“The Limits of Price Discrimination” by Dirk Bergemann, Benjamin Brooks, and Stephen Morris

Summary by Gina Markov

This paper analyzes the welfare consequences when a monopolist seller has additional information about consumers’ preferences. When a seller has additional information about consumers’ valuations of a product, the seller can engage in a practice called price discrimination. Price discrimination occurs when a seller charges different prices to different segments of the market. There are several types of price discrimination, depending on how the market is segmented. Third-degree price discrimination occurs when a seller charges different prices to different segments of the market; for example, train companies might engage in third-degree price discrimination by age category when selling train tickets, offering discounts to students and seniors. This paper primarily analyzes third-degree price discrimination. First-degree price discrimination is when a seller charges each buyer their exact valuation, thus segmenting the market on an individual level; second-degree price discrimination occurs when a seller charges different prices based on different quantities consumed. The paper focuses on the effects of price discrimination on producer, consumer, and total surplus. Producer surplus is defined as the difference between the price the producer is willing to sell at and the price the producer actually adopts. It is a measure of producer welfare. Similarly, consumer surplus is the difference between what a consumer is willing to pay and how much the consumer actually pays. Social (or total) surplus is the sum of producer and consumer surplus. Intuitively, price discrimination results in lower consumer surplus, because the additional information enables the seller to minimize the difference between the consumer’s valuation and price. However, this paper shows that, in fact, the market can be segmented in such a way that social and consumer surplus can both increase, both decrease, or respectively increase and decrease, while producer welfare will always benefit. The paper offers several segmentation strategies to achieve exact limits on surplus.

The authors establish the following limits on surplus in the market. If the monopolist has no additional information, it would charge the uniform monopoly price – this provides the lower bound for producer surplus. Consumer surplus will always be nonnegative, because a consumer would never buy a product above their valuation. However, consumer surplus can be zero if the monopolist has complete information about buyers’ valuations, and charges each buyer their valuation (first-degree price discrimination). Finally, total social surplus cannot exceed that generated by efficient trade (the sum of consumer and producer surplus). The authors continue by showing that all combinations of extreme welfare outcomes can be achieved through various strategies of market segmentation.

The model in the paper is presented as follows: a monopolist sells a good to consumers at zero marginal cost. A price, or pricing rule, is defined as optimal in a given market if the revenue to the seller is greater than or equal to the revenue that can be achieved through any other price. The first market segmentation strategy that the authors propose to achieve extreme welfare outcomes is based on extremal markets.

An extremal market is defined as a market x such that the monopolist is indifferent between charging any price inside x and the monopoly price. No consumers in the market have a valuation outside of x. While charging the highest and lowest valuation in x return the same revenue to the monopolist, they have very different welfare consequences. In the former case, very few buyers buy the good, and in the latter case, many buyers buy the good. The authors focus on segmenting the total market into these extremal markets. They adopt two main pricing rules: minimum and maximum. The minimum pricing rule simply charges the minimum valuation in a given market x, and the maximum pricing rule charges the maximum valuation in x. The authors find that in every extremal segmentation, the minimum and maximum pricing rules are optimal. When the minimum pricing rule is used, there is always an efficient allocation in the market, and efficient total surplus is attained. When the maximum pricing rule is used, there is zero consumer surplus; the buyers who purchase the product are all of the highest type and are buying at their valuation. By the definition of an extremal market, the monopolist is indifferent between these pricing rules. However, segmentation schemes can be perturbed slightly to obtain different allocations of surplus. For example, in each market, increasing the proportion of the lowest value consumers relative to the higher values helps realize the consumer surplus maximizing allocation; this entails a small transfer of surplus from consumers to monopolist.

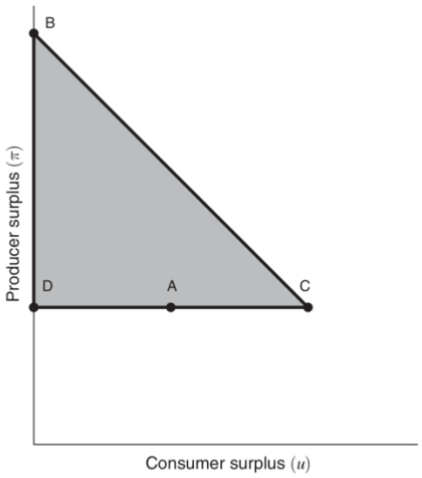

FIGURE 1. THE SURPLUS TRIANGLE

Throughout the paper, the authors make reference to the surplus triangle in Figure 1 to address various different allocations of surplus. Using the strategy of extremal segmentation described above, points A, C, and D are attainable. Point A is achieved if the monopolist charges the uniform monopoly price on each extreme segment; point C (consumer surplus maximization) is achieved through the minimal pricing scheme; point D (zero consumer surplus) is achieved through the maximal pricing scheme. Point B is achieved through perfect price discrimination.

The authors also note that every point in the shaded area of the triangle can be attained by segmenting a portion of the market using extremal markets, and segmenting the rest of the market to facilitate perfect price discrimination. In this mixed strategy, producer surplus is always between uniform monopoly and perfect discrimination profits, and the monopolist is indifferent between prices that yield a consumer surplus of zero and those that maximize attainable social surplus.

The authors propose several specific strategies for market segmentation to achieve welfare bounds. One uses a “greedy” algorithm, which creates segments that are extremal markets, and the other does not use extremal markets: it constructs a segmentation that maximizes attainable consumer surplus. A “greedy” algorithm is a procedure that makes a locally optimal choice at each time point. In this paper, the greedy

algorithm creates segments that are extremal markets as follows. It inserts as many consumers as possible into a given extremal market x such that the monopolist is indifferent between charging any price in x (any valuation). The remaining market – termed the residual market – is then segmented in the same way, putting as many consumers as possible into another extremal market based on the remaining valuations. The algorithm proceeds like this, eliminating one valuation from the residual market at each step until all valuations are placed into an extremal market. The second algorithm utilizes direct segmentation: the monopolist charges a certain (optimal) price per market. The segmentation procedure unfolds in the following way. Consumers' valuations are always going to be greater than or equal to the price for a given segment, and the monopolist must be indifferent between charging that price and the uniform monopoly price. The first segment contains all consumers with the lowest valuation in the market. Then, a proportion of those with a higher valuation will also be put into that segment, so that the producer's indifference condition is still satisfied. The residual segment is split up in the same way. This method maximizes consumer surplus and results in an efficient outcome, where the consumers receive any gains in efficiency relative to no price discrimination, but the producer surplus is still equal to that under uniform monopoly profit. Thus, monopolist may have incentive to price below the monopoly price if low valuation and high valuation consumers are pooled in the appropriate way. Even with weak incentive, consumers would capture any gains in efficiency.

After establishing these different market segmentation strategies, the authors discuss the implications of the price discrimination on production levels. They outline the conditions for the highest and lowest outputs. The upper bound on output – the efficient quantity – is attained when consumer surplus is maximized. This happens when the producer sells to all consumers under any efficient segmentation. The lower bound on output is conditioned first on achieving the lower bound on the social surplus. Social surplus is bounded when the producer attains uniform monopoly profits. The authors show that any conditionally efficient allocation (an allocation that sells to those with the highest valuation, conditional on the good being sold) with uniform monopoly profits will lead to the smallest output. They further show that it is always possible to find a conditionally efficient outcome using a maximum pricing strategy.

The authors confirm their results regarding the optimality of minimum and maximal pricing strategies when there is a continuum of valuations. They also discuss the case of nonlinear utility and cost functions. While they are not able to obtain exact bounds on the surplus amounts in the nonlinear case, the authors find that there are still many feasible surplus pairs, with varying levels of consumer surplus and profit levels above uniform profits. Finally, they examine the robustness of their results by varying consumers' utility for a good with quantity consumed. This setup results in second-degree price discrimination; the authors discuss that the vertices of the surplus triangle are still achievable through analogous methods as the previous paragraphs. However, in this case, it is not possible to find a general segmentation strategy that attains every point inside the triangle.

The paper presents two potential applications. First, the authors present a price setting game where producers make take-it-or-leave-it offers to consumers, who accept the offer only if the price is strictly lower than their valuation. They identify equilibria of the

game for any possible information structure available to the players, and calculate respective payoffs to producers and consumers. The other application is to the study of "Bayesian persuasion": a sender chooses how much information to transmit to a receiver *before* the sender can observe its private information. In this context, the receiver is the producer choosing prices, and the sender is a planner who desires to maximize some combination of consumer and producer surplus. The authors describe a strategy that mathematically manipulates the sender's utility as a function of the sender's types (the sender's surplus objectives) to attain the highest possible utility and to calculate all possible extreme welfare combinations.

There are several policy implications to the authors' findings. Increasingly, market segmentation is becoming endogenous, as information about consumers' valuations is collected in large amounts on the Internet. Sellers have an incentive to gather as much information as possible in order to engage in perfect price discrimination, but an Internet intermediary has the power to release only some amount of information about consumers to producers. Therefore, regulatory pressure or business priorities may induce the intermediary to adopt a model of information transmission that maximizes consumer welfare. This paper offers ways that such a consumer-minded Internet company could choose to structure its information transmission. It is also important to understand the welfare consequences of data collection when evaluating policies regarding consumer privacy. While it is frequently assumed that more data collection leads to consumer harm (in terms of welfare and privacy), this paper shows that this is not always the case; the impact of additional information on consumer welfare may be positive or negative, depending on how the market is segmented and the pricing strategy enforced. The connection between welfare and information can only be pinpointed in the context of how the data will be used and the preferences of the data collector. Thus, the authors emphasize that an important direction for future research – and policy decisions – would be to understand which forms of price discrimination arise endogenously in the market, and who they benefit; once this is understood, policies can be designed that incentivize those transmitting information (like Internet companies) to prioritize consumer welfare.