Does Large Price Discrimination Imply Great Market Power?

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Abstract

A simple model demonstrates that there is no theoretical connection between the extent of price discrimination and the extent of market power.

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1. Introduction

In a competitive market, price equals marginal cost. Wherever there is price discrimination, at least one of the prices deviates from marginal cost. Therefore, if there is price discrimination, there must be market power (see, e.g., Varian, 1989, Posner, 1990, and Stole, 2003). While this logic is sound, it has lead many policy-makers to believe that price discrimination and market power are strongly positively correlated, i.e., high price discrimination indicates high market power, while low price discrimination indicates low market power. Thus they have tended to impose antitrust remedies given evidence of highly discriminatory price structures, and to dismiss antitrust charges given evidence that price structures are relatively uniform.[1]

The purpose of this paper is to study the extent to which price discrimination is an indicator of the extent of market power. We analyze a simple Hotelling price-competition model, involving a monopolist selling a product differentiated from that of a competitive fringe. We find that measured price discrimination can be low while market power is high, and price discrimination can be high while market power is low, suggesting that there is no theoretical connection between the strength of price discrimination and that of market power.

Several authors have argued that price discrimination can exist in competitive

[1] See, for example, Coal Exporters Ass'n v. U.S. (745 F.2d 76, D.C. Cir. 1984) ("it is well established that the ability of a firm to price discriminate is an indicator of significant market power"); and U.S. v. Eastman Kodak Co. (63 F.3d 95, 2nd Cir. 1995) ("The theory that price discrimination is one of the indicia of market power… has received acceptance in the academic community). In U.S. v. Microsoft, expert witnesses for the government repeatedly testified that substantial price discrimination in OS prices is an indicator of Microsoft's considerable market power (see part C, sections 38.2 and 38.3, of *U.S. v. Microsoft: Proposed Findings of Fact*, at http://www.usdoj.gov/atr/cases/f2600/2613a_htm.htm).

markets. To show this, they extend the standard model of price discrimination in different directions. Locay (1992) introduces group purchases, Levine (1998) introduces common costs, and Dana (1998, 1999, 2001) introduces price rigidities and demand uncertainty. Locay shows that group-purchasing can sufficiently constrain individual group members to allow even competitive firms to engage in price discrimination. Levine shows that price discrimination can occur in competitive markets as a way of recovering costs that are common to producing more than one unit of a good. Without assuming any market power, Dana (1998) shows that advance purchase discounts are a profit-maximizing response by firms to demand uncertainty and inventory costs. Also assuming demand uncertainty and costly capacity, Dana (1999, 2001) shows that price dispersion may actually be increasing in the extent of competition. We appear to be the first to show that there is no general theoretical connection between price discrimination and market power even in a standard model (without group purchases, common costs, capacity costs, or demand uncertainty).

2. Theory

The model's actors are a discriminating monopolist and numerous competitive fringe firms. Customers are uniformly located on the $[0,2]$ segment.[2] The monopolist is located at $x_m = 0$, while the competitive fringe is located at the other end of the segment, i.e., $x_f = 2$. A firm must incur transportation cost $C(x)$ to serve a customer located at a distance x from it.

Given that the prices of fringe firms, p_f, are set at the competitive level, $C(2-x)$, the monopolist's profit-maximizing prices solve the following program:

[2] One can interpret the [0,2] segment as physical or characteristic space.

$$\underset{p}{Max}\ p - C(x) \quad s.t.\ p \leq p_f = C(2-x)\,. \tag{1}$$

The resulting set of optimal prices is

$$p_m = \begin{cases} C(2-x) & if \quad C(x) \leq C(2-x) \\ C(2-x) + \varepsilon & otherwise \end{cases} \tag{2}$$

for any $\varepsilon > 0$. In equilibrium, the monopolist supplies half of the market, i.e., $x_m^* = 1$.

This model is an appropriate vehicle for looking at the connection between price discrimination and market power because it allows a distinction between price differences due to cost differences and price differences due to differences in market power.[3]

The measure of the mean mark-up (market power) of the monopolist is:

$$\mu \equiv \int_0^1 C(2-x) - C(x)\, dF(x)\,. \tag{3}$$

How much price discrimination is a lot of price discrimination? Consider the measure of the extent of price discrimination that is the standard deviation of mark-ups:

$$\sigma \equiv \sqrt{\int_0^1 (C(2-x) - C(x))^2\, dF(x) - (\int_0^1 (C(2-x) - C(x))\, dF(x))^2}\,. \tag{4}$$

This measure of price discrimination makes the conventional wisdom true—an increase in market power (μ) through a scalar γ will generally go with an increase in price discrimination:

$$\begin{aligned} \sigma(\gamma) &= \sqrt{\int_0^1 (\gamma C(2-x) - \gamma C(x))^2\, dF(x) - (\int_0^1 (\gamma C(2-x) - \gamma C(x))\, dF(x))^2} \\ &= \gamma \sqrt{\int_0^1 (C(2-x) - C(x))^2\, dF(x) - (\int_0^1 (C(2-x) - C(x))\, dF(x))^2} = \gamma\sigma. \end{aligned} \tag{5}$$

However, this measure of price discrimination is flawed. Suppose that the industry experiences a negative shock that increases production costs by γ everywhere, and that the

[3] Models of this kind are often used in the spatial discrimination literature (see, e.g., Tirole, 2002, p. 140).

monopolist transfers the burden to consumers by raising all prices proportionally. Then, according to the standard deviation measure, the shock also increases price discrimination by γ, even though there is no change in the degree of price dispersion. The increase in price discrimination is only due to the increase in mark-up.

Similarly, the definition of price discrimination as the standard deviation of mark-ups makes price discrimination increase with inflation, a flaw in the definition. To overcome this problem, we propose to measure price discrimination in percent—how much do prices vary relative to the average prices? Specifically, we use the coefficient of variation (*CV*) of mark-ups, which is the standard deviation of mark-ups divided by the mean mark-up, to measure the level of price discrimination:

$$CV \equiv \frac{\sigma}{\mu} = \sqrt{\frac{\int_0^1 \left(C(2-x)-C(x)\right)^2 \, dF(x)}{\left(\int_0^1 (C(2-x)-C(x)) dF(x)\right)^2} - 1} \,. \tag{7}$$

This measure is unaffected by an increase in costs that are fully passed on to consumers. It is invariant to linear transformations of the cost function, so we can separate the impact of changes in market conditions on price discrimination from their impact on mark-ups. For any scaling factor $\gamma > 0$,

$$CV(\gamma) = \sqrt{\frac{\int_0^1 \left(\gamma C(2-x)-\gamma C(x)\right)^2 \, dF(x)}{\left(\int_0^1 (\gamma C(2-x)-\gamma C(x)) \, dF(x)\right)^2} - 1} = \sqrt{\frac{\int_0^1 \left(C(2-x)-C(x)\right)^2 \, dF(x)}{\left(\int_0^1 (C(2-x)-C(x)) \, dF(x)\right)^2} - 1} = CV \,. \tag{8}$$

On the other hand, the mean mark-up μ is an increasing function of the scaling factor γ:

$$\mu(\gamma) = \int_0^1 \gamma C(2-x) - \gamma C(x) \, dF(x) = \gamma\mu \,. \tag{9}$$

Therefore, for a given level of price discrimination (constant *CV*), the mean mark-up can be low or high depending on the level of γ. As $\gamma \to 0$, the monopolist's mark-up vanishes while the level of price discrimination—the variation in mark-ups—remains the same. Figure 1 illustrates the effect for a linear cost function.

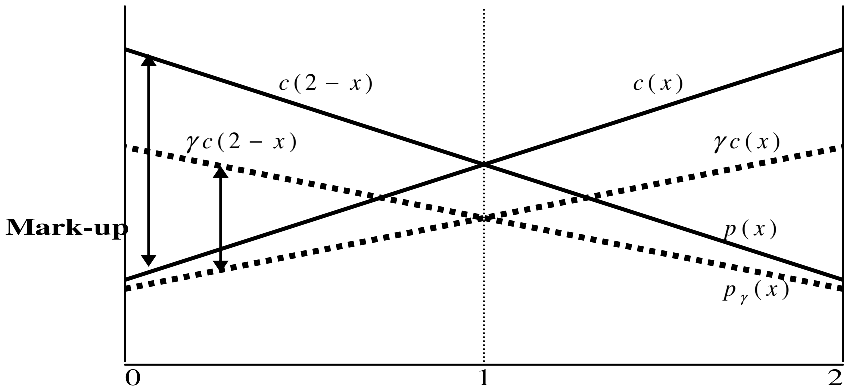

Figure 1: Price Discrimination Unaffected as Market Power Diminishes.

Any linear reduction in cost reduces the mark-up proportionally, but not the *CV*, because the *CV* measures dispersion relative to the level of the mean mark-up. A decrease in the mark-up also decreases price dispersion. But the decrease in price dispersion is the same as the decrease in the mean mark-up, leaving relative price dispersion intact.

The parameter γ is related to the degree of substitutability between the products of the monopolist and the fringe. If customers near the monopolist prefer the monopolist's product over the fringe's product only a little more than do customers located near the fringe, i.e., customers are almost identical, then the fringe incurs almost the same cost to tailor its product to the customers near the monopolist as it does to tailor its product to customers next store. This would naturally reduce the monopolist's power to set price above cost. But if customers are distinct in their tastes, γ is larger and the monopolist can maintain a higher mark-up for any given level of price discrimination. As consumers become identical, market power vanishes while price discrimination remains high. Thus, in an industry with a high degree of substitutability between the products of the monopolist and the fringe firms, we may observe low market power but relatively high price discrimination.

The experiment of reducing γ is similar to an increase in competition. Consider the standard circle model (Salop, 1979) with price discrimination.[4] With a unit-length circle and n firms, firms are $1/n$ apart. Consider a firm located at 0 and consumers in the interval $[0,1/n]$. A consumer at x will face a price equal to the maximum of $c(x)$ and $c(1/n-x)$; for a consumer to the left of $1/2n$, this gives a price equal to $c(1/n-x)$. Consequently, distributing firms on the circle replicates the analysis of Figure 1, with the provision that an increase in competition forces the firms closer together. If c is linear, increasing competition is the same as a reduction in γ, and in particular, we have that an increase in competition with a linear cost function leaves the measure of price dispersion unchanged.

In the case of non-linear c, we show in the appendix that if c is concave, or if c is convex and log(c) is concave, then the coefficient of variation is increasing in the level of competition. This covers the reasonable special case of $c(x)=x^a$ for any $a>0$. Thus, for a large class of environments, competition will increase measured price discrimination.

Profits can also remain large while price discrimination vanishes. To see this, consider industries where firms have access to more than one cost technology. Firms can optimize production by choosing a convex combination of technologies that minimizes the production cost with respect to the output level. For simplicity, assume two technologies are available, $c_1(x)$ and $c_2(x)$. A firm's cost minimization problem is characterized by $C(x)=\min\{c_1(x),c_2(x)\}$. Suppose there is an output level $\bar{x}>0$ that induces the following cost minimization behavior by firms:

[4] The circle model with price discrimination has been analyzed by Thisse and Vives (1988), among others.

$$C(x) = \begin{cases} c_1(x) & \text{for} \quad x \le \overline{x} \\ c_2(x) & \text{for} \quad x > \overline{x}. \end{cases} \tag{10}$$

Figure 2 illustrates a case where the first technology $c_1(x)$ is increasing in the shipping distance x, and increasing at an increasing rate, $c_1'(x) \ge 0$ and $c_1''(x) \ge 0$; the second technology $c_2(x) = \overline{c}$ is a flat fee to ship anywhere on the segment; and $\overline{x} = 1$. This shape of the cost function has a natural interpretation in physical space. To reach the customers located beyond some point (for example, out-of-city), the firm will find it better to use a flat fee courier service (e.g. Federal Express) than incur the rapidly increasing shipping costs associated with its own shipping method.

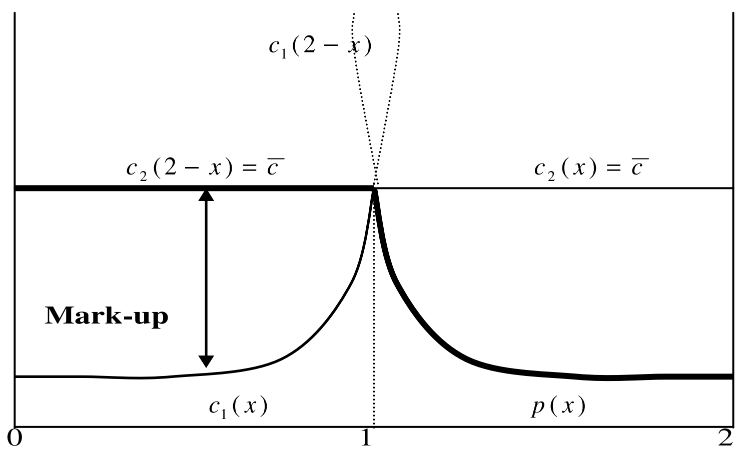

Figure 2. Convex Combination of Technologies.

Now consider two industries, 1 and 2, which are identical except for the first cost technology. Let $c_{11}(x)$ and $c_{12}(x)$ be the technology for "nearby" customers in industries 1 and 2, respectively, where the former is flatter than the latter over a longer output range. That is, the shipping cost in industry 1 does not rise as rapidly as that in industry 2. Figure 3 illustrates the situation. It is easy to see that price discrimination is lower, but the mean mark-up is higher, in industry 1.

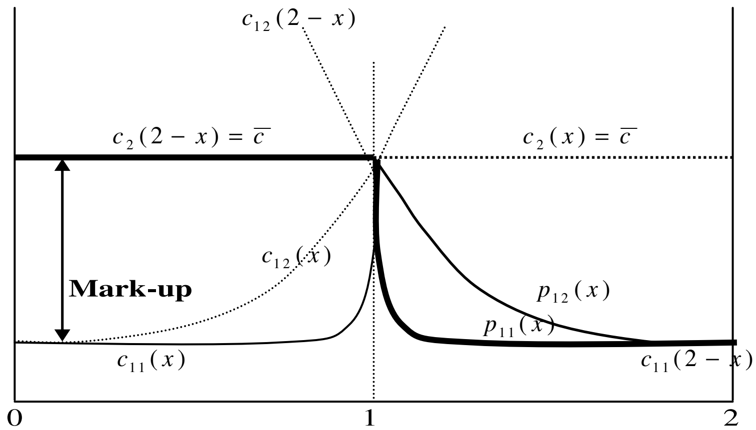

Figure 3. Market Power Higher and Price Discrimination Lower in Industry 1.

In both industries, the monopolists have the same pricing schedule, $c_2(2-x)=\overline{c}$, but the shipping cost is always lower in industry 1, that is, $c_{12}(x) \geq c_{11}(x)$ for all x. Since the shipping cost is lower, the monopolist's mean mark-up is higher in industry 1. Moreover, as the cost function flattens out for a wider range, the monopolist can tailor its product to customers located further away at nearer the same cost as customers located nearby. Thus, the variation in mark-ups is lower in industry 1. Since the mean mark-up is higher and the variation in mark-ups is lower in industry 1, price discrimination, as measured by the *CV*, is lower in industry 1. In the limit, if $c_{11}(x)$ becomes flat over most output ranges, measured price discrimination vanishes while market power remains very high.

Note that if we use the standard deviation of mark-ups, instead of the *CV*, as the measure of price discrimination, we find that measured price discrimination is higher in industry 1. For industry *i=1,2*, the mean mark-up is $\mu_i = \int_0^1 \overline{c} - c_{1i}(x)\, dF(x)$ and the standard deviation of mark-ups is $\sigma_i = \sqrt{\int_0^1 (\overline{c} - c_{1i}(x))^2 \, dF(x) - \mu_i^2}$. Since $\overline{c} - c_{11}(x) \geq \overline{c} - c_{12}(x)$ for $x \in [0,1]$, $\mu_1 - \mu_2 > 0$ and $\int_0^1 (\overline{c} - c_{11}(x))^2 \, dF(x) \geq \int_0^1 (\overline{c} - c_{12}(x))^2 \, dF(x)$. For *i=1,2*,

$\int_0^1 (\overline{c} - c_{1i}(x))^2 \; dF(x) \geq \mu_i^2$ by the Schwartz inequality. Thus, $\int_0^1 (\overline{c} - c_{11}(x))^2 \; dF(x) - \int_0^1 (\overline{c} - c_{12}(x))^2 \; dF(x) - (\mu_1^2 - \mu_2^2) \geq 0$. Therefore, the standard deviation of mark-ups is higher in industry 1. On the other hand, the *CV* measure correctly indicates that price discrimination is higher in industry 2, as is evident from Figure 3.

Hence, depending on the shape of the cost function for the firm and for the rival competitive industry, a high degree of price discrimination, as measured correctly by the *CV*, may be associated with a high or low degree of market power. Similarly, a low degree of price discrimination may be associated with either a high are low degree of market power.

3. Conclusion

We explored the theoretical relationship between price discrimination and market power in a simple model. Price discrimination was measured by the coefficient of variation in mark-ups, which was argued to be a better measure than the standard deviation of mark-ups. The model implied that a reduction in the differences in the costs of serving different customers would reduce market power while leaving measured price discrimination unaffected. In the presence of a flat fee for very costly customers, a reduction of this kind would reduce price discrimination while leaving market power unaffected or increasing it. Moreover, an increase in the number of firms would increase measured price discrimination for reasonable cost specifications. These results suggest that no generally positive relationship exists between the extent of price discrimination and that of market power.

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Appendix

We show that if c is concave, or c is convex and log(c) is concave, then the coefficient of variation is increasing in the level of competition.

To analyze the case with non-linear c, define $z = 1/2n$. Then the coefficient of variation is

$$CV = \sqrt{\frac{\int_0^z (c(2z-x)-c(x))^2 \, dF(x)}{\left(\int_0^z (c(2z-x)-c(x))dF(x)\right)^2} - 1} \qquad \text{(A1)}$$

This is increasing in n if an only if

$$CV = \frac{\int_0^z (c(2z-x)-c(x))^2 \, dF(x)}{\left(\int_0^z (c(2z-x)-c(x))dF(x)\right)^2} \text{ is decreasing in } z. \qquad \text{(A2)}$$

(A2) is equivalent to

$$\begin{aligned}&\int_0^z (c(2z-x)-c(x))dF(x)\int_0^z (c(2z-x)-c(x))c'(2z-x)dF(x) \le \\ &\int_0^z (c(2z-x)-c(x))^2 \, dF(x)\int_0^z c'(2z-x)dF(x).\end{aligned} \qquad \text{(A3)}$$

Define an expectation by

$$E(\bullet) = \frac{\int_0^z \bullet \; c'(2z-x)dF(x)}{\int_0^z c'(2z-x)dF(x)}. \qquad \text{(A4)}$$

Then (A2) is equivalent to

$$E\left(\frac{c(2z-x)-c(x)}{c'(2z-x)}\right)E\big(c(2z-x)-c(x)\big)\leq E\left(\frac{(c(2z-x)-c(x))^2}{c'(2z-x)}\right). \tag{A5}$$

Now $c(2z-x)-c(x)$ is a decreasing function of x. Thus, we have that a sufficient condition for (A2) is that $\frac{c(2z-x)-c(x)}{c'(2z-x)}$ is decreasing in x, for then $\frac{c(2z-x)-c(x)}{c'(2z-x)}$ and $c(2z-x)-c(x)$ are positively related and hence positively correlated, so that the product of the expectations is less than the expectation of the product. It remains to check that $\frac{c(2z-x)-c(x)}{c'(2z-x)}$ is decreasing in x. If c is concave, the numerator is positive and decreasing, while the denominator is increasing, so the check is automatic. Now suppose c is convex and $\log(c)$ is concave. Since c is convex, $\frac{-c(x)}{c'(2z-x)}$ is decreasing ($c(x)$ increasing, $c'(2z-x)$ decreasing). Since $\log(c)$ is concave, $\frac{c'(y)}{c(y)}$ is decreasing in y, so $\frac{c'(2z-x)}{c(2z-x)}$ is increasing in x, so $\frac{c(2z-x)}{c'(2z-x)}$ is decreasing in x. Together, these imply $\frac{c(2z-x)}{c'(2z-x)}+\frac{-c(x)}{c'(2z-x)}$ is decreasing in x. Hence, if c is concave, or c is convex and $\log(c)$ is concave, CV is actually increasing in the number of firms.