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Flexible procurement contracts for competing retailers

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ABSTRACT

We consider a manufacturer that offers one or both retailers opportunities to purchase in advance before uncertainty in market size is resolved. When the retailers order in advance, they may order simultaneously, or only one of them may order. Upon receiving orders, the manufacturer produces and delivers them. After uncertainty is resolved, the retailers may trade stock with each other. In addition, they may purchase more from the manufacturer. We identify sufficient conditions for the existence of pure-strategy equilibria and obtain sufficient conditions for advance stage procurement and recourse stage trading to occur. These structural properties are used in a numerical study that sheds insights into the manufacturer's and retailers' procurement contract design preferences and how these preferences are affected by production cost structure and demand variability.

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1. Introduction

Manufacturers and suppliers have long offered bilateral procurement contracts to their customers. Increasingly, such contracts are complemented by additional purchasing opportunities. For example, in the semiconductor industry, manufacturers of short-lived dynamic random access memory chips (DRAMs) use bilateral contracts to sell their products to original equipment manufacturers (OEMs) in the product design stage. Subsequently, after market demand is better understood, the manufacturers and the OEMs trade with each other to better match supply with demand (Mendelson and Tunca, 2007 and references therein).

While manufacturers in the DRAM market make bilateral arrangements simultaneously with all OEMs, manufacturers in other industries may offer advance purchase opportunities to only a limited number of buyers. For instance, a publisher may decide to pre-sell a new title only to a retailer such as amazon.com or to selected book clubs. However, for other titles, the same publisher may decide to release them widely by selling simultaneously through multiple channels spanning supermarket chains, big box stores, and smaller book stores through distributors. Subsequently, each of these retailers may place additional orders after the release date.

Offering more than one procurement opportunity to retailers is not limited to goods. Many service products are also sold with similar strategies. For example, in addition to direct sales, airlines have long pre-sold seats in bulk at discounted prices to consolidators whose distribution channels are different from those of travel agencies. As a result, complicated dynamics can ensue since travel agents may purchase seats from the consolidators, the travel agencies, or the airlines themselves.

As noted by Su (2010), analogous distribution strategies are evolving in the entertainment industry: tickets for sports and entertainment events purchased in advance are resold, sometimes with high premiums through third party consolidators such as StubHub!. Possibly as a belated competitive response, Ticketmaster announced later that it will introduce "flexible pricing", allowing it to sell tickets close to the event date at prices different from the initial ones (Sisario, 2011).

These motivating examples clearly demonstrate that a manufacturer or supplier of goods or services has to make several strategic decisions regarding production, pricing and distribution of its product. Should it allow the retailers to purchase in advance when demand uncertainty is high? If so, what price should be offered for the initial purchase quantity? Should it endow only some retailers (buyers) with the right to purchase in advance or offer this opportunity to all retailers? After market uncertainty is resolved, the retailers may find that they had ordered too much or too little; should the manufacturer offer them a recourse opportunity to purchase more? Furthermore, if the retailers have mismatches in their stock, is it beneficial for them to trade with each other?

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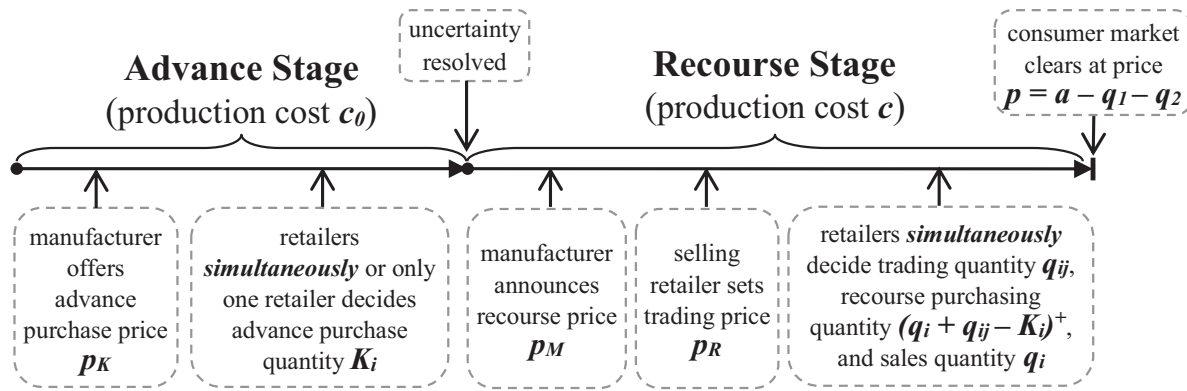


Fig. 1. Model timeline.

Table 1 Selected literature of advance purchase and reservation contracts.

Type	Paper	Model characteristics	Recourse price	Strategic M	Production costs	Rs	Demand function
Advance purchase (forward)	Allaz and Vila (1993)	Market efficiency	Endogenous	No	N/A	2	Linear (det.)
	Van Mieghem and Dada (1999)	Postponement strategies	None	No	N/A	2	Linear (random)
	Cvsa and Gilbert (2002)	Natural leader	Endogenous	Yes	0	2	Linear (random)
	Mendelson and Tunca (2007)	Asymmetric information	Endogenous	Yes	c	n	Linear (random)
	Oliveira et al. (2013)	Two-part tariff	Endogenous	Yes	Quadratic	n	Linear (det.)
	Xing et al. (2014)	Risk aversion	Exogenous	Yes	Convex	1	Linear (random)
Reservation (options)	Zhao et al. (2015)	Information updating	Exogenous	Yes	0	1	Random quantity
	Inderfurth, Kelle, and Kleber (2013)	Multi-period options	Exogenous	No	N/A	1	Random quantity
Integrated	Zhao et al. (2013)	Channel coordination	None	Yes	c	1	Random quantity
	Li et al. (2009)	Value of information	None	Yes	c_0/c	1	Random quantity
	Chen et al. (2016)	Contract portfolio	Endogenous	Yes	c_0/c	1	Linear (random)

Finally, how do demand uncertainty and the manufacturer's production cost structure influence the answers to the questions above?

To address these questions, we develop full-information, risk-neutral, two-stage, game-theoretic models that capture the essence of the strategic decisions made by such a manufacturer (M). We find it sufficient to consider a manufacturer that sells a product to two retailers (R₁ and R₂) that engage in Cournot (quantity) competition over a short selling season. The market price is a linear function of total output; market uncertainty is incorporated in our models by assuming that at the start of the game, the market size is unknown.

As can be seen in timeline on Fig. 1, in the first (advance) stage, before uncertainty is resolved, M anticipates the Rs' reactions when setting the advance purchase price. We focus on two possible arrangements that capture the competitive dynamics between the Rs: first, the simultaneous move case in which M offers identical procurement contracts to each of the two Rs who place orders simultaneously; and, second, the natural leadership case in which M offers the procurement contract only to one R. Subsequently, advance purchase orders are filled. Then, market size is revealed just prior to the second (recourse) stage of the game.

In the recourse stage, M sets the recourse price at which the Rs may procure more stock from it. If both Rs determine that they have sufficient stock, neither makes additional purchases. Alternatively, both may purchase more from M. However, if one R determines that it has purchased too much while the other desires to buy more, M may have created competition for itself because the selling R sets a trading price so that it and M engage in Bertrand (price) competition. After procurement is complete, the Rs then sell some or all of their stock in the consumer market.

Our paper is related to the growing literature in supply chain management on post procurement multi-lateral contracts. Since the comprehensive reviews by Kleindorfer and Wu (2003) and

Haksöz and Seshadri (2007), this stream of research has continued to expand as can be seen from the representative set of papers summarized in Table 1. Reflecting the richness of the underlying trading mechanisms, the first stream of research (summarized in the first part of Table 1) explores various ways to mitigate the risk of mismatches between supply and demand, including controlling risk exposure, information updating, and efficient recourse pricing mechanism under advance purchase (or forward) contracts. The second stream (summarized in the second part of Table 1) examines how reservations (or options) contracts influence supply chain members' inventory (and/or capacity) decisions. This line of research often considers only one retailer who is a price-taker. The third stream of research (summarized in the third part of Table 1) includes both advance purchases and reservations with a monopolist retailer. Incorporating advance and recourse purchases, our duopolistic model focuses on how demand uncertainty, competition, and the common manufacturer's production characteristics influence the three parties' decisions. Below we illustrate our contribution to this expanding literature relative to the works which are immediate antecedents of our model, advance purchase contracts, that are summarized in the first part of Table 1.

The models discussed below assume either that production is costless or that production occurs at the end of the recourse stage. In contrast, in our paper, M produces and fulfills orders at each stage at unit costs that need not be identical. This modeling feature is important because in practice the unit manufacturing cost can be lower in the advance stage as in quick response systems; alternatively, the unit cost may be lower in the recourse stage as in systems which exhibit learning effects. It is not uncommon to see cost differentials as high as multiples of each other, as in seasonal goods (DeYong & Cattani, 2012; Murphy, 2012) and construction equipment (Nepal, Monplaisir, & Famuyiwa, 2012).

Our models include as special cases the models considered by Cvsa and Gilbert (2002), who focus on the "natural leadership"

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