# Dynamic pricing in the presence of individual learning ☆

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## Abstract

This paper studies price dynamics in a setting in which a monopolist sells a new experience good over time to many buyers, and the seller can neither price discriminate among the buyers nor commit to a price rule. Buyers learn from their own experiences about the effectiveness of the product. Individual learning generates ex post heterogeneity, which affects the buyers' purchasing decisions, the monopolist's pricing strategy, and efficiency. When learning occurs through good news signals, buyers receive a rent because of the possible advantageous belief caused by short-lived deviations. If a good news signal arrives, the price can instantaneously increase or decrease depending on the arrival time of this signal. The equilibrium is inefficient because the monopolist's incentive to exploit known buyers leads to inefficient early termination of exploration. When learning occurs through bad news signals, ex post heterogeneity has no such effect, since only homogeneous unknown buyers purchase the experience good.
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## 1. Introduction

In many markets for new experience goods, buyers face huge uncertainty about the effectiveness or possible side effects of the product. Take as an example the market for new drugs. The effectiveness of a new drug critically depends on whether there is an appropriate match between this drug and each patient's particular problems [16]. Patients learn from their own experiences (*individual learning*) about this effectiveness.

This paper investigates how a monopolist sells a new experience good to many buyers over time in the presence of individual learning. The monopolist and the buyers initially are equally unsure about the effectiveness of the product. How will this monopolist price strategically if she observes each buyer's past actions and outcomes? Without having seen the effectiveness of the product, potential purchasers become increasingly pessimistic. In order to keep buyers purchasing the product, the price must be reduced. How will the monopolist react when the product is revealed to be effective for one buyer? Will strategic pricing achieve efficient allocation?

In this paper, dynamic monopoly pricing is modeled as an infinite-horizon, continuous-time process. The monopolist sells a perishable experience good. She can neither price-discriminate across buyers nor commit to a price rule. At each instant of time, the monopolist first posts a spot price, which is contingent on the available public information about the experiences of the buyers. Each buyer then decides to either buy one unit of the experience good or take an outside option (modeled as another good of known characteristics). The experience good generates random lump-sum payoffs according to independent Poisson processes. The arrival rate of the lump-sum payoffs depends on an unknown individual attribute, which is binary and uncorrelated across buyers. For tractability, we assume that the public arrival of lump-sum payoffs immediately resolves the idiosyncratic uncertainty of the receiver. A key feature of the model is that buyers can become *ex post heterogeneous* in two ways: heterogeneity can be induced by either different outcomes or different actions.

We consider two different cases. In the *good news case*, the experience good generates positive lump-sum payoffs; in the *bad news case*, it generates negative lump-sum damages (e.g., side effects of new drugs). This paper fully characterizes the symmetric Markov perfect equilibrium for both cases. If a monopolist sells to a single buyer, the equilibrium price is set such that the buyer is indifferent between purchasing the experience good and taking the outside option. The buyer's purchasing decision is purely myopic since her continuation value is independent of the learning outcomes. This leads to an efficient outcome since the monopolist fully internalizes the social surplus.

We first characterize the symmetric Markov perfect equilibrium for the good news case in which there are two buyers. In phase S, i.e., when no lump-sum payoff has yet arrived, the monopolist sells to both unknown buyers before quitting the market (an "unknown" buyer refers to a buyer whose valuation of the good has not been revealed); in phase I, i.e., after one buyer has received a lump-sum payoff, the critical tradeoff is whether to sell to both buyers or to sell only to the known buyer. In both phases, the equilibrium purchasing behavior is determined by a cutoff in the posterior belief about the unknown buyer's individual attribute. Each unknown buyer makes a purchase when the posterior belief is above this cutoff and takes the outside option otherwise.

In phase I, the unknown buyer's purchasing decision is purely myopic as in the single buyer case. The key reason for this is that if the monopolist sells to both buyers, the equilibrium price is set to make the more pessimistic unknown buyer indifferent. In phase S, however, the presence of ex post heterogeneity has two important implications for the equilibrium price.