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Evaluation of postponement structures to accommodate mass customization

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Abstract

In order to meet increasing customer demands for more diverse product offerings, firms are revising their supply chain structures to accommodate mass customization. The revised structures often involve delaying the delivery of the products until after the customer orders arrive, termed time postponement (TP), or delaying the differentiation of the products until later production stages, termed form postponement (FP). We develop models representing possible implementations of the TP and FP structures and compare their performance in total supply chain cost and expected customer waiting times. We find that once the number of different products increases above some threshold level, the TP structure is preferred under both performance metrics.

For the most general model, a numerical experiment was designed to investigate how different factors affect the performance of the TP and FP structures. Through this experiment we show that higher arrival time and process time variations make the FP structure more favorable while increases in the number of products and higher interest rates make the TP structure more favorable. We also offer guidance to managers using either structure on where to allocate resources for performance improvement. For example, to improve the customer waiting times under the FP structure, increasing the coverage of the generic component and reducing the number of products provide larger benefits than reducing the variability of the arrival and process times.

Keywords: Supply chain management; Operations strategy; Mass customization; Postponement

1. Introduction

Companies are providing a larger degree of product customization to fulfill the needs of increasingly differentiated customer segments. The Internet helps make this possible by providing companies with a low cost platform to interact with their customers. McCarthy (2000) described a Hong Kong-based Internet site where customers can design their own watches. Other examples of industries providing more customization include: eyeglasses (Gilmore and Pine, 1997), color paints (Pagh and Cooper, 1998), and automobiles (Pine et al., 1993).

To offer greater variety in a cost efficient way (also referred to as mass customization), various supply

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chain structures have been explored. Many of these structures involve either delaying the delivery of the products until after the customer orders arrive or delaying the differentiation of the products until later stages of the supply chain. Zinn and Bowersox (1988) labeled the former as time postponement (TP) and the later as form postponement (FP). They show that postponement structures allow firms to meet the increased customized demands with lower inventory levels in the case of TP, or with shorter lead-times in the case of FP. In a recent review paper on postponement, van Hoek (2001) states: ''Postponement is consistently mentioned as one of the central features of mass customization." Given their apparent advantages and widespread use in industry, each of these structures deserves a critical review and comparison.

Employing TP involves delaying the manufacturing and shipping of the product until after the customer orders are received, also commonly referred to as a ''make-to-order'' approach. Production and distribution of the product, as such, is most often centralized in a single facility. An example of a company using TP is Bang and Olufsen, a high-end television and stereo-system manufacturer based in Denmark. All Bang and Olufsen products are made-to-order at a centralized plant and shipped directly to customers. The need for holding safety stock is eliminated when using TP and customers must be willing to wait the entire manufacturing lead-time for their customized products.

In contrast to TP, employing FP involves shipping the products in a semi-finished state from the manufacturing facility to a downstream facility where final customization occurs. In order to delay the final customization of the product, the firm stocks a generic (semi-finished) component from which it draws upon for final assembly. Note that FP is not necessarily an assemble-to-order (ATO) process. An ATO process does not hold inventory of the finished product while the FP structure described here holds finished-goods inventory for each distinct product at the product's respective point of customization. A classic example of a company using FP is Hewlett-Packard's (HP) postponement of the final assembly of their DeskJet printers to their local distribution centers (Lee et al., 1993). Even though the localization of the printers was postponed, the regional distribution centers still produced the localized printers in a make-to-stock fashion.

Research on postponement dates back to Bucklin (1965), who was the first to mention the term ''postponement'' but did not provide any analytical results. Christopher (1992) provided case studies of how postponement works in the European market and Lee et al. (1993) presented the HP DeskJet printer case involving multiple international markets. In both cases, the authors found that significant supply chain savings could be achieved by redesigning the product or process to delay the differentiation decision, resulting in shorter lead-times, and thus, lower safety stocks. Feitzinger and Lee (1997), Lee and Tang (1997), and Grag and Tang (1997) provided analytical models measuring the costs and benefits of delayed differentiation, a type of FP. They showed that reductions in safety stock levels due to risk-pooling is the key benefit while the cost of designing and manufacturing the generic component is the main drawback.

Zinn and Bowersox (1988), Cooper (1993), and Pagh and Cooper (1998) overview different types of postponement structures and discuss their potential benefits but do not provide models to compare the structures analytically. Although the viability of various postponement structures has been discussed, the environments where one type of postponement structure may be better than another have not received sufficient attention. Also, despite the fact that increasing product proliferation is often a major factor behind a firm's decision to incorporate a postponement structure, its impact on the choice of what type of structure to implement has not been addressed. In this paper, we seek to fill these gaps.

We compare the TP structure and the FP structure by using queuing models and derive conditions under which each structure is preferred. In addition, we show how product proliferation affects the supply chain performance of both structures. Two performance measures are evaluated. The first is the total supply chain cost, which includes both the amortized fixed cost and the periodic operating cost. The second is the expected customer waiting time, i.e., the time to fulfill the orders. These two measures are important evaluation criteria for most supply chain managers (Morash, 2001). While cost is a common performance measure, Baljko (2003) shows that delivery speed