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Price-Discrimination with Nonlinear Contracts in Input Markets

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Abstract

Most of the literature on price discrimination in input markets has focused on linear per-unit prices used by a monopolist supplier. Here, we provide a complete characterization of the equilibrium two-part tariffs, which can allow the monopolist supplier to obtain (at a minimum) the profit that an efficient downstream firm would earn. Depending on the characteristics of the industry, the supplier can find it profitable to monopolize the downstream market. Price discrimination with nonlinear contracts can nonetheless improve welfare as it can eliminate the double marginalization problem and remove an inefficient firm from the market.

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1. Introduction

There has been a continuing evolution of the economic thinking about price discrimination in intermediate-good markets. Katz (1987) finds that third-degree price discrimination can reduce welfare when a large buyer threatens to integrate backward. Even though the large buyer obtains a discount over the linear wholesale price relative to the one charged to the small buyer, wholesale prices are raised for all. DeGraba (1990) finds that the monopolist supplier charges a higher per-unit price to the low-cost firm when downstream firms can choose their production technology (Yoshida, 2000, finds a similar result). Consequently, incentives to adopt a low-cost technology are lessen under price discrimination. And welfare is reduced compared to when the supplier uses uniform pricing.

In comparison, Inderst and Shaffer (2009) find that price discrimination by a monopolist supplier in an intermediate-good market results in a low (high) price charged to the low-(high-) cost downstream firm. The model's key feature is that the monopolist supplier maximizes industry profit and uses two-part tariffs. The nonlinear contracts, tailored for each downstream firm, amplify the cost difference between the low-cost and the high-cost firms and reduce the allocative efficiency. They conclude that banning price discrimination can reduce welfare. But Inderst and Shaffer (2009) impose a condition that guarantees an interior solution. As such, they do not allow for changes in the industry structure, i.e., for the exit of one of the downstream firm.

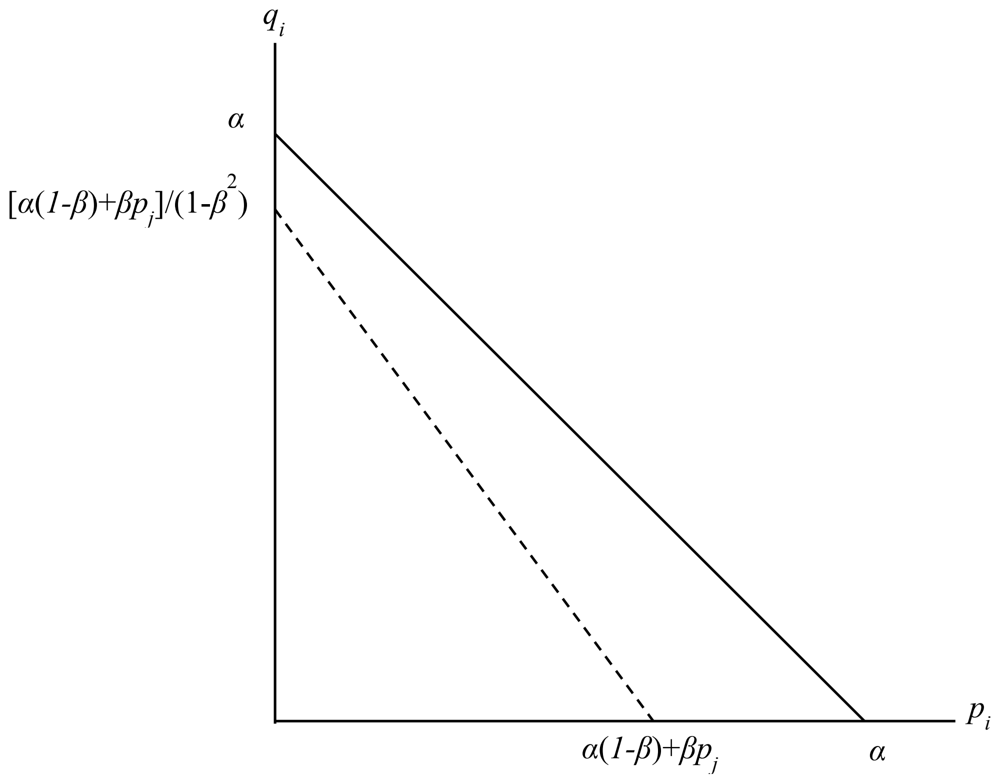
By considering this possibility, we find that the monopolist supplier can always obtain (at a minimum) the profit a monopolist operating in the downstream market would earn. The complete description of the equilibrium allows focusing on the industry's characteristics that determine the supplier's choice of two-part tariffs. Based on those characteristics, the supplier can profitably manipulate the structure of the downstream industry potentially creating a monopolist. And even though downstream competition can be eliminated, welfare can increase.

The paper is organized as follows. The model is presented in the next section. The results are derived in section 3. Section 4 offers concluding remarks.

2. Model

We consider the same model as the one used by Inderst and Shaffer (2009). In a downstream market, two firms $i = 1, 2$ are active, have constant own marginal costs c_i with $c_1 < c_2$, and set prices p_i. Downstream firms require one unit of input to produce one unit of the final good. A monopolist supplier with a constant marginal cost normalized to zero sells this input. The supplier makes observable take-it-or-leave-it offers specifying a fixed fee F_i and a constant per-unit wholesale price w_i for firm i. Then, downstream firms, which have an overall marginal cost $k_i = c_i + w_i$ simultaneously accept or reject the contract they are offered. A firm accepts the contract if its profit is greater than or equal to zero, which is the firm's reservation profit (i.e., the profit it obtains by refusing the contract). Finally, firms simultaneously set prices.

Figure 1
Firm *i*'s Demand



The demand side of the market is described by the preferences of a representative consumer over the set of available products. These preferences are represented by the utility function, $U = \alpha(q_1 + q_2) - (1/2)(q_1^2 + q_2^2 + 2\beta q_1 q_2) + m$, where m denotes income, q_i stands for the quantity purchased from firm i, and $\beta \in [0, 1)$ measures the degree of substitutability between products. Products are independent when $\beta = 0$ and tend to be perfect substitutes when $\beta \to 1$. The consumer's maximization problem leads to the following demand function for firm i

$$q_i = \begin{cases} \alpha - p_i & \text{if } p_i \text{ and } p_j \text{ are such that } \alpha(1-\beta) - p_j + \beta p_i \leq 0 \\ & \text{and } p_i \leq \alpha \\ \dfrac{\alpha(1-\beta) - p_i + \beta p_j}{1-\beta^2} & \text{if } p_i \text{ and } p_j \text{ are such that } \alpha(1-\beta) - p_i + \beta p_j \geq 0 \\ & \text{and } \alpha(1-\beta) - p_j + \beta p_i \geq 0 \\ 0 & \text{if } p_i \text{ and } p_j \text{ are such that } \alpha(1-\beta) - p_i + \beta p_j \leq 0 \end{cases}$$

which is illustrated in Figure 1. The solid line, $q_i = \alpha - p_i$, is obtained when $\alpha(1-\beta) + \beta p_i \leq p_j$ or $\beta = 0$. The dashed line depicts firm i's demand, $q_i = [\alpha(1-\beta) - p_i + \beta p_j]/(1-\beta^2)$, when firm j produces positive quantities, $p_j \leq \alpha(1-\beta)+\beta p_i \leq \alpha$, and $\beta > 0$. We assume $0 \leq p_i \leq \alpha$ for both i = 1, 2 throughout the paper.

3. Equilibria in the Marketplace

3.1 Downstream Firms' Best-Response Functions

To solve the model, we first need to find firm i's best-response function. Four cases need to be considered (although we do not know the value taken by w_i at this point, we only consider situations where $0 \leq p_i \leq \alpha$). First, suppose that firm i can set the monopoly price $p_i = (\alpha + k_i)/2 = p_i^M$ (i.e., firm i is an unconstrained monopoly). This means that firm j's output evaluated at p_i^M must be less than or equal to zero implying $p_j \geq [\alpha(2-\beta)+\beta k_i]/2 = \overline{p}_j$.

Second, consider that $0 \leq p_j \leq [k_i - \alpha(1-\beta)]/\beta = \underline{p}_j$. Then firm i's output evaluated at $p_i = k_i$ is less than or equal to zero. Any price for firm i greater than or equal to its overall marginal cost k_i is a best-response to $0 \leq p_j \leq \underline{p}_j$. This is not a problem, however, since the market outcome is the same (firm i (j)'s output = (>) 0). To ensure continuity we adopt the convention that k_i is firm i's best-response to $p_j \leq \underline{p}_j$.

Third, assume that firm j's price takes intermediate values and let us define $\tilde{p}_i = [\alpha(1-\beta)+k_i+\beta p_j]/2$, which maximizes firm i's profit when both firms sell positive quantities. Firm i's output evaluated at $p_i = \tilde{p}_i$ is positive if $p_j \leq \underline{p}_j$, while firm j's output evaluated at $p_i = \tilde{p}_i$ is positive when $p_j \leq [\alpha(1-\beta)(2+\beta)+\beta k_i]/(2-\beta^2) = \hat{p}_j$.

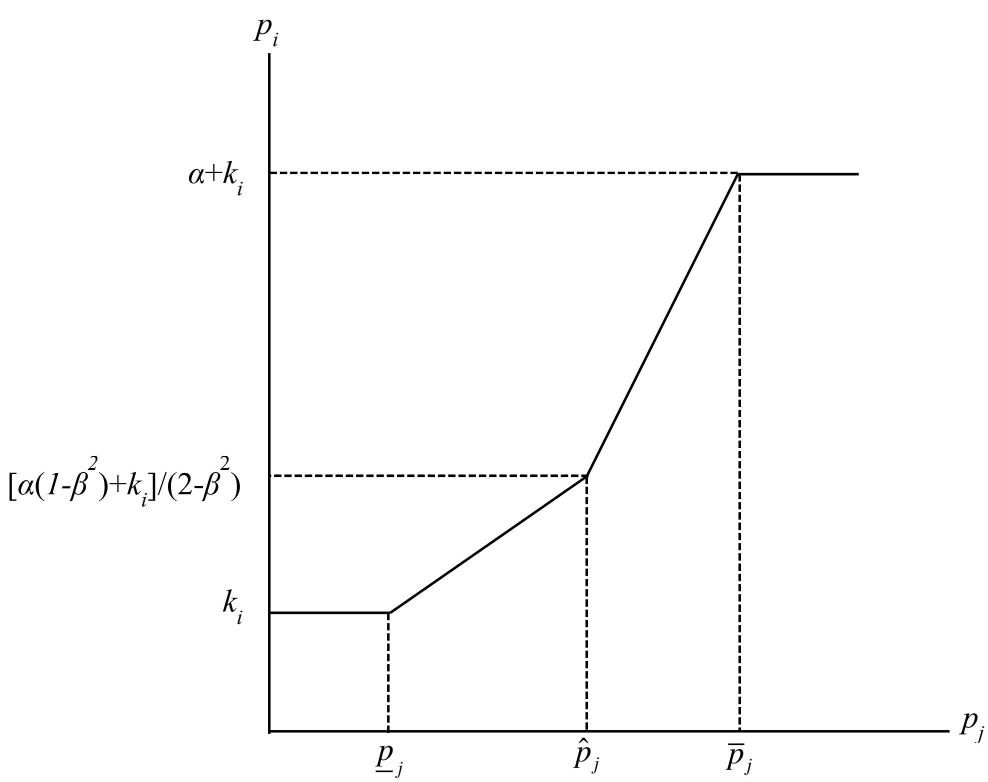
Finally, assume that we have simultaneously $p_j \geq \hat{p}_j$ (resulting in firm j's output being less than or equal to zero when evaluated at $p_i = \tilde{p}_i$) and $p_j \leq \overline{p}_j$ (implying that firm j's output is greater than or equal to zero when evaluated at $p_i = p_i^M$). This means that neither $\tilde{p}_i$ nor p_i^M can be firm i's best-response. To find firm i's best-response let $\tilde{p}_i < p_i^{\max} = [-\alpha(1-\beta)+p_j]/2 < p_i^M$ be firm i's maximum price such that firm j's output equals zero. Because $\tilde{p}_i$ does not maximize firm i's profit acting as a monopolist, $\pi_i(p_i)$, we have $\partial\pi_i(p_i)/\partial p_i > 0$ when evaluated at $\tilde{p}_i$ and firm i wants to increase its price. Also, since p_i^M does not maximize firm i's profit in a duopoly, $\pi_i(p_i, p_j)$, we have $\partial\pi_i(p_i,p_j)/\partial p_i < 0$ when evaluated at p_i^M and firm i wants to decrease its price. Moreover, $\partial\pi_i(p_i)/\partial p_i > 0$ and $\partial\pi_i(p_i,p_j)/\partial p_i < 0$ when both are evaluated at $p_i^{\max}$ for $p_j \in [\hat{p}_j, \overline{p}_j]$. These remarks lead to $p_i^{\max}$ being firm i's best-response for $p_j \in [\hat{p}_j, \overline{p}_j]$ and firm i is a constrained monopoly.

Putting things together, firm i's best-response is

$$p_i^{BR} = \begin{cases} [\alpha + (c_i + w_i)]/2 & \text{if } p_j \geq \overline{p}_j \\ [-\alpha(1-\beta) + p_j]/\beta & \text{if } p_j \in [\hat{p}_j, \overline{p}_j] \\ [\alpha(1-\beta) + (c_i + w_i) + \beta p_j]/2 & \text{if } p_j \in [\underline{p}_j, \hat{p}_j] \\ c_i + w_i & \text{if } p_j \leq \underline{p}_j \end{cases}$$

which is depicted in Figure 2.

Figure 2
Firm *i*'s Best-Response Function



3.2 Downstream Firms' Prices and Profits

By assumption, any firm accepts the supplier's contract since it always obtains a profit greater than or equal to the one it would earn by refusing the contract.

We can now determine the firms' prices and profits (gross of the fixed fee). First, consider the case where $k_i = k_j$. Both firms are symmetric and produce positive quantities. The equilibrium price and profit for firm *i* in this symmetric duopoly (SD) are

$$p_i^{SD} = \frac{\alpha(1-\beta)+k_i}{2-\beta}$$
$$\pi_i^{SD} = \left(\frac{1-\beta}{1+\beta}\right)\left(\frac{\alpha-k_i}{2-\beta}\right)^2.$$

Second, consider the case where k_j - k_i > 0 and the difference is sufficiently small so that both produce positive quantities. Firm i's equilibrium price and profit in this asymmetric duopoly (AD), which are found in Inderst and Shaffer (2009), are

$$p_i^{AD} = \frac{\alpha(1-\beta)(2+\beta)+2k_i+\beta k_j}{4-\beta^2}$$
$$\pi_i^{AD} = \left(\frac{1}{1-\beta^2}\right)\left[\frac{\alpha(1-\beta)(2+\beta)-(2-\beta^2)k_i+\beta k_j}{4-\beta^2}\right]^2.$$

Third, firm j's best-response is to set a price equal to its marginal cost and firm i acts as a constrained monopolist (CM) when k_j - k_i > 0 and the difference is sufficiently large. We then have $p_j^{CM} = k_j$ and $p_i^{CM} = [-\alpha(1-\beta)+k_j]/\beta$ when $w_j \in [\hat{p}_j - c_j, \overline{p}_j - c_j]$. The corresponding profits are

$$\pi_i^{CM} = \frac{[k_j - \beta k_i - \alpha(1-\beta)](\alpha - k_j)}{\beta^2}$$
$$\pi_j^{CM} = 0.$$

Finally, assume that the difference k_j – k_i is so large that $k_j \geq \overline{p}_j$ and firm i is an unconstrained monopoly (M). Firms i and j's prices are $p_i = p_i^M$ and $p_j = k_j$, respectively, and their profits are

$$\pi_i^M = \left(\frac{\alpha-k_i}{2}\right)^2$$
$$\pi_j^M = 0.$$

Notice that π_i^M decreases when k_i increases and recall the assumption that $c_1 < c_2$. This implies that if it is possible for the supplier to exclude one retailer and extract the profit of the remaining one, then it should foreclose the inefficient retailer.

3.3 Optimal Two-Part Contracts

We denote by $T_i = (w_i, F_i)$ the supplier's two-part tariff offered to firm i. The supplier can always obtain the profit a monopolist with marginal cost c_1 would earn in the downstream market by setting $T_1^* = (0, \pi_i^M)$ and $T_2^* = (\overline{p}_2 - c_2, 0)$. The wholesale price charged to firm 1 corresponds to the supplier's marginal cost and the wholesale price charged to firm 2 can take any value greater than or equal to $\overline{p}_2 - c_2$.

Inderst and Shaffer (2009) let the supplier choose wholesale prices to maximize the industry profit, $\sum_{i=1,2} w_i q_i + (p_i - k_i) q_i$, and set fixed fees to extract the downstream firms' profit assuming that they both sell positive quantities. The wholesale prices they find are

$$w_1^{IS} = \frac{\beta(\alpha - c_2)}{2}$$
$$w_2^{IS} = \frac{\beta(\alpha - c_1)}{2}$$

and the supplier earns a profit of

$$\pi_S^{IS} = \frac{2\alpha(1-\beta)(\alpha - c_1 - c_2) + c_1^2 + c_2^2 - 2\beta c_1 c_2}{4(1-\beta)^2}.$$

Inderst and Shaffer (2009)'s equilibrium two-part tariffs are $T_1^{IS} = (w_1^{IS}, \pi_1^{AD})$ and $T_2^{IS} = (w_2^{IS}, \pi_2^{AD})$ where it is understood that w_1^{IS} and w_2^{IS} have been inserted into π_1^{AD} and π_2^{AD} in place of w_1 and w_2.

The difference between π_S^{IS} and π_1^M equals $[(1-\beta)\alpha + \beta c_1 - c_2] / 4(1-\beta^2)$. The two-part equilibrium tariffs are (T_1^{IS}, T_2^{IS}) when $(1-\beta)\alpha + \beta c_1 > c_2$, which is the condition assumed by Inderst and Shaffer (2009) to ensure that both downstream firms remain active. However, the equilibrium contracts are $(T_1^*,\ T_2^*)$ when $(1-\beta)\alpha + \beta c_1 \le c_2$. Hence, the choice of the equilibrium two-part tariffs rests on the industry's characteristics, i.e., the asymmetry between firms and the degree of substitutability.

For instance, suppose that the differentiation parameter β is close to 1. The supplier excludes the high-cost firm and sells the input at its marginal cost to the low-cost firm while extracting the monopoly profit with the fixed fee. When $\beta = 0$, the supplier sells to both firms at its marginal cost while charging a personalized fixed fee that equals the individual monopoly profits. For high enough values of β, the intra-brand competition is too strong from the supplier's perspective. Allowing competition downstream would create a surplus loss, which leads the supplier to exclude the high-cost firm. When β becomes sufficiently low, however, the gain from having multiple products offset the loss in surplus from having competition in the market. This latter result coincides with the equilibrium in Inderst and Shaffer (2009).

As for welfare, it is higher under $(T_1^*,\ T_2^*)$ than with (T_1^{IS}, T_2^{IS}) when $(1-\beta)\alpha + \beta c_1 \le c_2$. Even though the market is monopolized, the elimination of the double marginalization problem and of the allocative inefficiency can increase welfare. Moreover, total output is lower under no price discrimination (i.e., when the supplier chooses a constant per-unit wholesale price) than with (T_1^*, T_2^*).[1] Hence, a ban on price discrimination can lead to a reduction in welfare.

Inderst and Shaffer (2009) make it clear that two-part discriminatory contracts increase efficiency. Here we add that they can also lead to exclusion. To see how this result can be linked to the exclusionary literature, assume that the starting point is a bilateral monopoly rather than a supplier facing a duopoly. In this context, the supplier's two-part tariffs represent a barrier to entry against inefficient entry and can be pro-competitive (the supplier's threat to sponsor new entry and to exclude the current downstream firm keeps the reservation profit of the latter equal to zero in the bilateral monopoly setting). The banning of price discrimination could, then, lead to higher prices (by creating the double marginalization problem) and to more allocative inefficiency (by encouraging inefficient entry).

We should also mention that the analysis conducted here applies directly to asymmetry in terms of demand rather than cost. Indeed, assume that $c_1 = c - \varepsilon < c_2 = c$ with $\varepsilon \in [0, c]$. This is equivalent to $\alpha_1 = \alpha + \varepsilon > \alpha_2 = \alpha$.

4. Conclusion

We completely determine the equilibrium two-part tariffs that maximize the profit of a discriminating monopolist supplier selling to two competing but asymmetric downstream firms. With the use of price discrimination, the supplier can control the structure of the downstream market (potentially deterring production or entry of inefficient downstream firms). As a result, the supplier is guaranteed to obtain (at a minimum) the profit that an efficient monopolist would earn in the downstream market. Although the downstream market can be monopolized, welfare can nonetheless increase as the equilibrium two-part tariffs can eliminate both the double marginalization problem and the inefficient firm. Banning price discrimination, even if can lead to exclusion, can therefore lead to a decrease in welfare.

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[1] This assumes that both firms are active when there is no price discrimination.