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Decision Support

Supplier–manufacturer coordination in capacitated two-stage supply chains

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Abstract

Manufacture-to-order is an increasingly popular strategy in commodity electronics and other similar markets where many different product configurations can be produced from common components. To succeed in this environment, manufacturers need to keep both cost and order fulfillment time low. In this article, we compare three different mechanisms that a manufacturer, whose revenues depend on order delays, may use to affect its component supplier's inventory decisions. These mechanisms are specifying components inventory level, offering a share of the earned revenues to the supplier (called simple revenue sharing), and offering a two-part revenue-sharing scheme. We show that whereas the first two approaches do not lead to supply chain coordination, the two-part scheme does. We demonstrate with numerical experiments that up to a point, the component supplier benefits from having a high utilization of its production facility, whereas the manufacturer benefits from having excess production capacity.

Keywords: Game theory; Inventory; Supply chain coordination; Incentives; Production economics

1. Introduction

The ability to quickly assemble and deliver custom products is a winning competitive strategy; customers get what they want and the manufacturer avoids the costs of shortages and overages (Serwer, 2002). Those who succeed in this business need to have short order-turnaround times and cost-efficient production

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methods. A common practice by manufacturers (also called buyers hereafter) is to require their suppliers to keep ample inventories of components; often as a condition for winning the supply contract. This practice helps reduce order fulfillment time and may lower cost to buyers since investment in each unit of supplier-held inventory is at the marginal cost of production, rather than being at the higher wholesale price charged to buyers. A well-known and successful model of this type of manufacturing operations is the Dell Computer Corporation. It outsources the manufacture of many components and relies on quick deliveries from suppliers to keep order turnaround times low; reported to be about 18 days (Anonymous, 2000).

Naturally, it is appropriate to ask whether the practice of mandating a certain level of components stock is optimal for the supply chain? How can a manufacturer leverage the supply contract with its key components supplier to achieve faster order fulfillment and cost-efficient production? Which types of contracts are Pareto and channel optimal? We attempt to answer such questions in this article.

A manufacturer's demand rate and the sensitivity of its revenues to actual delivery times can vary significantly depending upon it's choices regarding positioning, market characteristics, and competitors' responses. Although our models focus on bilateral (supplier–manufacturer) interactions, the factors mentioned above make the manufacturer's sales revenues negatively correlated with order fulfillment times. The exact nature of this dependence can vary from situation to situation. For example, the manufacturer may incur a tardiness penalty based on the actual delivery time, or else it may need to pay for expedited shipping when orders are delayed (see Section 3 for more details). It should not come as surprise that the simultaneous management of lead times and inventories (particularly component inventories) has attracted considerable attention from industries that are moving toward a manufacture- or configure-to-order strategy (for example, see Ervolina and Katircioglu, 2000; Yao et al., 2000). Our focus is primarily on how supply contracts can be used by the manufacturer to support its strategic choices. That is, our models treat the choice of the size of the product portfolio and the promised speed of delivery as exogenous.

Specifically, in this paper we investigate the interaction between a manufacturer (M) and its component supplier (S) under two situations: central-planner and decentralized decision-making. The central planner model acts primarily as a benchmark against which the more common decentralized supply chain design can be compared. Our approach is to first analyze the simpler case in which the manufacturer's revenue depends on the actual delivery time for each item. Later, we expand our results in two directions by modeling other types of revenue functions, and by relaxing certain assumptions about the characteristics of the supply system.

As mentioned earlier, we have anecdotal evidence which suggests that in several industries it is common for M's purchasing managers to require S to maintain a minimum level of inventory of ready-to-ship components, from which M can draw supplies as demand unfolds. We assume that the supplier attempts to keep a stable stock of components by performing an item-for-item replenishment. In the inventory literature, this type of inventory control policy is called the *base-stock* policy. Mandatory stock keeping increases S's costs, which in the long run are passed on to M in the form of a higher per-unit wholesale price. We show later in this article that when the wholesale price is based on cost plus a fixed markup, which is a common industry practice, mandatory stock keeping is suboptimal. In other words, this arrangement fails to deliver *channel coordination*. Throughout this article, we assume that complete information is available to both players about each other's costs and about the characteristics of each other's production systems.

We propose a benchmark revenue sharing scheme in which M first declares its intention to share a fraction α of its realized revenues with S. This creates an incentive for S to maintain some inventory of components since that reduces order fulfillment time, which in turn increases per-unit revenue. The supplier trades off the benefits of receiving a fraction of the higher per-unit revenue that results from larger components inventory against the increased holding costs, and responds by choosing the target inventory level of components that maximizes its profit. We show that for each offered revenue-fraction, there exists a unique profit-maximizing target stock level for the supplier. Each pair of revenue-fraction and the corresponding target stocking level is called a *contract*. Only those combinations that result in positive expected payoffs to