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A dynamic model of price discrimination and inventory management at the Fulton Fish Market☆

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ABSTRACT

We estimate a dynamic profit-maximization model of a fish wholesaler who can observe consumer characteristics, set individual prices, and thus engage in third-degree price discrimination. Simulated prices and quantities from the model exhibit the key features observed in a set of high quality transaction-level data on fish sales collected at the Fulton Fish Market. The model's predictions are then compared to the case in which the wholesaler must post a single price to all retailers. We find the added revenue the wholesaler receives from price discriminating to be small.

1. Introduction

What are the benefits to a wholesaler of price discrimination resulting from privately negotiated prices versus posting a single price? At first glance, one might expect a fish wholesale market to be highly competitive. However, the Fulton Fish Market, with its storied history of mafia involvement, has substantial barriers to entry. These barriers to entry have caused an imperfectly competitive environment characterized by negotiated prices. Our aim in this paper is to measure the magnitude of the increase in profits resulting from price discrimination versus posting a single price.

We solve and estimate a dynamic profit-maximization model of a fish wholesaler. Stocks of fish arrive every morning, and the fish must be sold within a relatively short period of time. Throughout the day, retailers arrive sequentially and randomly, but when a retailer shows up, the wholesaler observes his type and thus knows his price elasticity. Therefore the wholesaler can price discriminate across different types of retailers. The fish wholesaler is solving two problems simultaneously: (1) how to optimally price his stock of fish which is falling in value over time and is replenished only once a day; and (2) how to optimally price discriminate across customers with differing price elasticities.

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Our model is able to successfully match several key features of the Fulton Fish Market. In particular the model predicts, as we see in the data, that Asian retailers pay about 5 cents per pound less for fish than white retailers. More generally the model matches the mean and variance of prices with large differences in prices across different days as well as considerable intra-day price volatility. Overall, we conclude that the model is a reasonable approximation of the behavior of a Fulton Fish Market wholesaler.

We then impose the restriction that the fish wholesaler must post a uniform price to all retailers, and is therefore unable to price discriminate. In this case, white retailers with inelastic demand pay lower prices and purchase larger quantities of fish. The more price-elastic Asian retailers pay higher prices and purchase less fish. From both types, the wholesaler earns less revenue. However the magnitudes are small. We find that posting a single price only generates about 6 dollars per day less revenue (about 15/100 of 1 percent of total revenue) compared to price discriminating.

While our model is intended to provide an accurate representation of the behavior of a particular fish wholesaler, the problem of determining the optimal price of a stock of depreciating assets is a classic problem in economics and operations research. In operations research the study of dynamically pricing an inventory stock falls under the headings *revenue management* or *yield management*.[2] In the economics literature, work by Reagan (1982), Aguirregabiria (1999), Zettelmeyer et al. (2003), Chan et al. (2004), Sweeting (2008), and Copeland et al. (forthcoming) study the interaction between inventory management and pricing. Our model differs from these others in that the timing of new procurements of inventories is fixed though the quantity is stochastic. While these other papers focus on durable goods, such as automobiles and steel, or goods that expire at a pre-determined date, such as baseball tickets, hotel rooms and airline seats, our paper focuses on fish – a good that depreciates steadily but quickly.

This paper proceeds as follows. In the next section we discuss the importance of price discrimination and previous papers that have highlighted discriminatory settings. In Section 3, we discuss the details of the Fulton Fish Market, the market on which our structural model is based. In Section 4 we develop our model, and in Section 5, we present our estimation strategy. We report our findings in Section 6 and conclude our analysis in Section 7.

2. Price discrimination versus a single posted price

In an early empirical paper on price discrimination, Borenstein (1991) demonstrated price discrimination in the retail gasoline market, a market that at first glance appeared to be more competitive than monopolistic (and in this way similar to the Fulton Fish Market) by estimating price-cost margins. More recent work has focused on conducting welfare analyses of price discrimination by using structural models. Hastings (2009) focuses on the wholesale gasoline market, Villas-Boas (2009) focuses on the German coffee market, and Langer (2009) focuses on price discrimination in new vehicle sales. In each of these papers, the authors estimate a model of supply and demand with price discrimination and then use these estimates to investigate a counterfactual scenario with a single posted price. A primary purpose of their analyses is to compare total welfare under various scenarios.

Our paper is similar to the above papers in that it estimates a model of supply and demand with price discrimination and then investigates a counterfactual scenario with a single posted price. However, our paper differs in that its focus is the advantage to the dealer of price discrimination versus posted prices. Both in purpose and in methodology, our paper is closest to Chan et al. (2004), in which the authors compare the case of price discrimination in the steel market by a wholesaler to the case of uniform pricing by estimating a dynamic model of price discrimination and inventory adjustment.

Everything else equal, if a firm has the ability to price discriminate, then the firm can raise its revenue by doing so. However, everything else is very rarely equal. Price discrimination, by its nature, incurs a number of costs that are difficult to measure. As Rust and Hall (2003) argue, posting a fixed price eliminates the need for consumers to engage in costly search and thus may increase demand from consumers with high search costs. Secondly, price discrimination that results from bargaining incurs negotiation costs. As pointed out by Wang (1995), bargaining versus posting a price requires the seller to hire additional employees to mingle with buyers; posting a price is simpler and cheaper, but does not allow discrimination. Finally, price discrimination can result in psychological costs to buyers that over the long term can be harmful to sellers. These costs are similar to the constraints on profit seeking resulting from fairness concerns as pointed out by Kahneman et al. (1986).

These transaction costs, most of which are very difficult to measure directly, are necessarily bounded by the marginal profits – with everything else held equal – that a seller receives from price discrimination. By using a structural analysis, we bound these costs by estimating the marginal profits from price discrimination relative to a single price strategy under a counterfactual scenario holding everything else equal.

3. The Fulton Fish Market

In this section, we provide details of the Fulton Fish Market. Through a contact at the Fulton Fish Market in New York City, one of the authors, Kathryn Graddy, collected a detailed set of transaction level data for a single fish wholesaler for 22

[2] This literature which started with Whiten (1955) and Karlin and Carr (1962) is reviewed by Federgruen and Heching (1999) and Elmaghraby and Keskinocak (2003).