry using the digital printing technology, which may be distributed via the Internet to potential users. It suggests a framework for the cross-media customization of tourism and travel brochures to take advantage of personalization trends. As technology has changed, the traditional printed brochures are giving way to digital printing and the creation of dynamic and customized options.

Using the channel theory framework, based on the MC concept, ref. [12] investigated the online involvement of consumers in a product design environment. It was a web-based simulation experiment that showed the Internet provides an effective, interactive platform and distribution channel for selling mass-customized clothing, which should be considered by e-tailers. The research showed the presence of high customer satisfaction with design involvement in a web-based MC process. However, increasing the design features does not necessarily translate to higher customer satisfaction. The MC implementation issues were analyzed in [22], which concluded that companies wishing to adopt an MC strategy must be able to understand various market and customer demand factors. Specifically, it found that the information technology-related factors and process capabilities are the most difficult to implement. On the other hand, modularization for service operations is relatively easy to achieve. Furthermore, knowledge-based services provide better customization opportunities than physical goods due to the higher level of customer contacts. Elsewhere, ref. [10] presented a revised framework for MC that can be used as a means to achieve a competitive advantage for service organizations by effectively meeting the diversity of customer requests. With examples from the banking and software services industry, it was argued that services should be viewed as a process of customer co-creation creating substantial customer value instead of focusing solely on cost reduction through economies of scale. The research also points to the differences between MC in goods and services, stating a higher difficulty in achieving MC in services.

6. Conclusion:

Mass Customization is a business strategy that, if implemented appropriately, could result in significant benefits for a company. The development of a continuous elicitation process with the customers, a flexible manufacturing and operational system, and a dependable logistics system are the basic principles for the design of the production process. Without doubt, the mass customization principles can be applied in both manufacturing and service operations. This paper provides a literature review of the application of mass customization in businesses that create and deliver both tangible goods and intangible services in order to satisfy their customers' needs and expectations.

It could be stated that there exist plenty of possible applications of mass customization that have not yet been explored. Technology has played an important role in the application of mass customization in many business environments and will continue to do so in the future. Advances in technology as well as the ever changing

customer needs and market competition will compel manufacturers to find innovative ways of adding value to their products and services. Mass customization will remain one of the options that many firms will need to pursue.

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