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## Int. J. Production Economics

journal homepage: [www.elsevier.com/locate/ijpe](http://www.elsevier.com/locate/ijpe)

# Optimization analysis of supply chain scheduling in mass customization

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## ARTICLE INFO

### Article history:

Received 12 June 2006

Accepted 20 October 2008

Available online 5 November 2008

### Keywords:

Mass customization

Supply chain scheduling

Dominant contradictions

Optimization

## ABSTRACT

How to deal with the contradiction between scale production effect and customized demand is the key problem on studying mass customization (MC). When MC is operating in supply chain environment, on one hand, the excellent operating character of the supply chain will give conditions for solving this problem. On the other hand, it will bring out several complicated contradictions and increase the difficulties of the analysis and research on the supply chain operating and scheduling, so it is important to settle the contradictions. Based on our earlier work, the dominant contradictions of the supply chain scheduling in MC and the ways to relieve them are briefly summarized in this paper. A dynamic and multi-objective optimization mathematical model and the appropriate solving algorithm are set up by introducing these relieving methods into the operating process. It is pointed out that the characteristics of the model and algorithm cannot only reflect the unique operating requirements for this special production mode, but also merge with the thought of relieving the dominant contradictions. The feasibility of the model and algorithm in practical application to improve the scheduling efficiency and to settle the key problem mentioned above ultimately gets validated through the analysis of an application case we followed and through the algorithm simulation of a numerical scheduling case.

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## 1. Introduction

'Mass customization (MC) relates to the ability to provide customized products or services through flexible processes in high volumes and at reasonably low costs' (Silveira et al., 2001). How to deal with the contradictions between scale production effect and the satisfied level of customized demand is the key problem on studying MC (e.g. Pine II, 1993; Fogliatto and da Silveira, 2008). In this aspect, the postponement has been widely used by many scholars (e.g. Brun and Zorzini, 2008; Li et al., 2007; Jiao et al., 2003; Ma et al., 2002; Ernst and Kamrad, 2000). The result of this tactics reflects mainly on

the reduction and optimization of the customized quantity, and its core is to delay the customer order decoupling points (CODP) (e.g. Gu et al., 2002). However, the optimizing result may lead to the lower level of the customized diversification, which will finally affect the promotion of the customer satisfaction level. On the other hand, with the unceasing change of people's consumption pattern and the increasing promotion of the customized level, the modes of approximately full customization and urgent customization will occur. These two modes are the concentrative reflections of the high degree of the customized demand. Then, there will be some contrary relations between the high customized demand and the traditional optimizing mechanism of the postponement to a certain extent. Therefore, it is required to look for a new effective method for this problem.

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When MC is operating in supply chain environment with the high flexibility, on one hand, the excellent character of the supply chain system will create the conditions for settling this key problem; on the other hand, the random information of the customer orders and the relation complexity of the supply chain cooperators will cause many complicated contradictions in operating process and increase the difficulty of the supply chain management (SCM). In this aspect, the main problem we should be concerned with is the supply chain scheduling optimization in MC. As a new production mode, the key problem of MC is to simultaneously obtain the satisfied customer response, cost benefit and production scale (Tu et al., 2001), and the operating efficiency will be embodied in the optimization of production management. So, the rational scheduling optimization will be a key idea to settle the problem in the former paragraph.

Bose and Pekny (2000) pointed out that 'the supply chain scheduling is a process to carry out effectively the flow of materials in the supply chain system'. This is the general description of the supply chain scheduling. However, the supply chain scheduling in MC is a typical stochastic and dynamic process. The dynamic character comes from the stochastic demand and the stochastic production capacity of different cooperators in supply chain environment (Yao and Zhou, 2003). It is well known that stochastic and dynamic problems are hard to solve (e.g. Gerard, 1999; Charles, 2001; Tormos and Lova, 2001; Cochran and Uribe, 2005). So to improve the efficiency of the supply chain scheduling, we should reasonably handle the problems in the stochastic and dynamic process. For these complicated stochastic and dynamic characters will probably induce several restriction factors to the scheduling process and then initiate the complicated contradictions and scheduling bottleneck problems, to settle or relieve the contradictions is the key in our paper. Therefore, the aim of our paper is to unearth the dominant contradictions of the supply chain scheduling in MC and to put forward the methods to relieve them. Then we will imbed these methods into the dynamic scheduling optimizing process and the settling process, and apply them to improve the customized service level and the comprehensive benefit level of the supply chain cooperators.

## 2. Related work

### 2.1. Problems in present study

The supply chain scheduling optimization in MC belongs to a forefront research field, and the complete analysis and settling process of it are not found in the related works. So, we should understand the present researches from several different aspects and make them the background of our work. According to the main idea of this paper, we will briefly analyze the optimization of MC, the optimization of the supply chain and the combination of these two modes. By analyses, we are mainly to find out the ideas to settle the contradictions between the scale production effect and the customized level in MC, the

stochastic and dynamic characters in supply chain operation and the multi-objective problem of the production optimization.

Since MC was put forward as a mainstream production mode in 21st century by Pine II (1993), it has been intensively studied in recent years (e.g. MacCarthy et al., 2003; Duray et al., 2000; Smirnov et al., 2003). To the optimization idea of it, most authors focused on the object dimension (the make-up and design of products) in two-dimensional production system. Jiao et al. (2003) pointed out that the basis of MC is the ability of corporations to forecast and capture the potential demand information and the ability to develop according to the various demand. However, it is very important to deal with the inherent contradictions among quick responsiveness, customization and economy of scale in the implementation of MC. In other words, a successful MC should have the equilibrium of three factors including character, cost and scheduling. Then he put forward an idea to optimize MC by maximally using common components.

As can be seen from the introduction, in the aspect of dealing with the contradictions between the scale production effect and the customized demand in MC, the postponement is widely used by many scholars (e.g. Jiao et al., 2003; Ernst and Kamrad, 2000). Gu et al. (2002) made a relatively comprehensive analysis of the operation optimization in MC in his paper, named 'Research of the optimization methods for mass customization'. Firstly, he illustrate that the implementation of MC is a progressive procedure by an efficient optimization model; secondly, he put forward two optimization models to minimize the customization. Its core idea is to expand the optimizing range of product class and push CODP to downstream at the same time. These former works laid the foundation of optimizing MC to a certain extent that is to decrease the customization and mostly utilize the common components and technological process to reduce the customization composition. Then, it can reduce the class variety induced by the customized demand and finally realize the unity of the scale production and the customized production. The essential of this idea is to give full scope to the postponement and then to promote the scale effect, which is obviously reasonable. The key of this optimization is to improve the flexibility of MC and the realization way of it lies in the improvement of the product developing and production technology.

However, the promotion of the customized level reflected by the diversification of the product character and the delivery date will be probably influenced by reducing and optimizing the customization. There is obviously a contradiction in it and how to settle the contradiction is the key in present study. To settle this key problem, we integrate the mode of MC into the special operational environment of the supply chain, for the excellent flexibility of the supply chain system is advantageous to relieve this contradiction.

The early idea of integrating MC with the supply chain can be seen in Pine II (1993). With the theoretical and practical development of SCM, this idea is increasingly unfolded before our eyes by many authors (e.g. Jack, 2001; Jonah et al., 2003; Akkermans et al., 2003). They point out

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