Revenue Management of a Make-to-Stock Queue

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Motivated by recent electronic marketplaces, we consider a single-product make-to-stock manufacturing system that uses two alternative selling channels: long-term contracts and a spot market of electronic orders. At time 0, the risk-averse manufacturer selects the long-term contract price, at which point buyers choose one of the two channels. The resulting long-term contract demand is a deterministic fluid, while the spot-market demand is modeled as a stochastic renewal process. An exponential reflected random walk model is used to model the spot-market price, which is correlated with the spot-market demand process. The manufacturer accepts or rejects each electronic order, and long-term contracts and accepted electronic orders are backordered if necessary. The manufacturer's control problem is to select the optimal long-term contract price as well as the optimal production (i.e., busy/idle) and electronic-order admission policies to maximize revenue minus inventory holding and backorder costs. Under heavy-traffic conditions, the problem is approximated by a diffusion-control problem, and analytical approximations are used to derive a policy that is simple, and reasonably accurate and robust.

1. Introduction

Electronic marketplaces have changed the way many industries do business. Roughly speaking, an e-marketplace is an Internet trading community that includes buyers, suppliers, manufacturers, their channels of distribution, and support services that deliver finished goods and other value-added services. At the core of an e-marketplace is a secure communication channel that allows participants to interchange real-time market information. Depending on the stage of development of an e-marketplace, the type of information can vary from purely descriptive (such as technical specifications about products and services) to concrete commercial transactions. In terms of applications, business-to-business e-marketplaces have been developed for a wide variety of products such as electronic components (www.brokerforum.com), chemical and plastic products (www.skchem.com), steel (www.e-steel.com), jewelry (www.polygon.net), and industrial equipment (www.truckpartslocator), among many others.

As a concrete example of an e-marketplace, we briefly describe The Broker Forum (www.brokerforum.com), a provider of a Web-based platform that enables online transactions for electronic components on a 24/7 basis. Buyers or sellers can post items they wish to buy or sell at their chosen prices and can even target which sellers

or buyers have access to these offers. A buyer or seller, upon observing a posted item that is deemed attractive, can complete the transaction online in a neutral, secure environment. Buyers and sellers can post as many items as they want in a dynamic fashion; e.g., if a buyer placed an item with a low price and had no takers, he could raise the price in the hopes of attracting a seller. Hence, The Broker Forum has essentially created a spot market for a manufactured, storable good. Most buyers and sellers perform only a fraction of their business at an e-marketplace, and continue to buy and sell items using traditional long-term contracts. Further discussion and examples of e-marketplaces can be found in Kafka et al. (2000), Kaplan and Sawhney (2000), Geunes et al. (2002, part I), Keskinocak et al. (2001), and references therein.

In this paper, we develop an idealized model, which is formulated in §2, for how a single manufacturer uses an e-marketplace to sell a portion of his manufactured, storable product (such as electronic components). In addition to participating in an electronic spot market, the manufacturer in our model also employs long-term contracts to sell its product. We assume that the manufacturer, which is modeled here as a single-server queue operating in a make-to-stock mode of production, initially chooses a fixed price at which buyers can purchase units of the product via a long-term contract. The manufacturer knows the