



A decision support model in mass customization

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ABSTRACT

Mass customization (MC) is one of the leading strategies used in production industries in today's market filled with competition. MC is an oxymoron of controlling production costs and satisfying customers' individual requirements. It is well known that economy of scale and economy of scope is a pair of conflicts, and how to get the balance between them is the key issue to promote enterprises' competition. By analyzing and processing information of customer preference, product features and cost, this paper proposes a decision support model in mass customization to obtain the optimized production solution. Genetic algorithm is used for optimization, and the results of an illustrative example show that the model is efficient in production industries.

1. Introduction

With the rapid improvement of human's production level and information processing ability, simply considering the mode of mass production and/or personalized customization cannot meet people's requirements. New production paradigms are driving by changeable markets and diverse evolved social needs (Koren, 2010). Companies began to call for a comprehensive production mode considering both customers' personalized needs and low cost brought by mass production, which can promise sustainable development of companies. With continuous exploration and practice, a new production mode is gradually applied in manufacturing industries, which is known as mass customization. In "Future Shock", Toffler, 1970 creatively proposed an innovative idea which can meet the specified requirements of customers with cost close to that of standardized production. Davis, 1987 named the proposed production mode as mass customization in "Future Shock". Mass customization considers both the economics of scale and economics of scope, in order to achieve personalized customer demand at the cost of mass production. Mass customization (MC) is usually referred as a term as an oxymoron of mass production and customized goods (Kaplan & Haenlein, 2006), and it has become an undisputable reality that MC is one of the leading strategies in satisfying customers and assuring companies survival in today's markets characterized by constantly changing environment, rapid technology progress and fierce market competition (Daaboul, DaCunha, Bernard, & Laroche, 2011).

With the improvement of peoples' living standards, consumers no longer simply focus on product function, but more and more prefer personalized products, which can satisfy their subjective perception

(Trentin, Perin, & Forza, 2014). On the other hand, personalized production will cause reduction of production scale, expansion of product range and cost rising, because it is unable to make multiple products with a single production template. Different modern production systems are used to solve the above mentioned problems, such as lean manufacturing, cellular manufacturing and batch production. Lean manufacturing is a management philosophy derived mostly from the Toyota Production System (TPS). It is a systematic method for waste minimization within a manufacturing system without sacrificing productivity, by reducing everything which is not adding value (Onyeocha, Khoury, & Geraghty, 2015). As a subsection of lean manufacturing and just-in-time (JIT) manufacturing, cellular manufacturing is a process of manufacturing which encompass group technology. It moves as quickly as possible, while making a wide variety of similar products and, at the same time, as little waste as possible (Bootaki, Mahdavi, & Paydar, 2016). Different from mass production, also called as flow production or continuous production, which is a production mode to provide large amounts of standardized products, batch production is a technique used in manufacturing, in which a series of workstations stage by stage is created, and different batches of products are made (Al-Salamah, 2016). Different from those modern production system, mass customization aims at providing diversified products and service to consumers, and ensuring that each consumer can get the specific product he/she needed with a reasonable price (Trentin, Forza, & Perin, 2015). Mass customization will not meet all of consumers' individual needs regardless of cost, because relatively high cost is not economical for both consumers and companies. The features of mass customization are: reducing production cost by economics of scale and better meeting

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clients' requirements by economics of scope. As a result, mass customization will become the main production mode used in manufacturing industries.

2. Mass customization analysis

Mass customization refers to the capability to provide customized product/service for a mass market. The essential value of mass customization is to satisfy customers' individual preference at a low cost brought by mass production (Wang, Zhang, Sun, & Zhu, 2016). High quality and high efficiency are required in mass customization, and customers are usually involved in the production and service process, so as to get the products featured by their own personal attributes.

Mass customization makes high added-value products/services, and enhances profitability by reducing the costs of production and logistics and better satisfying the customer personalized requirements (Grenci & Watts, 2007; Jiao, Ma, & Tseng, 2003). When an enterprise is able to offer personalized or customized products, customer is then involved in the product design process, which may increase the value of the product – customer perceived value (CPV) (Gautam & Singh, 2008). One of the most distinguished features of mass customization is to provide customers with the possibility to co-design products/services according to their personalized preferences and interests (Ogawa & Piller, 2006). Products/services can be considered to be an integration of different modules, and different features of these modules can satisfy customers' needs and provide value, which requires an efficient product family design strategy (Tyagi, Yang, Tyagi, & Verma, 2012). However, excess complexity in product configuration has a negative impact on performance, especially for small companies, as Brunoe and Nielsen (2016) pointed out. Fang, Li, and Lu (2016) pointed out that learning and innovation can also significantly influence process automation so as to enhance performance.

Implementing mass customization in manufacturing industry is quite challenging and a variety of elements such as customer requirement and preference, supply chain management, customer relationship management, manufacturing process, price issues should be considered. Information about all these elements is recognized as a manageable key resource for enterprises to survive and develop (Bernard & Tichkiewitch, 2008), and people are paying more and more attention in knowledge and information processing during production development (Xu, Bernard, Perry, Xu, & Sugimoto, 2014). How to process production information in a quantitative way is very crucial to improve decision support model in a given business context, for example, mass customization. Scale effect is one of the primary means to reduce costs (Easton & Sommers, 2003). A decision support model should be applied to balance the two sides of scale effect and customized requirements. This paper will make a quantitative study to solve the core problem in mass customization: to what extent the benefit brought by customization can compensate the increased cost caused by quantity reduction.

One important issue to be discussed is how to determine the customization degree in mass customization from the point of view of product lifecycle. Manufacturers should take into account clients' requirements and production cost to decide what categories of product should be produced at what quantity, then make production plan of each stage of the whole product lifecycle. Taking clothing industry as example, apart from luxurious product such as customized suit, clothing industry is mainly based on mass production strategy. However, as new brands are emerging on the market, more competitors are dividing the market, so that personalized production directed by distinguished customer groups is a trend. Therefore, it is necessary to consider using mass customization model in clothing industry, and to integrate factors like diverse customers' needs gathered through market research, production cost, time delay, etc. By constructing a quantitative model, producers can decide the best balance point between customers' preference and product cost.

Due to the diversity of market and the limit of enterprise resource, enterprise can hardly meet any needs of all the customers. A relatively rational strategy for enterprise is to make market division so as to fix the target markets and potential consumers, and then clarify market and consumer positioning. On one hand, enterprises should concentrate resources to meet part of customers' needs, and on the other hand, enterprises should consider alternative choice to substitute the other part of customers' need, in order to maximize company's profit by reducing costs and promoting sales.

Due to the fixed costs and technique development, economies of scale would reduce the average cost of products to some extent, so mass production strategy is usually chosen by companies. However, homogenous products can hardly meet consumers' diverse needs. Taking sport clothing industry as example, it is a buyer's market and consumers have many choices as alternatives that are quite available.

If enterprises choose mass production mode without specifying customers' requirements and personal preferences, it will likely lead to the loss of customers, or the decrease of customer's satisfaction and loyalty. In such cases, significant decline in sales will reduce company's profit, or even lead to losses. Potential impacts may include harm to corporate image. So choosing traditional mode of production or marketing is not appropriate. On the other hand, although to provide clients with fully customized product will meet their personal needs and ensure high customer satisfaction and loyalty, product sales quantity will be quite few, especially in luxury industry. Further, fully customized product leads to high costs. Clients have a diversity of requirements, mapping to diverse products, and each type of product has quasi-fixed cost (cost which will happen if this type of product is produced, otherwise no cost is needed), so if production quantity of each type of product is too small, income may not cover cost and overall profit will drop. As for sport clothing industry, apart from special customization for professional athletes, most companies rely on large quantity sales, so pure customization mode is not appropriate either. As insightful results in mass customization application, Yao and Liu (2009) set up a dynamic and multi-objective optimization mathematical model and appropriate solving algorithm to solve optimization and scheduling problems in mass customization. Yang, Dong, and Chang (2012) presented a direct approach to encoding configuration models into the Dynamic Constraint Satisfaction Problems (DCSP), where low-level components join in the solving process only after its high-level component is selected in the configuration. Dou, Zhang, and Nan (2016a) proposed an approach to customer-oriented product collaborative customization for manufacturer to improve the design process, and experimental results demonstrated that the approach could effectively identify customers' preference and obviously improve their customization efficiency. Dou, Zong, and Nan (2016b) proposed a multi-stage interactive genetic algorithm (MS-IGA) to ameliorate user experience and evaluation process, and when it is applied to the conceptual design system, the knowledge of users' personalized requirements is better captured.

From analysis above, we may infer that traditional mass production method and pure customization mode are either appropriate choice for sport clothing companies, so mass customization, which is a balance between them, could be an ideal choice to maximize companies' profit.

In spite of a certain degree of risk caused by the attempt of applying mass customization, it is worth making this choice as customer satisfaction and loyalty can be greatly improved without increasing too much cost, especially in today's society characterized by individualization and differentiation.

The most interesting task of mass customization is how to increase product diversification and customization without too much increase of product costs. Thus, mass customization is applied by more and more enterprises to attract customers and make more profits. A survey based on market investigation shows that customers are willing to pay more to get customized sport clothes (different colors, logos, words, graphics, etc., which can be determined by customers) rather than homogeneous

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