Strategic Inventory with Uncertain Demands

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Abstract

At a decentralized supply chain, the presence of initial inventory at the retailer is believed to cause the manufacturer to set a lower wholesale price than otherwise. In a two-period setting a retailer will thus tend to "overstock" in the first period, so the manufacturer will lower the wholesale price for the second period – a retail practice referred to as holding Strategic Inventory. But in the presence of inventory holding costs, there is a tradeoff and it is not obvious how much strategic inventory will be held, if any.

Previous research in this area (Anand et al. 2008, Arya and Mittendorf 2013, Hartwig et al. 2015) assumed *deterministic* demands. Thus the second period was not a "recourse", but rather can be planned exactly from the start. We, on the other hand, consider *uncertain demand.* Thus "overstocking" in the first period, if any, is vis-à-vis the solution of a single period problem with uncertain demand. We solve the problem recursively, for both the retailer and the manufacturer. We first assume that the manufacturer knows the retailer's initial inventory level in second period.

We first consider a setting with fixed retail prices. Note that a higher retail price in the second period is not by itself a reason to overstock in the first. After finding how the retailer's order quantity in the second period depends on the wholesale price and on initial inventory, we explore the direction of wholesale price's dependence on (known) initial inventory. We then compute the parties' resulting expected profits in the second period, as a function of initial inventory. In the first period the retailer selects an order quantity which is larger then what it would have chosen if that was the only period. Yet for finite (e.g., uniformly distributed) demand it will not order more than the largest possible first-period demand.

We next consider similar settings but with retail pricing in both periods. The demand functions we consider are 1. Linear with additive noise. 2. Linear with multiplicative noise. 3. Iso-elastic with multiplicative noise. Here the retailer selects both order quantity and retail price, and the manufacturer, in setting the wholesale price, has to consider its impact on retail price and thus on demand.

We perform similar recursive computations to fixed-retail-prices case.

Had the system been centralized, one would have a standard two-periods problem. The expected profit would naturally be larger than the sum of retailer's and supplier's expected profits in decentralized scenario (due to the effect of inventory holding costs). What is needed is a type of contract which will cause the retailer *not* to intentionally hold strategic inventory.

One extensions that could be considered include addressing an infinite-horizon (repetitive) setting. Another extension would be making the manufacturer's production costs non-linear. For the effect of non-linear production costs in a single period decentralized setting with multiple retailers see Gerchak and Schwartz 2014.

References

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