Transportation Research Part E 83 (2015) 189–215

Contents lists available at ScienceDirect

Transportation Research Part E

journal homepage: www.elsevier.com/locate/tre

# A scheduling model of logistics service supply chain based on the mass customization service and uncertainty of FLSP's operation time

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ARTICLE INFO

*Article history:*
Received 9 February 2015
Received in revised form 14 August 2015
Accepted 15 September 2015

*Keywords:*
Logistics service supply chain
Mass customization service
Scheduling
Uncertainty of operation time
Goal programming method

ABSTRACT

Building on previous research, this paper establishes a new multi-objective program scheduling model of Logistics service supply chain that considers the uncertainty of operation time for functional logistics service providers (FLSPs) in a mass customization service environment. This model aims to minimize total scheduling costs, minimize the difference between the scheduled and actual time of each service process, and maximize the average satisfaction of FLSPs. Considering the differences in target priority, the goal programming method is applied to solve the model hierarchically. In addition, the effects of scheduling parameters on scheduling objectives are provided after numerical analysis.


## 1. Introduction

As an advanced production operation mode, mass customization has been gradually applied in the service sector. For example, in the logistics industry, as customer requirements for specialized and customized logistics services increase, many logistics enterprises have begun to change their service mode from large-scale logistics services to mass customization logistics services (Chandra and Kamrani, 2004). In the mass customization logistics services (MCLS) environment, many logistics enterprises have spontaneously formed logistics service supply chains (LSSCs) through alliances and integrations to satisfy customers' customization requirements, to increase scale benefits, and to reduce the uncertainty in the service process (Choy et al., 2007; Liu et al., 2011). The basic structure of the LSSC is functional logistics service provider (FLSP) → logistics service integrator (LSI) → customer (such as manufacturing enterprises and retail enterprises) (Liu et al., 2006).

The LSI plays an important role in mass customization logistics services. On one hand, the LSI must negotiate with the customer to clarify time and customization requirements; on the other hand, the LSI must purchase logistics capabilities from FLSPs to meet the customer's service requirements. To ensure that the completion of the logistics service is consistent with customer requirements, an LSI typically requires FLSPs to provide the standard time to complete one service process. However, in actual service, FLSPs are susceptible to external environmental factors (such as weather and traffic) that may cause the actual service time to deviate from the standard time (Weng and McClurg, 2003; Kaminsky and Kaya, 2008;

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http://dx.doi.org/10.1016/j.tre.2015.09.003
1366-5545/

Guiffridaa and Jaberb, 2008; Hsu et al., 2008; Liu et al., 2015). Therefore, when making the LSSC's schedule, the LSI should fully consider the uncertainty of the providers' operation times.

In LSSCs, time is an important index of logistics service level, so time scheduling is a key issue in logistics service supply chain scheduling. The schedule must reasonably consider customers' demands and service capacity supply and strike a balance between the two competing demands. From a theoretical perspective, research on time scheduling in the manufacturing supply chain has recently caught the attention of many scholars (Lee et al., 2006; Wang and Cheng, 2007; Yimer and Demirli, 2010; Bhatnagar et al., 2011; Osman and Demirli, 2012; Liu and Chen, 2012; Low et al., 2013; Thomas et al., 2014; Selvarajah and Zhang, 2014; Agnetis et al., 2014; Chauhan et al., 2007; Naso et al., 2007; Pei et al., 2015; Karimi and Davoudpour, 2015; Han et al., 2015). However, there is still a dearth of research on time scheduling in the service supply chain. Although the most relevant publications are previous studies that have discussed the scheduling model of the logistics service supply chain in recent years (Liu et al., 2012, 2014, 2015), uncertainty of operation time is not integrated well in previous models. The deficiencies in these models are as follows.

First, the previous research regarding service scheduling does not consider the time uncertainty problem involved with supplier operations, which might be delayed or ahead of schedule (Miao et al., 2012; Liu et al., 2012, 2014). Upstream FLSPs that arrive early or late in one process affect subsequent FLSPs' normal operations downstream, which in turn affects the overall performance of supply chain scheduling. However, the various influences that upstream FLSPs have on downstream FLSPs have not been considered in the models on supply chain scheduling (Liu et al., 2012, 2014, 2015). Therefore, it is important to consider the uncertainty of FLSPs' operation times when the LSI makes scheduling plans.

Second, the previous research on supply chain scheduling does not consider the hierarchy of objective weight (Yeung et al., 2011). In terms of objectives, supply chain scheduling is a multi-objective programming problem (Chauhan et al., 2007; Liu et al., 2012; Karimi and Davoudpour, 2015; Han et al., 2015) that involves a balance of time, cost, and FLSP satisfaction. Similarly, each objective may have a different priority. In terms of service stages, a large-scale service stage is more concerned with cost, whereas a customized service stage is more concerned with time. Thus, in the MCLS environment, both the hierarchy of each scheduling target and the weight of the same objective in different stages should be considered.

Third, previous scheduling studies tend to assume that an FLSP's operation is continuous, i.e., that the processes in a supply chain are conducted one after another successively, without interruption. If the first service process is finished (no matter whether it is finished in advance of or behind schedule), the next process will simply start successively and seamlessly (Liu et al., 2012, 2014, 2015). However, in practice, service interruption occurs when the service connection linking upstream and downstream does not run smoothly. Therefore, when studying scheduling models, service interruption between FLSPs must be considered.

To solve these problems, this paper builds on Liu et al. (2012, 2014), and Liu et al. (2015) and establishes a new scheduling multi-objective programming LSSC model that considers uncertainty in FLSP operation time. Moreover, this model aims to minimize both the total scheduling cost and the difference between the scheduled and actual times of each service process and to maximize the average level of satisfaction degree of the FLSPs. Then, the goal programming method is used to solve the multiple-objective model hierarchically. Thus, our contributions in this paper are as follows.

First, this paper differs from previous related research by considering the uncertainty of time scheduling. The service time of each process is expressed with uniform distribution, and the possibility of interruptions between the prior service processes and the latter subsequent processes is involved accounted for in the model. Various combinations between of the actual complete time of the $i$th FLSP in upstream and that of the $(i+1)$th FLSP in downstream are taken into account. Both the advancing early punishment costs and the delayed punishment costs for different scenarios are well considered.

Second, our model identifies the influence of objective priority on scheduling results using large-scale numerical analysis, which is clearly different from the methods employed in previous research. Based on the differences in objective priorities that are inherent in different objectives and service stages, a multi-objective programming model –, as a goal programming model –, is built. Then, and the sequential optimization algorithm is applied to solve the goal programming model.

Third, some significant findings obtained in this study differ from the previous literature (such as Liu et al. (2012) and Liu et al. (2014)). For example, the results in this paper indicate that the LSI should adopt different time scheduling when the priorities of the scheduling objectives concerned involved are different. If the customer's expected order completion time can be appropriately delayed, the optimal level of each scheduling objective can be improved. Furthermore, when the priorities of scheduling objectives vary, the influence of the rewards and punishment cost coefficients on scheduling objectives is significantly different. In addition, the variation law has no relationship with the change in the custom order decoupling point (CODP).

This paper is organized as follows. Section 2 presents a literature review, which systematically summarizes the uncertainty of the FLSP's operation time, mass customization, and the supply chain time scheduling model. Section 3 describes the problem and assumptions. Section 4 presents the model and explains its solution. Section 5 presents numerical analyses with multiple sets of data and includes a discussion of the influence of certain important parameters on LSSC scheduling objectives. The main conclusions and management insights are discussed in Section 6, which provides the reference values for researchers and managers. Section 7 presents the limitations of the paper and discusses future work in the field.