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Personalized pricing and advertising: An asymmetric equilibrium analysis ☆

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ABSTRACT

We study personalized price competition with costly advertising among n quality-cost differentiated firms. Strategies involve mixing over both prices and whether to advertise. In equilibrium, only the top two firms advertise, earning "Bertrand-like" profits. Welfare losses initially rise then fall with the ad cost, with losses due to excessive advertising and sales by the "wrong" firm. When firms are symmetric, the symmetric equilibrium yields perverse comparative statics and is unstable. Our key results apply when demand is elastic, when ad costs are heterogeneous, and with noise in consumer tastes.

1. Introduction

"*Recent advances in information technology have…made possible the instantaneous delivery of customized pricing offers to individual consumers.*" (Pricing with Precision and Impact, Boston Consulting Group 2002)

Mass marketing made possible through TV, newspapers, and billboards is increasingly evolving into individualized marketing. Firms previously limited to sending messages to heterogeneous groups of consumers (on network TV say) are now able to purchase information on *relatively* homogeneous sets of individuals from intermediary information brokers.[1] With finer levels of categorization, marketing precision is moving to the individual level. Comprehensive purchase history from various retailers can now be merged with demographic and web-site visit data to render very specific individual information on tastes, and firms can deliver individually-tailored price offers based on such information. This means that firms have the potential to compete at the level of the individual consumer. As technological capacity develops and the cost of personalized pricing decreases, the potential for individualized price competition will only increase.

Motivated by these observations, in this paper we develop a model of advertising and price competition in which the individual consumer is the basic unit of analysis. A consumer is characterized by her profile of valuations for the products

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[1] We abstract away from the strategic role that such brokers may exercise in pricing information.

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offered by different firms. While each firm is aware that consumers with this particular taste profile exist, reaching them with personalized-price advertisements is costly. This cost might reflect payment to a data broker to deliver the name and contact information of a consumer with this taste profile. It also reflects the "postage and handling" costs of preparing and delivering an individualized offer. (One could think of these offers as going out by text message, email, or personalized coupons in the mail, as opposed to *en masse* marketing.) Meanwhile, as in Butters (1977), Grossman and Shapiro (1984), and Stahl (1994), a consumer does not know that a product is available unless she receives an advertised offer from the firm selling it. Among the offers she receives, she chooses the one that yields her the greatest consumer surplus.[2]

Given a potential consumer with a particular taste profile, firms simultaneously choose whether to advertise to her and if so, what individualized price to offer her. We call the joint price and advertising decisions the Personalized Pricing and Advertising Model, henceforth PPAM. Because sending an offer is costly, equilibria involve mixed strategies over both prices and the decision to advertise.

Though we do not focus on it, the model accommodates the possibility that firms simultaneously compete for a broad range of consumers with different tastes. However, under our assumptions about the precision of targeting, a firm's strategy with respect to one consumer is completely separable from its strategy with respect to another consumer, so competition for an entire consumer population may be treated as a collection of independent instances of our model.[3]

Our main focus is on the asymmetric valuation case in which a consumer values some products more highly than others. We find that with n firms, the $n-2$ "worst" ones sit out and do not advertise at all. The second "best" one advertises with positive probability below one, and earns zero expected profits; while the best one always advertises and earns a rent equaling its social surplus advantage (valuation minus cost superiority) over its closest rival. We also find that social efficiency falls then rises with advertisement costs, with losses due to wasteful advertisements and non-optimal purchases. These inefficiencies vanish when advertising costs go to zero or when they rise high enough to give the "best" firm a monopoly.

The pattern of our equilibrium results has some precedent in other asymmetric games with discontinuous pay-offs and (non-degenerate) mixed strategy equilibria. One point of resemblance is with the All-Pay-Auction treated in Hillman and Riley (1989) where different bidders have different values from winning. Baye et al. (1996) present a broader set of symmetric and asymmetric combinations to this game by allowing ties in payoffs. A second prominent example is Varian's (1980) Model of Sales, extended to allow for heterogeneous numbers of "loyal" consumers across firms by Narasimhan (1988) for duopoly and by Kocas and Kiyak (2006) for oligopoly.[4] In both games, there is a winner-take-all prize for the fiercest competitor, but competing incurs costs that "losers" do not recover. In the all-pay auction, the interpretation of the prize and costs is straightforward. In the Model of Sales, the "prize" is sales to the set of informed consumers, while the cost of competing for these consumers by offering a discounted price is the foregone profit on a firm's loyal consumers.[5] In both games, only the two players with the highest win value contend the prize, and all other players choose not to (by bidding zero or not discounting, respectively). While the results in these two models and ours share a "family resemblance," the models themselves have significant differences such that no pair is formally equivalent (even when reduced to their symmetric versions). Hence, our results cannot be derived from existing ones in the literature.

By taking advertising costs to zero, we can provide a fresh perspective on the long-standing selection problem of multiple equilibria in the classic model of Bertrand competition with asymmetric costs. (That is to say, homogeneous goods, no advertising, and different (constant) marginal costs across firms.) We select the equilibrium where the most efficient firm prices (with probability one) at the cost of its closest rival. Interestingly, the second-best firm makes an offer just often enough to keep the top firm from deviating to its monopoly price.

Analysis of equilibrium price distributions in the literature frequently assumes that firms are symmetric and focuses on a symmetric mixed strategy equilibrium. We argue that the symmetric equilibrium, when it exists in our model, may be seriously misleading. First, we show the striking comparative static prediction that when a consumer views products as homogeneous, the symmetric equilibrium has consumer surplus and welfare decreasing in the number of competing firms. This strong result stems from the indifference condition required to elicit advertising by all n firms. However, this equilibrium is not robust: with any heterogeneity in the consumer's valuations, the set of advertisers collapses down to two firms. Thus the perverse comparative static properties of the symmetric equilibrium may be seen as a symptom of this

[2] The possibility of consumer search is introduced in a later section of Butters (1977) and is an integral part of the model of Robert and Stahl (1993). Shaffer and Zhang (1995, 2002) and Bester and Petrakis (1995, 1996) have considered targeting by location and have included the cost of sending offers to customers. They assume offers are coarse, such as a common discount to a heterogeneous consumer group.

[3] This separability is reasonable if (as we assume) a firm faces constant marginal costs to produce its product and to reach an additional consumer with a targeted ad. The latter is consistent with firms buying data about blocks of consumers (rather than individual by individual) as long as pricing is on a per-consumer basis and blocks of individuals with the same tastes are on offer.

[4] Baye et al. (1992) find all the equilibria for the Model of Sales when all firms have the same number of loyal consumers (as in the original). In addition to the symmetric equilibrium analyzed by Varian (1980), there are also asymmetric ones. In these, at least two firms must be active: when there are only two firms in the market the symmetric equilibrium is the unique one, but not otherwise. Of particular interest for what follows in our paper is their result (Example 2, p. 500) that with $n > 2$ there are equilibria with $k \geq 2$ firms symmetrically randomizing their prices and the others just charge the consumer reservation price.

[5] As clarified by Janssen and Moraga-González (2004), the Model of Sales is also at the heart of the literature on firm pricing and consumer search following Stahl (1989). In these search models, "informed" consumers (or "shoppers") know all prices, while others face a search cost and in equilibrium stop at the first firm sampled, and hence play the role of the "loyal" consumers. Baye and Morgan (2001) successfully expand the basic MoS framework to a two-sided market setting.