A Queueing-Game Model for Making Decisions About Order Penetration Point in Supply Chain in Competitive Environment

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ABSTRACT

This study is dedicated to Order Penetration Point (OPP) strategic decision making which is the boundary between Make-To-Order (MTO) and Make-To-Stock (MTS) policies. This paper considers two competing supply chains in which a manufacturer produces semi-finished items on a MTS basis for a retailer that will customize the items on a MTO basis. The two-echelon supply chain offers multi-product to a market comprised of homogenous customers who have different preferences and willingness to pay. The retailer wishes to determine the optimal OPP, the optimal semi-finished goods buffer size, and the price of the products. Moreover, the authors consider both integrated scenario (shared capacity model) and competition scenario (Stackelberg queueing-game model) in this paper. A matrix geometric method is utilized to evaluate various performance measures for this system and then, optimal solutions are obtained by enumeration techniques. The suggested queueing approach is based on a new perspective between the operation and marketing functions which captures the interactions between several factors including inventory level, price, OPP, and delivery lead time. Finally, parameter sensitivity analyses are carried out and the effect of demand on the profit function, the effect of prices ratio on completion rates ratio and buffer sizes ratio and the variations of profit function for different prices, completion percents, and buffer sizes are examined in both scenarios.

Keywords: *Competitive Environment, Game Theory, Integrated Operations-Marketing Perspective, Make-To-Order (MTO), Make-To-Stock (MTS), Matrix Geometric Method (MGM), MTS-MTO Queue, Order Penetration Point (OPP), Queueing System, Supply Chain*

DOI: 10.4018/ijsds.2013100101

1. INTRODUCTION

One production system which has recently attracted researchers' and practitioners' consideration is hybrid MTS-MTO (Rafiei & Rabbani, 2012). The MTS production system can meet customer orders fast, but confronts inventory risks associated with short product life cycles and unpredictable demands. In contrast, the MTO producers can provide a variety of products and custom orders with lower inventory risks, although they usually have longer customer lead times. Moreover, in MTS production, products are stocked in advance, while in MTO production, a product only starts to be produced when an order of demand is received. The MTS-MTO supply chain is appropriate where common modules are shared by various finished products through divergent finalization. The MTS-MTO supply chain inherits two key characteristics. First, it can lower the cost by taking advantage of economies of scale during the MTS stage for the production of standard modules. Second, it can concurrently satisfy the requirement of high product variety by taking advantage of the MTO stage's flexibility (Wang et al., 2011). The Order Penetration Point (OPP) specifies where the customer's desired specifications influence the production value chain (Hoekstra et al., 1992) and the customer's specifications are considered in different places along the production systems in MTS, MTO and MTS-MTO.

The positioning of OPP is a challenging area that has received increasing attention in the manufacturing strategy literature (Hallgren & Olhager, 2006). According to Teimoury and Fathi (2013), OPP is taken into consideration in different locations along the production systems in MTS, MTO and MTS-MTO. Accordingly, we consider three environments MTS, MTO and MTS-MTO for positioning OPP in supply chain networks as the analysis of the problem is different for each environment. By bringing Table 1, we prefer to display a general overview of our developed OPP models for readers in this section. As shown in Table 1, our developed OPP models in Teimoury et al. (2010), Teimoury et al. (2011) and Teimoury et al. (2012), Teimoury and Fathi (2012), Teimoury and Fathi (2013), Teimoury et al. (2013), current research) are in MTS, MTO, and MTS-MTO environment, respectively.

The motivation for this study is that companies are showing increasing interest in incorporating the OPP as an important input into the strategic design of supply chains in competitive environment. Moreover, making decision on the price of products in competitive supply chains with price sensitive demand function is considered as a strategic decision-making with respect to location of the OPP. In practical competitive supply chain management, financial aspects such as the price of a finished product, which has a direct relationship with customer satisfaction, play a vital role. This competitive decision making is affected by different factors such as supply chain configuration and structure, and delivery lead-time. Therefore, we believe that the integrated operations-marketing perspective is needed in positioning OPP in supply chain networks in competitive environment. The rest of the paper is organized as follows. The corresponding literature is reviewed in the next section. The problem description and list of notation are explained in Section 3. The model formulation is studied integrated scenario (shared capacity model) in Section 4.1 and competition scenario (Stackelberg queueing-game model) scenarios in Section 4.2. Besides, the queueing aspect and performance evaluation indices are studied. Section 5 is dedicated to a two products supply chain numerical example. And finally, the study is concluded in Section 6.

2. LITERATURE REVIEW

2.1. Order Penetration Point

There are a number of papers addressing the issue of making decisions on OPP which appeared in the literature with various names such as Decoupling Point (DP), Delayed Product Differentiation (DPD) and product customization postponement. The term DP, in the logistics framework was first introduced by Sharman