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ABSTRACT

This paper studies technology choice as a relevant aspect to be considered when analyzing price discrimination and welfare. Our results reinforce the traditional wisdom that an increase in output is a necessary condition for price discrimination to improve social welfare. But we also find that the positive output effect does not need to be as large as previously supposed since, under some conditions, the monopoly will move to a socially preferred technology only if third-degree price discrimination is allowed.

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Technology choice and third degree price discrimination in a monopoly

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Abstract

This paper studies technology choice as a relevant aspect to be considered when analyzing price discrimination and welfare. Our results reinforce the traditional wisdom that an increase in output is a necessary condition for price discrimination to improve social welfare. But we also find that the positive output effect does not need to be as large as previously supposed since, under some conditions, the monopoly will move to a socially preferred technology only if third-degree price discrimination is allowed.

Keywords:
monopoly, technology choice, third degree price discrimination
JEL: D42, L12, L13.

1. Introduction

Price discrimination is a common practice. In a regime of third-degree price discrimination the producer charges different prices to buyers who belong to different markets. For instance, markets can be separated geographically or customers may be differentiated by age, employment status (discounts for retired and unemployed workers), time of purchase (last moment discounts) and many other variables. The overall effect of third-degree price discrimination on welfare is undetermined. Price discrimination allows firms to increase their profits. Consumers who pay a lower price are also better off. But price discrimination harms consumers in markets with higher prices.

The impact of price discrimination on welfare can be rearranged in a different way: the misallocation effect and the output effect. The misallocation effect is always negative for welfare, because a change from uniform pricing to

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price discrimination moves some output from high value buyers to low value consumers. However, the output effect can be positive, and it has the potential to overcome the misallocation effect, but only if the increase in output is big enough. In consequence, a necessary condition for price discrimination to increase welfare is that total output rises (see Schmalensee (1981), Varian (1985) and Schwartz (1990)).

Recently Aguirre et al. (2010) presented a general analysis of the two effects on welfare –misallocation and output– in a framework of monopolistic third-degree price discrimination. They establish sufficient conditions under which discrimination has positive effects on output and social welfare.

The misallocation effect and the output effect are always present in any model of third degree price discrimination. But other variables have to be considered since more effects may appear. For example, Ikeda and Toshimitsu (2010) show that a monopoly, facing linear demands and able to choose the quality of its product, will invest more in quality when price discrimination is allowed, overcoming the misallocation effect in such a way that price discrimination increases social welfare even if the output effect is nil.

This paper deals with social welfare and third-degree monopolistic price discrimination in the presence of another relevant effect: technology choice. This effect should be taken into account in order to better understand the welfare effects of monopolistic third-degree price discrimination. In particular, it should be included when studying the conditions that determine the sign of these welfare effects.

Technology changes can be understood as firms investing to improve the efficiency of their productive processes. These investments can take many forms. Some imply minor modifications (such as small purchases, task reorganizations or in-the-job training) while others result in significant changes and costs (for example purchases of new machinery, the building of a new plant, cost reduction task forces, etc). For the sake of this paper, technology choice means a reduction in variable costs at the expense of some fixed costs.

A social inefficiency may exist when a monopoly does not adopt a new technology with lower marginal costs because the associated fixed costs are too high. Here, we find cases where third-degree price discrimination outperforms uniform pricing, since it provides the monopoly with the right incentives for the adoption of the new technology.

First, we prove that if a profit-maximizing monopoly decides to adopt a new technology that increases output, society will also be better off. We then show that, in some cases, when society prefers the monopoly to adopt the new technology, third-degree price discrimination (but not uniform pricing) can make it profitable for the firm to do so. Of course, this is not to mean that price discrimination is always preferable to uniform pricing. Our point is that a number of considerations must be made when assessing which price regime would maximize social welfare; and technology choice is a reasonable example. From a normative point of view, our result calls for caution when applying theoretical results for policy making.

2. Technology choice, price discrimination and social welfare

Let's consider a monopoly facing the possibility of adopting a new technology, which increases output. The monopoly will only implement this technological change if it is profitable. If we consider two price regimes and only one of them leads the monopoly to adopt the output-increasing technology, this regime would be more socially desirable.

Proposition 1. *If the monopoly prefers a technological change that increases its production level ($Q^n \geq Q$), so will society.*

Proof. Let us first consider the case where $Q^n = Q$. If the monopoly prefers the new technology so will society, since profits increase and consumer surplus remains the same.

When $Q^n > Q$, consumers are better off because prices are lower. Again, if the monopoly prefers the new technology, so will society since consumers and government are also better off.

Note, however, that it is possible for society to prefer a price-lowering technology that the monopoly does not want to adopt. One such example can be found for a monopoly with constant marginal costs of 2, facing a demand given by $p = 6 - Q$. Under these conditions, profits are equal to 4, while society's welfare (consumer surplus plus profits) is 6. If a new technology becomes available with zero marginal costs and a fixed cost of 6, the profits of the monopoly would be lower (3), but welfare would be higher (7.5).

Let's now consider under which price regime a monopoly is more likely to adopt the socially desirable technology.

Proposition 2. *Suppose a monopolist with constant marginal cost, c, and two possible regimes: uniform price and third degree price discrimination. Then, in either regime, the derivative with respect to c of the profit function is the quantity produced. In consequence, the monopoly is more likely to adopt a cost reducing technology under the price regime with higher output.*

Proof. A monopolist facing constant marginal cost, c, sells its product in two markets, A and B. Let the demand of the monopolist be $Q = A(p) + B(p)$, where $A(p)$ and $B(p)$ represent the demand in these two different markets. The monopolist can reduce variable costs at the expense of some fixed costs.

Under a uniform pricing regime, the monopolist' profit, net of fixed cost, is given by

$$\Pi_U(p) = (p - c)\left(A(p) + B(p)\right).$$

The monopolist will choose an optimal price p_U^*. Applying the envelope theorem we get

$$\frac{d\Pi_U(p_U^*)}{dc} = \frac{\partial \Pi_U(p)}{\partial c}\Big|_{p_U^*} = -(A(p_U^*) + B(p_U^*)).$$

Alternatively, under third degree price discrimination, the monopolist' profit is given by

$$\Pi_D(p_A, p_B) = (p_A - c)A(p_A) + (p_B - c)B(p_B).$$

The monopolist will choose two optimal prices: p_A^* and p_B^*. Again, by the envelope theorem, we get

$$\frac{d\Pi_D(p_A^*, p_B^*)}{dc} = \frac{\partial \Pi_D(p_A, p_B)}{\partial c}\Big|_{p_A^*, p_B^*} = -\left(A(p_A^*) + B(p_B^*)\right).$$

Suppose now that there are two possible technologies, L and H, such that their variable costs are $c_L < c_H$; and there is a fixed cost, F, associated to this reduction in marginal cost. It is clear that

$$\Pi_D(c_L) - \Pi_D(c_H) = \int_{c_H}^{c_L} \frac{d\Pi_D(p_A^*, p_B^*)}{dc} dc,$$

and

$$\Pi_U(c_L) - \Pi_U(c_H) = \int_{c_H}^{c_L} \frac{d\Pi_U(p_U^*)}{dc} dc.$$

When $\Pi_D(c_L) - \Pi_D(c_H) > \Pi_U(c_L) - \Pi_U(c_H)$, some F can be found such that $\Pi_D(c_L) - \Pi_D(c_H) > F > \Pi_U(c_L) - \Pi_U(c_H)$. In that case, the monopoly has incentives to move to the lower cost technology only under the price discrimination regime, but not with uniform pricing. This result would always hold if, for every $c \in [c_L, c_H]$, the output under uniform price is lower than the output under price discrimination. More generally, when facing a technology choice that would lower variable costs, the monopoly will be more likely to act according to the interest of society under the price regime with higher output.

This result reinforces the well-known criterion in price discrimination: welfare cannot improve with price discrimination when total output falls. Otherwise stated, an output increase is a necessary but not sufficient condition for price discrimination to improve welfare. But if we take into account the possibility of the monopoly adopting a lower cost technology, price discrimination can lead to higher welfare even if the positive output effect is small.

In order to illustrate our result, we provide an example related to Aguirre et al. (2010), who in proposition 6, state that: "When demand functions have constant elasticities: (i) total output is higher with discrimination, and (ii) social welfare is lower with discrimination if the difference between the elasticities is at most 1."

This proposition holds if we keep everything else constant. However, it can be reversed in some cases if technological change is taken into consideration. We illustrate this possibility with a numerical example.

2.1. Numerical example

Let the demands be given by $A(p) = \alpha_A p^{-\epsilon_A}$ and $B(p) = \alpha_B p^{-\epsilon_B}$, with ϵ_A, $\epsilon_B > 1$. Technological change can reduce marginal costs from c_H to c_L.

Under price discrimination, the two prices can be calculated with the expression $\frac{p-c}{p} = \frac{1}{\epsilon_i}$, $i = A, B$; that is, with $k = L, H$, prices are

$$p_i(c_k) = \frac{c_k \epsilon_i}{\epsilon_i - 1}. \tag{1}$$

The welfare in market $i = A, B$, with marginal cost c_k, is

$$W_i(p_i) = \int_0^{\alpha_i p_i^{-\epsilon_i}} \left(\left(\frac{\alpha_i}{Q} \right)^{\frac{1}{\epsilon_i}} - c_k \right) dQ = \frac{\alpha_i}{p_i^{\epsilon_i}} \left(\frac{\epsilon_i p_i}{\epsilon_i - 1} - c_k \right). \tag{2}$$

To obtain the prices for the uniform price regime, we derive the profit function

$$\Pi_U(c_k) = \left(\frac{\alpha_A}{p^{\epsilon_A}} + \frac{\alpha_B}{p^{\epsilon_B}} \right) (p - c_k), \tag{3}$$

with respect to p, to obtain

$$\frac{\partial \Pi_U(c_k)}{\partial p} = \frac{\alpha_B p^{\epsilon_A + 1} + \alpha_A p^{\epsilon_B + 1} - (p - c_k)(\alpha_A \epsilon_A p^{\epsilon_B} + \alpha_B \epsilon_B p^{\epsilon_A})}{p^{\epsilon_A + \epsilon_B + 1}} = 0. \tag{4}$$

Expresion 3, with ϵ_A, $\epsilon_B > 1$ and $|\epsilon_A - \epsilon_B| < 1$ is indeed very complicated to solve analytically. So, we will use a numeric example to ilustrate our point. Let us suppose that $\alpha_A = \alpha_B = 100$, $\epsilon_A = 1.1$, $\epsilon_B = 2$, $c_H = 2$ and $c_L = 1$.

The first order condition, equation 4, holds for price values $p_U(c_H) = 13.04$ and $p_U(c_L) = 4.52$. With price discrimination regime, from equation 1 prices change from $p_A(c_H) = 22$ and $p_B(c_H) = 4$ to $p_A(c_L) = 11$ and $p_B(c_L) = 2$.

Table 1 shows the levels of output, profits and welfare for all combinations of technology and price regimes. The welfare levels can be calculated with equation 2. The profit with uniform price is in equation 3, while the profit with price discrimination is

$$\Pi_D(c_k) = \frac{\alpha_A}{{p_A}^{\epsilon_A}} (p_A - c_k) + \frac{\alpha_B}{{p_B}^{\epsilon_B}} (p_B - c_k).$$

	Uniform price			Price discrimination		
	Q_U	Π_U	W_U	Q_D	Π_D	W_D
$c_L = 1$	6.52	84.20	966.3	9.59	96.53	933.3
$c_H = 2$	23.92	71.98	853.2	32.15	79.24	838.3

Table 1: Output, Profits and Welfare

We can see that the proposition of Aguirre et al. (2010) holds: total output rises with price discrimination, but social welfare is always higher under uniform pricing. But we also need to consider the incentives of the monopoly to adopt the new technology and the effects on welfare. Under both price regimes, profits increase if the new technology is adopted but –as Proposition 2 states– the

increase is greater under price discrimination (17.29) than under uniform prices (12.22). Then, (i) if the cost of adopting the new technology is less than 12.22, the technology will be adopted under both regimes; (ii) if the cost is higher than 17.29, the new technology will never be adopted; but (iii) if the cost is between 12.22 and 17.29, the new technology will be adopted only under third degree price discrimination.

As we can see from Table 1, society has different threshold values for the cost of adopting the new technology. Under the price discrimination regime, the change would be desirable for consumers for any cost below $933.3 - 838.3 = 95$. Under the uniform price schedule, the threshold is $966.3 - 853.2 = 113.1$.

Therefore, if the costs of adopting the new technology are between 12.22 and 17.29, that is, clearly below 95 and 113.1, society would prefer that the firm adopts the new technology, but the monopoly would do so only under third degree price discrimination. Then, we can conclude that in some cases technology choice makes third degree price discrimination welfare-superior to uniform pricing even with a small output effect.

Cowan (2012) shows that discrimination can be good for consumers in aggregate cuando se dan ciertas condiciones en las demandas. Como la discriminacion de precios es siempre buena para el monopolista, esto implica que el efecto output debe superar al efecto misallocation, y por lo tanto debe ser positivo. Por tanto como el efecto output es positivo, siempre hay mas incentivos a bajar los costes con precio diferenciado que con precio uniforme, como establece nuestra proposicion 2.

En nuestro ejemplo se ve que la discriminacion de precios es buena para los consumidores porque el precio baja de 15.04 con regimen uniforme a unos precios de 11 y 2, con regimen diferenciado. Pero nuestras demandas no cumplen las condiciones de Cowan (2012).

Por tanto vemos que esas condiciones pueden ser demasiado estrictas cuando se tiene en cuenta que las empresas pueden disminuir sus costes marginales a cambio de incrementos en los costes fijos.

3. Final remarks

This paper deals with the well-known problem of monopolistic third-degree price discrimination and social welfare when all markets are served. A classical result in the literature is that the effect of price discrimination can be positive or negative for welfare depending on the direction and magnitude of the quantity or output effect. Third degree price discrimination reduces welfare when the output effect cannot overcome the misallocation effect.

However, our paper provides additional conditions under which monopolistic third-degree price discrimination may increase social welfare. The main result is that, under some assumptions, the profit-maximizing monopolist will choose to adopt a socially preferred technology if and only if third-degree price discrimination is allowed. Thus, a ban on third-degree price discrimination, even if seemingly beneficial, may prove detrimental by preventing the monopolist from adopting a socially superior technology.

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