Intertemporal Pricing without Priors

René Caldentey, Ying Liu, Ilan Lobel
Leonard N. Stern School of Business, New York University, New York, NY 10012
{rcaldent, yliu2, ilobel}@stern.nyu.edu

We consider the pricing problem faced by a monopolist who sells a product to a population of consumers over a finite time horizon. Customers are heterogeneous along two dimensions: (i) willingness-to-pay for the product and (ii) arrival time during the selling season. We assume that the seller knows only the support of the customers’ valuations and do not make any other distributional assumptions about customers’ willingness-to-pay or arrival times. In this setting, we consider a robust formulation of the seller’s pricing problem which is based on the minimization of her worst-case regret. This regret is defined as the difference between her payoff under full demand information and her realized payoff. We consider two distinct cases of customers’ purchasing behavior: myopic and strategic customers. For each of these demand models, we characterize the optimal pricing strategy and corresponding minimum regret. We show that an optimal pricing strategy is not (necessarily) unique and derive a number of properties including its monotonicity and relationship to the upper and lower limits of the customers’ valuation support.

Key words: optimal pricing, strategic consumers, demand uncertainty, robust optimization

1. Introduction

Over the last couple of decades, dynamic pricing has been transformed from a curious and somewhat controversial practice used primarily by upstart airlines into a technique that is widely used in a variety of industries. As technology has evolved and reduced menu costs, retailers of all sorts have adopted intertemporal pricing practices. The key economic driver behind the rapid dissemination of dynamic pricing is demand uncertainty: there is enormous value for a firm in being able to change prices over time in situations where the firm does not know how much customers are willing to pay for its products.

In response to the increasing use of dynamic pricing in practice, academics have proposed a variety of techniques for algorithmically determining pricing policies. However, the vast majority of these approaches require the firm to know the probability distributions of customer valuation and arrival time. Assuming that the firm knows a full probabilistic model of customer valuations and arrival times is problematic for at least two reasons. The first reason is the obvious one: firms do not have access to such probability distributions; even when they have sales data, they typically do not have