Dynamic Supplier Contracts Under Asymmetric Inventory Information

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In this paper, we examine a supply chain in which a single supplier sells to a downstream retailer. We consider a multiperiod model with the following sequence of events. In period $t$ the supplier offers a contract to the retailer, and the retailer makes her purchasing decision in anticipation of the random demand. The demand then unravels, and the retailer carries over any excess inventory to the next period (unmet demand is lost). In period $t+1$ the supplier designs a new contract based on his belief of the retailer’s inventory, and the game is played dynamically. We assume that short-term contracts are used, i.e., the contracting is dynamically conducted at the beginning of each period. We also assume that the retailer’s inventory before ordering is not observed by the supplier. This setting describes scenarios in which the downstream retailer does not share inventory/sales information with the supplier. We cast our problem as a dynamic adverse-selection problem and show that, given relatively high production and holding costs, the optimal contract can take the form of a batch-order contract, which minimizes the retailer’s information advantage. We then analyze the performance of this type of contract with respect to some useful benchmarks and quantify the value of prudent contract design and the value of inventory information to the supply chain. Markovian adverse-selection models, in which the state and action in a period affect the state in the subsequent period, are recognized as theoretically challenging and are relatively less understood. We take a nontrivial step towards a better understanding of such models under short-term contracting.

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1. Introduction

Consider a two-echelon supply chain in which a retailer (“she”) buys inventory from an upstream supplier (“he”) in anticipation of random demand. The supplier decides on the type of contract and its terms, subject to the retailer’s participation. Numerous studies have analyzed various important phenomena in this setting, in which all information is public knowledge and there is one period. Broadly speaking, this stream of research analyzes what are referred to as “selling to the newsvendor” models. Important issues that have been analyzed include supply chain coordination (Pasternack 1985, Cachon 2003, and others), quantifying the loss to the system under commonly used contracts (i.e., the price of anarchy—Lariviere and Porteus 2001, Perakis and Roels 2007) and various other contracting issues.

In this paper, we make two assumptions that enrich this relatively well-understood model. First, we look at a standard multiperiod inventory model and assume that dynamic short-term contracts are used by the players. Thus, in any period $t$, the supplier offers a purchasing contract to the downstream retailer, who may choose to buy in anticipation of random demand. Once the purchasing decision is made by the retailer, units are immediately transferred to the retailer and payments are received as per the contract terms. Then, the demand in period $t$ unravels. The retailer carries over excess inventory (if any) to the subsequent period $t+1$ (unsatisfied demand is lost). In period $t+1$, the supplier offers a new contract to the retailer. Second, we assume that sales at the retailer in any period are unobservable by the supplier. Because the supplier knows the distribution of the demand and the quantity purchased in period $t$, he can merely infer the distribution of the retailer’s beginning inventory in period $t+1$. Thus, in any period, the supplier has imperfect information about the retailer’s beginning inventory and factors this in when designing the contract. As a result, we analyze a dynamic adverse-selection model with Markovian dynamics, i.e.,